A current view of Canadian cardiorespiratory fitness

D. A. Bailey,* M.SC., P.E.D., R. J. Shephard,† M.D., PH.D., R. L. Mirwald,‡ M.SC., PH.D. and G. A. McBride,¶ M.D., *Saskatoon, Sask.*

Summary: A standard Åstrand bicycle ergometer test was used to predict the maximum oxygen intake of 672 female and 558 male volunteers ranging in age from 15 to 69 years. In terms of this index of cardiorespiratory performance Canadians were unfit relative to Swedish norms. Also, some 47% of women and 40% of men achieved only low or fair fitness categories when evaluated relative to American Heart Association recommendations. These results are poorer than those reported for Torontonians in 1966. Men perceive their cardiorespiratory fitness accurately but women do not. In both sexes adequate recreational activity apparently leads to maintenance of cardiorespiratory fitness.

Résumé: *Un rapport récent de la forme physique des Canadiens, au point de vue cardiorespiratoire*

Nous avons utilisé une bicyclette ergométrique Åstrand standard pour prédire la consommation maximum d'oxygène de 1230 volontaires (672 femmes et 558 hommes) dont l'âge variait de 15 à 69 ans. D'après ce paramètre de la performance cardiorespiratoire, la santé des Canadiens était considérée comme mauvaise par rapport aux normes suédoises. Par ailleurs, près de 47% des femmes et 40% des hommes n'avaient qu'une forme physique basse ou médiocre par rapport aux recommandations de l'American Heart Association. Ces résultats sont même inférieurs à ceux qui ont été rapportés chez les Torontois en 1966. Les hommes se rendent compte avec précision de leur performance cardiorespiratoire, les femmes non. Chez les deux sexes, une activité récréative convenable semble favoriser le maintien d'une forme cardiorespiratoire convenable.

In recent months Canadians have seen a mounting campaign by government and other agencies to develop public awareness of the need for increased physical activity. Advertising campaigns of the type sponsored by Participaction Canada have commenced the task of persuading Canadians to attain a higher level of cardiorespiratory fitness.

*Director, Saskatchewan Child Growth and Development Study, College of Physical Education, University of Saskatchewan, Saskatoon

†Department of Environmental Health, School of Hygiene, University of Toronto

‡College of Physical Education, University of Saskatchewan

¶Student Health Center, University of Saskatchewan

Reprint requests to: Dr. D. A. Bailey, College of Physical Education, University of Saskatchewan, Saskatoon, Sask. S7N 0W0

The success of such approaches depends, at least partly, on convincing opinion-makers such as physicians and teachers, and also the general public, that there is a problem. Vague pronouncements that the fitness of Canadians is lagging behind that found in other countries are not enough; specific facts and comprehensive data are needed. Opportunity to collect this type of information was presented when Health and Welfare Canada approached the authors with a request to develop a self-administered home test of cardiorespiratory fitness (Bailey and Shephard, in preparation). In the process of refining and validating the test it was necessary to assess accurately the cardiorespiratory fitness levels of a large and representative population, using the widely accepted Åstrand bicycle ergometer test.[1] The results provide Canadians with a disturbing description of their current fitness.

Methods and materials

Sample selection

A total of 1230 men and women between the ages of 15 and 69 years were tested during a five-week period in May and June 1973 (Fig. 1). Some 2648 people were contacted by telephone following random selection from the Saskatoon telephone directory. Others came forward as a result of the assistance of several schools, radio and television stations, and the Saskatoon fire and police departments. All were volunteers. At the initial contact subjects were asked two simple questions: (1) Have you ever had heart trouble? and (2) Have you ever had or do you now have persistent chest pains? If the answer to either of these questions was yes the individual was thanked for his interest in the program and advised that he could not be tested. If the answer to both questions was no the potential subject was given an appointment to attend the test centre. Here a registered nurse administered a simple medical questionnaire which included six further items. We excluded anyone with responses suggestive of hypertension, heart disease or chest disease, as well as individuals taking specific medication on a regular basis and anyone who had been hospitalized in the six months preceding the study.

Subjects passing this preliminary screening proceeded to a step-testing station where the supervising physician and coronary care nurse took a resting electrocardiogram. If clinical or ECG abnormalities were noted either at rest or during the subsequent stepping exercise, investigative procedures were halted and the subject was eliminated

from the study. Those who completed the stepping test successfully were given a further appointment for the bicycle ergometer test. At the second visit the subjects were again questioned as to their general health, resting and exercise ECGs were repeated, and some further subjects were eliminated in the light of new or previously undetected adverse findings.

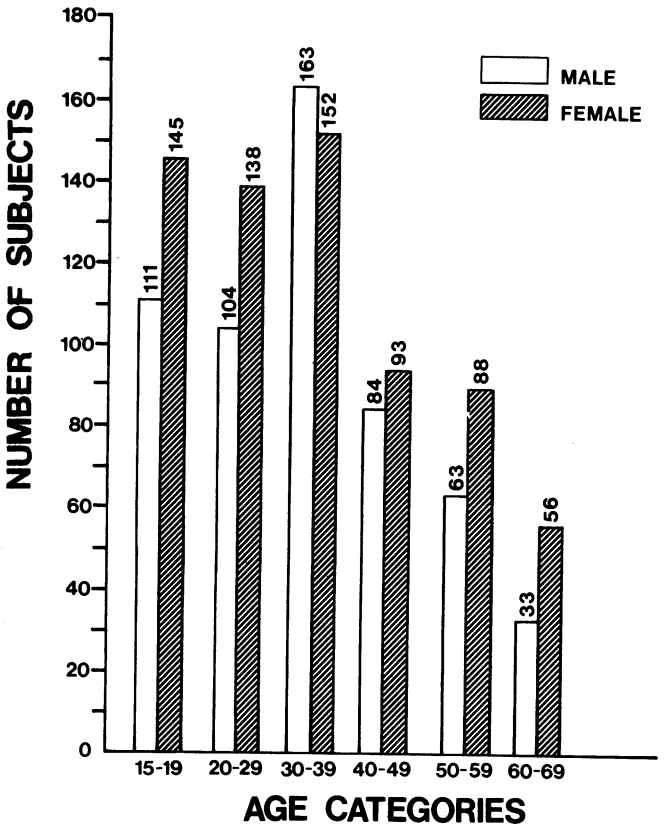


FIG. 1—Age frequency distribution of male and female participants in the Saskatoon study of cardiorespiratory fitness.

The attrition process for the 2648 telephone contacts is illustrated in Fig. 2. The two-item telephone questionnaire eliminated 118 (5%) of the prospective volunteers. A surprisingly large percentage of acceptable recruits (899 persons, 36%) agreed to participate. The other 64% were either uninterested or unable to attend because of overriding commitments. All but 49 (5%) of the 899 volunteers kept their first appointment. However, 72 were rejected because of an unfavourable medical history elicited by the nurse-receptionist. Thus 778 remained to report to the exercise/ECG test station. A further 8% were eliminated here because of an abnormal resting ECG or a poor medical response to exercise (appearance of excessive fatigue, exhaustion, and a variety of ECG abnormalities, including evidence of ischemia and arrhythmias). Seven hundred and thirteen of the original 2648 telephone contacts returned for the ergometer test. Additional medical disqualifications were made on the basis of abnormal resting or exercise ECGs, leaving 686 subjects. Overall, the four levels of medical screening disqualified a total of 282 people, 10.6% of the original 2648 random contacts. The residual group of 686 was complemented by 544 volunteers from other sources, covering a broad socio-economic spec-

FIG. 3—Sixteen-station bicycle test centre.

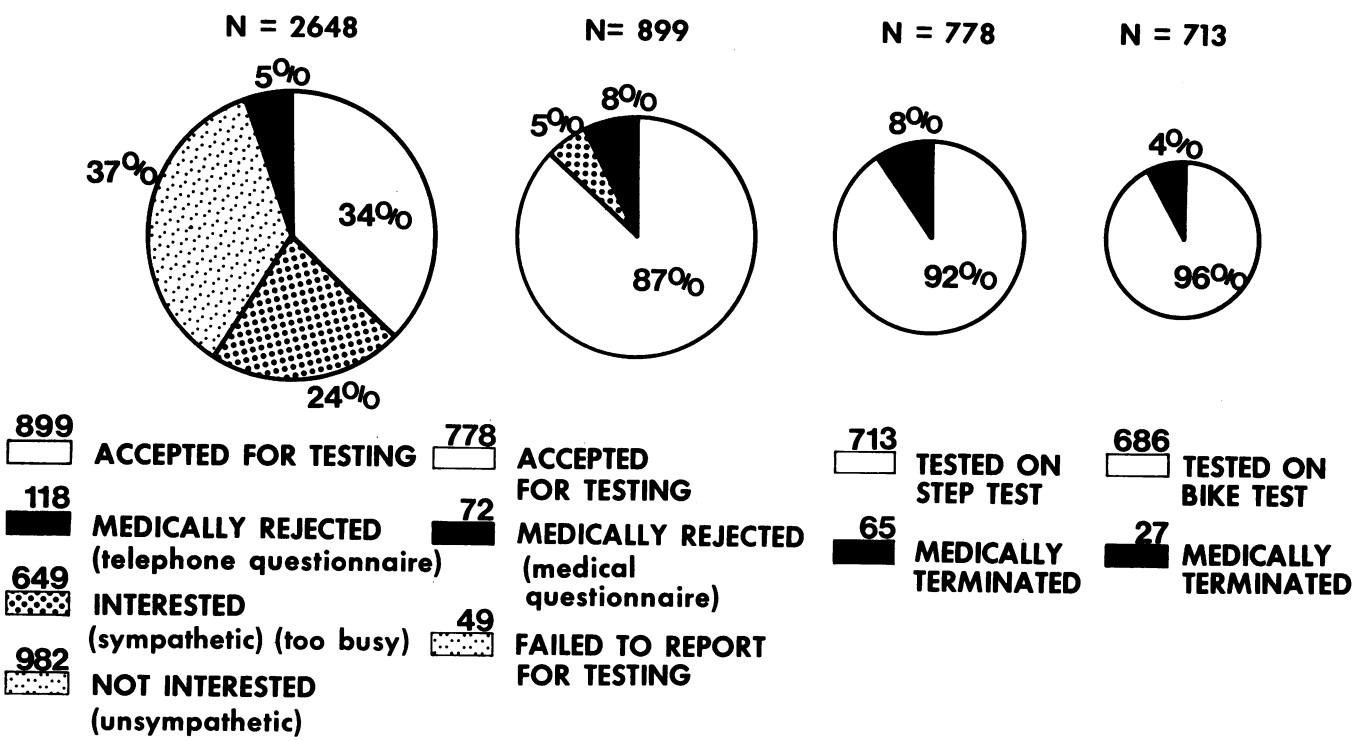


FIG. 2—Progressive attrition of original random sample as drawn from the Saskatoon telephone directory.

trum representative of the average Saskatoon resident and fairly typical of the average Canadian.

Exercise test procedure

Aerobic power ($\dot{V}O_2$ max) was predicted using the technique of Åstrand and Ryhming.[2] The least controversial method of measuring aerobic power is to collect expired gas during graded exercise to exhaustion. However, this approach is not commonly used either for clinical purposes or in population surveys because of possible danger to the subjects and difficulty in persuading older or unfit individuals to reach a satisfactory maximal oxygen intake plateau. We therefore had recourse to indirect estimates. Most indirect procedures are based on two assumptions: (1) that pulse rate is linearly related to oxygen intake between 50 and 100% of maximum oxygen intake, and (2) that there is a consistent maximum pulse rate at a given age. While debate continues on the validity of these two assumptions,[3-7] the questions raised are not sufficient to rule out the use of indirect procedures in assessing the status of populations.[8-10]

The methodology of the Åstrand-Ryhming test is well documented[1] and it has previously been administered to a number of specific populations.[8,11] Basically, the aerobic power is predicted from the steady-state heart-rate response to a standardized bicycle ergometer work load, making a correction for the age-related decline in anticipated maximum heart rate. Our tests were conducted in such a manner that most subjects reached Åstrand's definition of a "steady-state" heart rate (less than six beats' difference between values for the fifth and sixth minutes of exercise). The final heart rates also fell in the accepted range of 122 to 170 beats per minute. Male subjects usually started pedalling at a work load of 600 kg-m/min and female subjects at 300 kg-m/min. The work load was adjusted during the first minute of exercise in occasional individuals when it appeared likely that the final heart rate would not fall within the required range. In a very small number of cases the heart rate had not reached the lower limit of 122 after six minutes of effort; in such subjects the work load was increased by 150 kg-m/min and the exercise continued until a new steady state was achieved. Predictions of aerobic power were carried out by IBM computer, using an appropriate modification of the program suggested by Shephard.[12]

Electrocardiographic monitoring

The ECG waveform (CM_5 lead placement) was viewed before and during exercise. High quality, light-weight silver chloride electrodes were used to minimize polarization potentials. The top layer of skin was removed with "Biobrade" adhesive and the electrodes were secured with hypoallergenic micropore adhesive tape. Highly flexible shielded cables were fitted with press-stud contacts to minimize fitting time. Sixteen subjects were monitored simultaneously (Fig. 3) using two eight-channel intensive care monitors adapted for this purpose by Quinton Instruments (Canada). Instan-

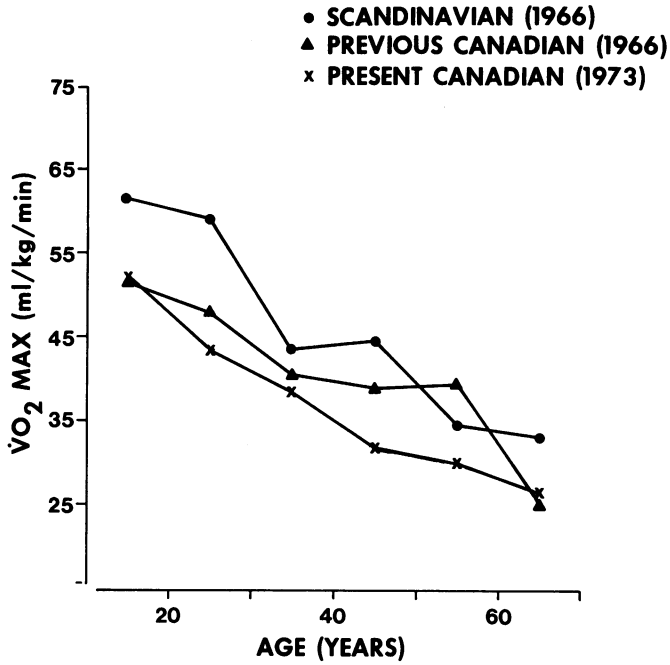


FIG. 4—Predicted maximum oxygen intake of 558 male subjects compared with previous Canadian and Scandinavian values (all data adjusted as suggested by Shephard[8]).

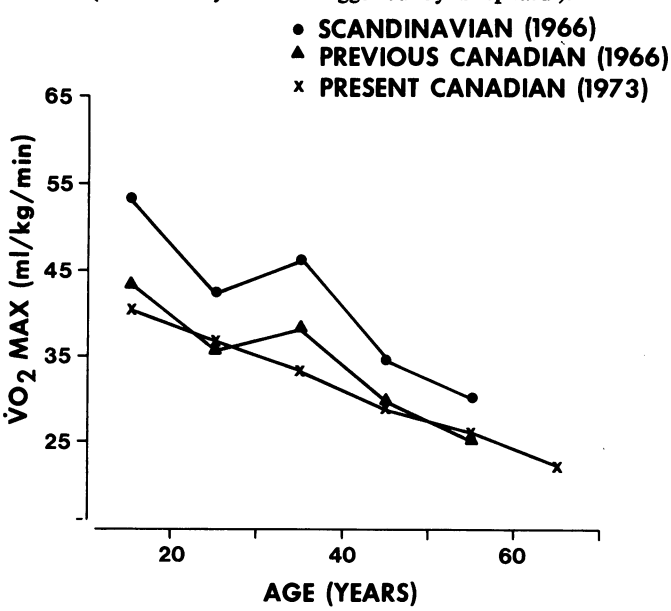


FIG. 5—Predicted maximum oxygen intake of 672 female subjects compared with previous Canadian and Scandinavian values (all data adjusted as suggested by Shephard[8]).

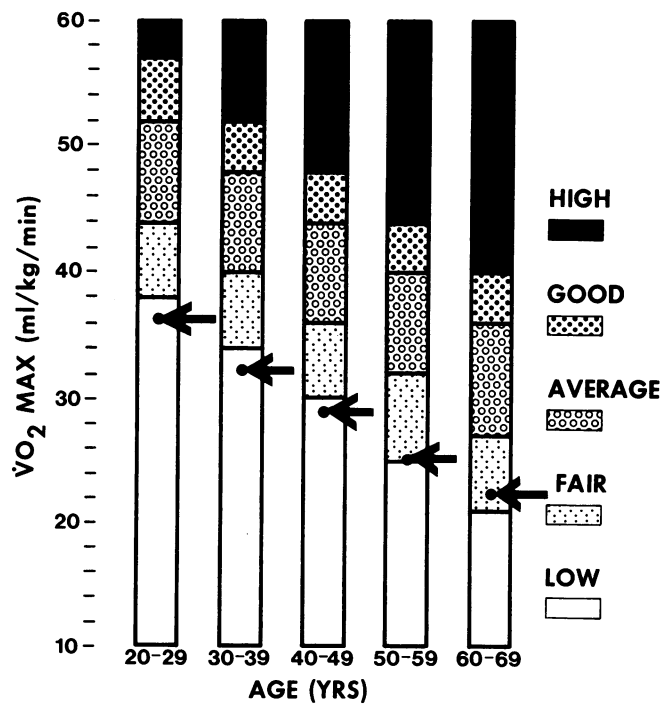


FIG. 6—Maximum oxygen intake of Canadian men relative to Swedish norms.[1] Arrows indicate present Canadian mean values.

taneous heart rates were digitally displayed by cardiotachometer (precision ± 1% to heart rates of 150/min, ± 2% at higher heart rates). A push-button selector provided paper records of the ECG when required.

Medical supervision

Medical supervision was provided by personnel from the Department of Medicine (Exercise Laboratory), University Hospital, Saskatoon. Heart rate and ECG waveform were observed continuously throughout the exercise period. Provision was made for treatment of any cardiac emergencies, including a full range of appropriate drugs, oxygen, defibrillator, and spare 12-lead ECG systems. Fortunately, it was not necessary to use any of this equipment. Minor abnormalities noted by the supervising physician were referred to the patient's family doctor as necessary.

Results

The mean aerobic power for each age decade is shown in Table I along with data for height and weight. The current Canadian status can be compared with previously reported values (Figs. 4 and 5); our present results have been adjusted upwards by 15% to make them comparable with previously adjusted Canadian and Swedish data.[11] The rationale of the adjustment is to allow for an 8% underestimation of aerobic power by submaximal tests and a further 7% underestimation by the bicycle ergometer relative to treadmill exercise. Having made these adjustments, the present Canadian curves for both men and women lie slightly below values obtained on Torontonians some seven years ago.[8] Since both the Toronto and Saskatoon samples were reasonably representative of their respective communities, this raises the disquieting possibility that the cardiorespiratory fitness of Canadians may have deteriorated over the past seven years. The results obtained on both samples of Canadians are inferior to those from the Swedish citizens tested by P. O. Åstrand[2] in the early 1950s and Irma Åstrand[1] in the period 1958 to 1960. The poor relative performance of the Canadians can be illustrated by comparing our present data with the norms that Irma Åstrand considered appropriate for the Swedish population of 1960 (Figs. 6 and 7). She indicated levels of fitness ranging from low to high for each decade. The arrows show where the present data rank relative to the Swedish norms. Her standards were proposed for submaximal bicycle ergometer tests, and should be met without upward adjustment of our data. In fact, young and middle-aged Canadian men fall well below the standards proposed for Swedes; in the third to fifth decades our mean values lie in the low category, and those in the sixth and seventh decades are only slightly better. The women as a group also fall far short of the average set for Swedes, with younger women ranking only slightly higher than older women.

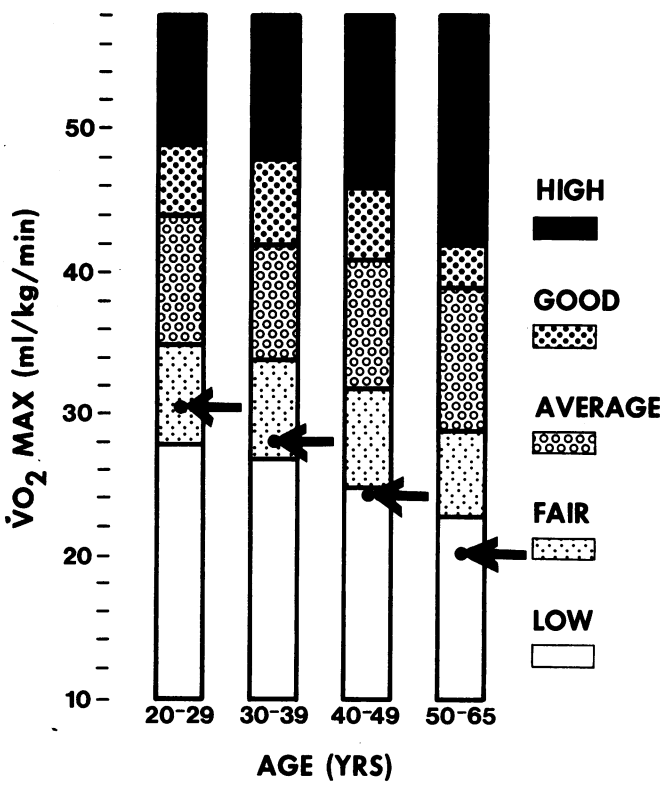


FIG. 7—Maximum oxygen intake of Canadian women relative to Swedish norms.[1] Arrows indicate present Canadian mean values.

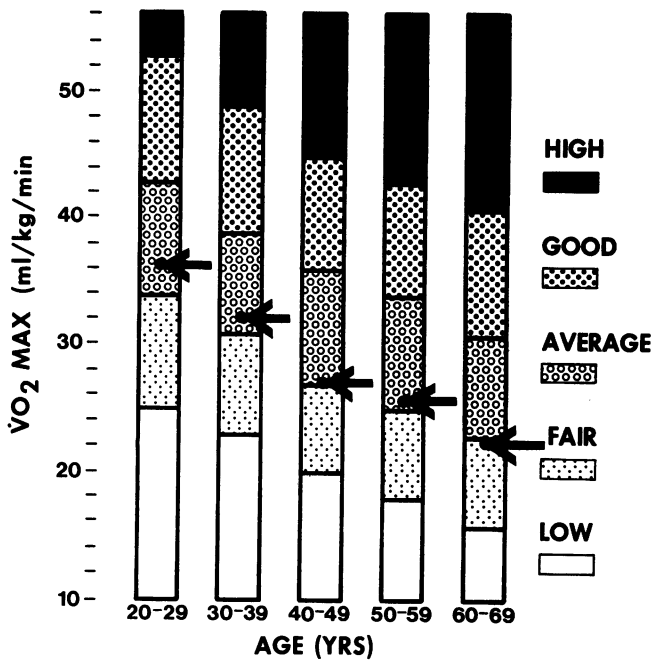


Fig. 8—Maximum oxygen intake of Canadian men relative to American Heart Association recommendations.[13]

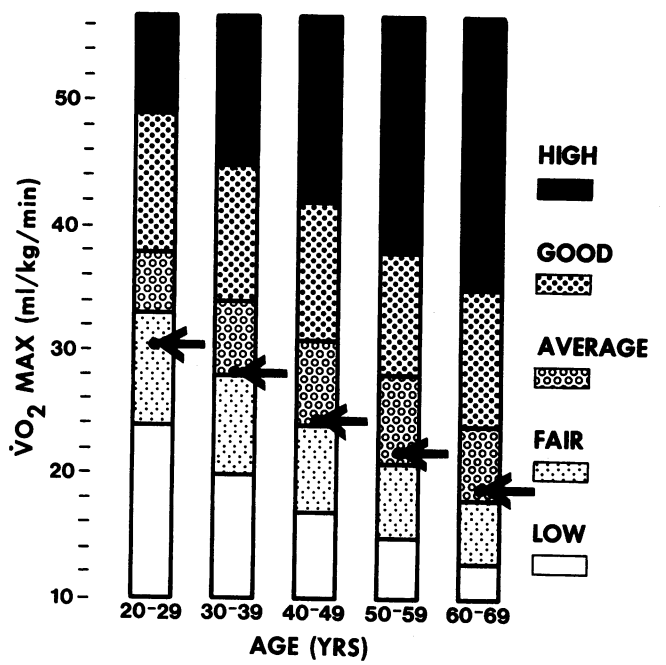


FIG. 9—Maximum oxygen intake of Canadian women relative to American Heart Association recommendations.[13]

Lest the Swedish norms be unrealistically high for Canadians, we have also compared the aerobic power of our sample with the less exacting standards recently recommended by the American Heart Association.[13] While Canadians rank somewhat better relative to the AHA recommendations (Figs. 8 and 9), they still fail to meet the recommended average values; their distribution between the several fitness categories is illustrated in Fig. 10. Only 14 to 21% of the women and 7 to 35% of the men fall into good or high fitness categories. Nearly 50% of every age group except the 15- to 19-year-old males fail to reach even the lower limit of the suggested average fitness range. It is particularly disturbing to find young Canadian women in the prime of the childbearing period (20 to 29 years) with such a poor showing relative to the recommended values for their age group.

Women also have a limited perception of their own level of physical fitness. We asked each subject to rate his or her fitness as below average, average, or above average, and compared these ratings with the corresponding predictions of aerobic power (Fig. 11). The men assessed themselves fairly accurately. The 26% who felt that they were of above-average fitness had a higher aerobic power (33.3 ml/kg/min) than those who rated themselves as average or below average. Those who were of below-average fitness also assessed their condition accurately, the mean aerobic power of this group being only 27.7 ml/kg/min. In contrast, the 20% of the women who thought that they were of above-average fitness had the lowest group mean aerobic power (25.2 ml/kg/min). The difference was negligible between women who rated themselves as average or below average.

It may now be asked whether Canadians would improve their cardiorespiratory fitness if they embarked on a planned program of physical exercise. We believe they would. When the present series of $\dot{V}O_2$ max values are distributed into categories corresponding to the reported physical activity over the preceding three months (infrequent, regular or very frequent), both men and women who reported that they exercised very frequently* have high values for aerobic power (Fig. 12). Individuals whose

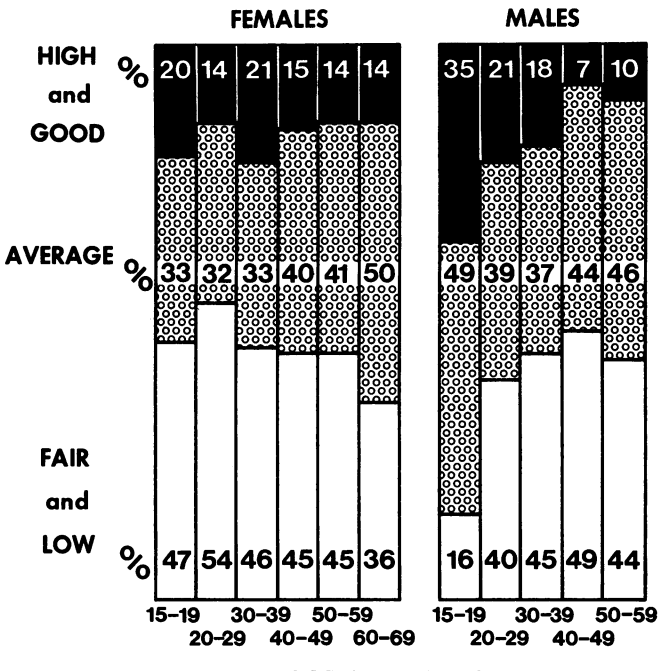
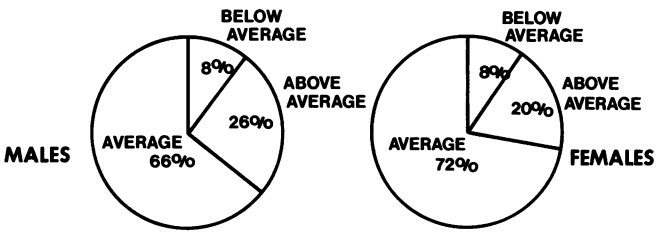


FIG. 10—Percentage of subjects in the series falling in the high to good, average, and fair to low fitness categories recommended by the American Heart Association.[13]



MEAN BICYCLE $\dot{V}O_2$ MAX (ml/kg/min) BY CATEGORY		
MALES		FEMALES
27.7	BELOW AVERAGE	27.3
32.1	AVERAGE	27.8
33.3	ABOVE AVERAGE	25.2

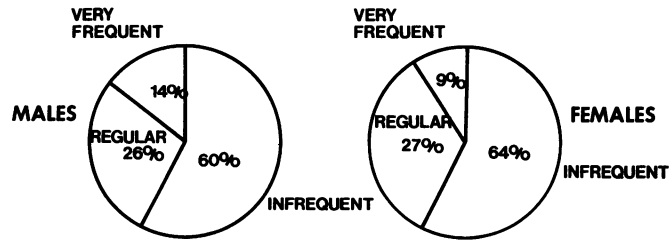
FIG. 11—Aerobic power of men and women when categorized according to personally perceived fitness rating.

*Four to five sessions per week of moderate activity (walking a mile or more, jogging, tennis, squash, swimming four or more lengths) or regular training (three to five sessions per week) for a specific sport.

Table I—Physical characteristics (mean ± S.D.) of 1230 participants in Saskatoon study

Age categories	Age (yr)	Height (cm)	Weight (kg)	$\dot{V}_{O_2}$ max* (ml/kg)	N
		Men			
15 - 19	15.9 ± 1.3	174.3 ± 6.6	66.0 ± 10.0	43.1 ± 8.2	111
20 - 29	25.7 ± 2.8	176.9 ± 7.3	77.5 ± 10.6	36.4 ± 8.0	104
30 - 39	33.9 ± 2.7	176.3 ± 5.4	79.4 ± 10.8	32.2 ± 6.6	163
40 - 49	44.1 ± 3.0	175.8 ± 6.0	81.2 ± 11.0	26.9 ± 6.1	84
50 - 59	54.1 ± 2.9	172.4 ± 5.9	76.7 ± 9.9	25.7 ± 4.9	63
60 - 69	64.5 ± 2.5	171.5 ± 7.3	76.9 ± 10.9	22.8 ± 5.1	33
					558
		Women			
15 - 19	16.0 ± 1.6	162.5 ± 6.4	56.7 ± 9.3	34.0 ± 9.0	145
20 - 29	23.8 ± 2.9	162.1 ± 5.6	57.4 ± 7.0	30.6 ± 7.2	138
30 - 39	34.0 ± 3.0	162.7 ± 5.7	60.6 ± 8.2	27.8 ± 6.9	152
40 - 49	44.2 ± 2.9	161.9 ± 6.3	61.6 ± 8.5	24.3 ± 5.9	93
50 - 59	54.2 ± 2.7	160.3 ± 5.3	62.6 ± 8.0	21.9 ± 5.6	88
60 - 69	64.2 ± 2.8	160.2 ± 5.7	62.6 ± 9.3	19.0 ± 4.3	56
					672

*Bicycle ergometer predictions of $\dot{V}_{O_2}$ max based on work load scale of Åstrand-Ryhming nomogram.[2]



MEAN BICYCLE $\dot{V}O_2$ MAX (ml/kg/min) BY CATEGORY		
MALES		FEMALES
29.9	INFREQUENT	26.1
33.3	REGULAR	28.7
39.3	VERY FREQUENT	31.2

FIG. 12—Aerobic power of men and women when categorized according to personally perceived physical activity pattern for the three-month period prior to testing.

pattern of physical activity was regular (two to three sessions of moderate activity per week) or infrequent have correspondingly poorer aerobic power. The difference between groups could reflect, in part, differences of constitution. Nevertheless, the magnitude of the observed effect (20 to 25% of $\dot{V}O_2$ max) corresponds well with the anticipated gains from an endurance training program, and would be enough to carry the average Canadian from a "fair" to a "good" fitness rating.

Discussion

This study represents perhaps the largest and most representative evaluation of adult cardiorespiratory fitness yet to be attempted in this country or elsewhere. As in a previous experiment by the Canadian Association of Health, Physical Education and Recreation[14] our original objective of complete random sampling was thwarted. It seems unlikely from our attrition figures that a random sample of adults could be obtained while preserving the necessary requirements of voluntary consent. On the other hand, there is good reason to suppose our results are reasonably representative of the national status. If there is a bias, we are probably presenting an optimistic view of current fitness since a large number of potential subjects were disqualified by personal choice or for medical reasons; their absence is likely to leave a sample that is somewhat healthier than the general unselected population. Our results therefore strongly suggest that in terms of our chosen criterion of cardiorespiratory performance (predicted aerobic power) the average Canadian is unfit. He or she fails to meet not only Scandinavian norms but also the American Heart Association standards. On both classifications Canadian women fare somewhat worse than men, with the poor showing of teen-age and 20- to 29-year-old women a particular source of concern. The health-oriented sampling bias is inevitably most marked in our older age categories, and it is therefore wrong to congratulate the nation upon the apparently higher percentage of fit individuals in those over the age of 40.

The present results also show that physically active individuals achieve higher cardiorespiratory fitness scores than those who are inactive, irrespective of age. All age groups could thus expect to benefit from the endurance activity programs currently being advocated by organizations such as Participaction Canada.

The authors would like to express their appreciation to Health and Welfare Canada for its support and material assistance. We would also like to thank Mr. Clinton Weese for computer and data-handling assistance, Mr. Ken Keirstead of Quinton Instruments for providing equipment and technical expertise, and Dr. John Merriman for his involvement in the medical supervision during the study.

References

1. Åstrand I: Aerobic work capacity in men and women with special reference to age. *Acta Physiol Scand* 49 (suppl 169): 45, 1960
2. Åstrand PO, Ryhming I: A nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during submaximal work. *J Appl Physiol* 7: 218, 1954
3. Maritz JS, Morrison JF, Peter J, et al: A practical method of estimating an individual's maximum oxygen intake. *Ergonomics* 4: 97, 1961
4. Davies CTM: Submaximal tests for estimating maximum oxygen intake (commentary). *Can Med Assoc J* 96: 743, 1967
5. Shephard RJ: A new look at aerobic power (in preparation)
6. Davies CTM: Limitations to the prediction of maximum oxygen intake from cardiac frequency measurements. *J Appl Physiol* 24: 700, 1969
7. Rowell LB, Taylor HL, Wang Y: Limitations to predictions of maximum oxygen intake. *J Appl Physiol* 19: 919, 1964
8. Shephard RJ: *Endurance Fitness.* Toronto, U of Toronto Pr, 1969
9. Shephard RJ, Allen C, Banade AJ, et al: Standardization of submaximal exercise tests. *Bull WHO* 38: 765, 1968
10. Weiner JS, Lourie JA: *Human Biology: A Guide To Field Methods.* Oxford, Blackwell, 1969
11. Shephard RJ: World standards of cardiorespiratory performance. *Arch Environ Health* 13: 664, 1966
12. Shephard RJ: Computer programs for solution of the Åstrand nomogram and the calculation of body surface area. *J Sports Med Phys Fitness* 10: 206, 1970
13. Committee on Exercise: *Exercise Testing and Training of Apparently Healthy Individuals: A Handbook for Physicians.* New York, Am Heart Assoc, publ no EM-565, 1972
14. Metivier G, Orban WAR: *The Physical Fitness Performance and Work Capacity of Canadian Adults.* Ottawa, CAHPER, 1968