Evaluation of the Canadian Home Fitness Test in middle-aged men

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The Canadian Home Fitness Test (CHFT) and the Bruce treadmill test were performed by 230 men aged 45 to 69 years. Because of inaccuracies in the counting of heart rates, less was known about the fitness of the men after testing than before. In addition, inaccuracies in the test record and design were uncovered. A more accurate estimate of fitness could be obtained when the subjects' own rating of exertional intensity was substituted for heart rate counting. The CHFT is a marketing tool of Health and Welfare Canada that may be useful in selling fitness, but as a measure of fitness in Canadian homes it is likely to be misleading.

Le Physitest Canadien à Domicile (PCD) et l'épreuve du tapis roulant de Bruce ont été pratiqués chez 230 hommes âgés de 45 à 69 ans. À cause des inexactitudes dans la mesure du rythme cardiaque, on en savait moins sur la condition physique de ces hommes après les tests qu'avant. De plus, on a découvert des inexactitudes dans l'enregistrement et les modalités du test. Une appréciation plus précise de la condition physique a pu être obtenue en substituant l'évaluation personnelle du sujet de l'intensité de sa fatigue à la mesure du rythme cardiaque. Le PCD est un outil de marketing de Santé et Bien-être social Canada qui peut être utile pour vendre le conditionnement physique, mais comme instrument de mesure de la condition physique des Canadiens à domicile il risque d'être trompeur.

The Canadian Home Fitness Test (CHFT) has been marketed by Recreation Canada, a division of the fitness and amateur sport branch of Health and Welfare Canada, with the hope that it will motivate many Canadians to improve their fitness.[1] After stepping up and down two ordinary steps at home in time with music provided by a phonograph record, subjects estimate their fitness by counting their post-exercise pulse rates. Maximal oxygen uptake ($\dot{V}O_2$ max) is predicted from this rate by the method developed for both bicycle and stepping exercises by Astrand and Ryhmming[1] in 1954. The developers of the CHFT have claimed it to be a practical method for the public to estimate their own $\dot{V}O_2$ max and, hence, fitness.[2,3]

We evaluated the accuracy of the CHFT in 230 men aged 45 to 69 years — the age group in our population with the highest incidence of coronary heart disease in which the possible protective effects of exercise and fitness are most required. The Borg method[4] of estimating exercise intensity was explored as an alternative to counting the heart rate.

Subjects and methods

A total of 230 men aged 45 to 69 years of age, part of a population being followed for a study of coronary heart disease,[5] volunteered for the test. All but a few of the 230 subjects had had at least two previous maximal exercise tests, one on the bicycle ergometer and one on the treadmill. None had had symptomatic coronary heart disease at their enrolment in the study 6 years previously, but at the time of this investigation two had had myocardial infarctions and eight had angina.

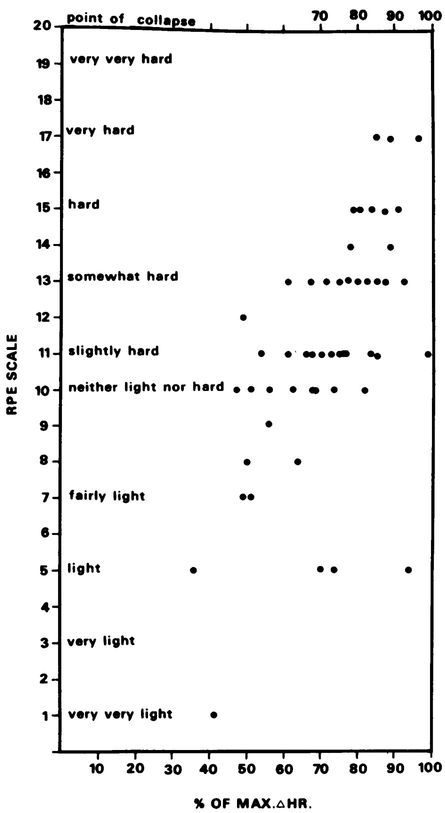

FIG. 1—The Borg scale. RPE is an arbitrary numerical scale for rate of perceived exertion. The abcissa is the subject's heart rate during the second stage of the step test, presented as a percent of the maximal increase in heart rate above resting.

The CHFT was performed by 195 subjects exactly as recommended on the record jacket; the other 35 subjects exercised at one stage above that recommended for persons their age. Subjects were studied individually in a laboratory, with personal instruction in stepping and maintaining a stepping cadence, and in locating and counting the radial pulse; practice counts were done at rest until accuracy was obtained. The oxygen cost of the step test was predicted with the assumption of an efficiency of 16%. The steps were 22.9 cm high instead of the 20.3 cm suggested for the CHFT, the height of most steps in Canadian homes. Appropriate changes in the calculations were made. $\dot{V}O_2$ max was predicted from the Astrand nomogram, with the age correction factors of Astrand.[6]

The subjects performed the Bruce treadmill test[7] 15 minutes after performing the CHFT, continuing until unable to do so. $\dot{V}O_2$ max was estimated from the treadmill endurance time according to the method of Bruce, Kusumi and Hosmer.[7]

The last 50 subjects were asked to rate their estimation of the intensity of each exercise stage by means of Borg's numerical scale[4] (Fig. 1) as each load was completed for the treadmill walking and after both stepping exercises were completed.

From the monitoring of electrocardiogram (ECG) lead CM_5 (done in both tests) the heart rate was obtained for the last 10 seconds of the step test and the period 5 to 15 seconds after the test. Heart rate was measured from the interval between 5 beats. After exercise an average rate was obtained from 5-beat counts at the beginning, middle and end of the 10-second period, and, for comparison, heart rates were also obtained in 50 subjects from the ECG for the exact recovery period of 10 seconds over which the subject counted. An ischemic response as shown on the ECG was defined as 0.1 mV of horizontal or downsloping ST-segment depression persisting 80 ms or more after the S wave, or 0.2 mV of J (RS–T junction) depression with an ST-segment slope of less than 1.0 mV/s.

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Results

The mean heart rates and predicted $\dot{V}O_2$ max values are shown in Table I; data for the six subjects who did not complete the test were excluded.

With ECG counts the mean heart rates during the last 10 seconds of stepping were within a few beats of the mean recovery rates 5 to 15 seconds after cessation of stepping. The recovery rates were the same whether obtained from only 5 beats in the middle of the recovery period; or from an average of three 5-beat counts at the beginning, middle and end of recovery; or from all beats in the 10-second recovery period. With the subjects' counts the mean heart rates for all 224 men were well below the rates determined from the ECG. When data for the 7% of subjects who obtained no counts and the 19% who obtained rates of less than 90 beats/min were eliminated, the mean rates recorded by the patients were 13, 8 and 5 beats/min below the mean ECG rates in the three age groups.

The mean $\dot{V}O_2$ max values predicted from the step test with ECG heart rates and from the treadmill test were remarkably close. When the subjects' counts of heart rate were used (with those for 26% of subjects eliminated as above), the mean predicted $\dot{V}O_2$ max was too high by 26% in the age groups 45 to 49 and 50 to 59 years but by only 1.4% in the age group 60 to 69 years.

The frequency of errors in heart rate counts and in predicted $\dot{V}O_2$ max values is shown in Table II: 34% of the subjects erred in counting their heart rate by more than 30 beats/min; the error in $\dot{V}O_2$ max prediction was more than 20% in 41% of the subjects, and more than 50% in 19% of the subjects when values were calculated from the subjects' counts as compared with the ECG heart rates for the step test.

Despite reasonable agreement with mean values, the correlation between the predicted $\dot{V}O_2$ max values obtained from the step test (with ECG heart rates) and from the treadmill was low, with r values of only 0.22, 0.46 and 0.62 for the age groups 40 to 49, 50 to 59 and 60 to 69 years, respectively. The coefficient of variation for $\dot{V}O_2$ max with the treadmill test was about 14% — much lower than the average of 27% for the step test even when the ECG heart rate was used.

The frequency of ECG changes is shown in Table III. In one subject known to have angina before the tests, angina occurred during the second stepping exercise. One subject stopped stepping because of ventricular tachycardia; he was known to have this rhythm problem from previous tests. Four additional subjects failed to complete the step test because of leg cramps. The results for these six subjects were eliminated from this analysis. An ischemic pattern was produced with exercise in 71 subjects, 34 during the step test and 70 during the treadmill test. Ventricular ectopic beats not present at rest were recorded during or after the step test in 22 subjects, and during or after the treadmill exercise in 27 subjects. Atrial ectopic beats occurred in 12 subjects and were more common with the step test.

The Borg rating showed a strong correlation (r = 0.76) with the heart rate in the second stage of stepping when the rate was expressed as a percent of the maximal increase in heart rate (Fig. 1) according to the following formula, where HR represents heart rate:

$$\% \triangle \text{HR} = \frac{\text{observed HR} - \text{resting HR}}{\text{maximal HR (treadmill)} - \text{resting HR}}$$

The oxygen cost of each stage of the treadmill test was predicted from the values given by Bruce and colleagues[7] and converted to a percent of the $\dot{V}O_2$ max predicted from the treadmill test for each subject. The Borg rating showed a strong correlation (r = 0.81) with the metabolic load of the treadmill test calculated in this way, with the following regression:

$$\% \text{ of } \dot{V}O_2 \text{ max} = 35.5 + 3.5 \cdot \text{Borg rating}$$

From this formula the Borg rating can be used to predict $\dot{V}O_2$ max for any exercise as follows:

$$\dot{V}O_2 \text{ max} = \dot{V}O_2 \text{ of submaximal exercise} \times \frac{100}{35.5 + 3.5 \cdot \text{Borg rating}}$$

This was done for each subject for the step test (the average metabolic cost of each stepping stage being known) with both the ECG heart rate and the subject's count. The Borg prediction of $\dot{V}O_2$ max thus obtained was much better than the prediction obtained from the heart rate counted by the subject: the correlation coefficients were 0.53 and 0.12, respectively.

Discussion

The results of this study indicate that even with individual instruction many middle-aged men failed to count their postexercise heart rates with sufficient precision to allow a meaningful prediction of their fitness. This made the CHFT unsuitable for the home meas-

Table I—Mean heart rates (± standard deviation), counted from electrocardiogram (ECG) or by subject, and predicted maximal oxygen uptake ($\dot{V}O_2$ max) in 224 men*

	Age group (yr)		
Variable	45–49 (n = 52)	50–59 (n = 121)	60–69 (n = 51)
Heart rate (HR) (beats/min)			
Step test			
Last 10 seconds (ECG)	150 ± 16	139 ± 16	129 ± 18
First 5 — 15 seconds of recovery			
ECG	148 ± 19	136 ± 18	129 ± 19
Subjects' counts			
Mean*	123 ± 44	110 ± 41	98 ± 45
Adjusted†	135 ± 19	128 ± 20	124 ± 22
Treadmill, maximum	182 ± 13	174 ± 13	161 ± 17
Predicted $\dot{V}O_2$ max (mL/kg·min), method of estimation			
From step test			
With ECG HR	37.8 ± 7.6	34.2 ± 8.6	33.4 ± 12.9
With subjects' counts of HR*	47.6 ± 18.3	43.1 ± 17.3	33.9 ± 8.1
From treadmill endurance time	37.7 ± 4.5	34.4 ± 5.3	31.5 ± 4.8

*Data excluded for the 7% of subjects who obtained no counts.
†Data excluded for the 7% of subjects who obtained no counts and the 19% whose counted rates were less than 90 beats/min.

Table II—Frequency of errors in heart rate counts and $\dot{V}O_2$ max estimations

Error	% of 224 subjects
Heart rate (beats/min)	
0–6	32
7–12	12
13–19	14
20–29	8
> 30	34
Predicted $\dot{V}O_2$ max (%)*	
< 10	36
10–19	23
20–49	22
> 50	19

*Difference between $\dot{V}O_2$ max predicted from ECG heart rate and that from heart rate counted by subject for step test.

Table III—Frequency of ECG changes with exercise

Change	Test; % of 224 subjects			
	Step only	Treadmill only	Both	Total
Ischemia*	0.4	16.5	14.7	31.7
Ventricular ectopic beats	6.8	9.0	3.2	19.0
Atrial ectopic beats	4.1	0.5	0.9	5.5

*Defined as 0.1 mV of horizontal or downsloping ST-segment depression persisting 80 ms or more after the S wave, or 0.2 mV of J (RS–T junction) depression with an ST-segment slope of less than 1.0 mV/s.

urement of fitness in this population. The counting error led to an overprediction of "fitness" by more than 20% in over two fifths of the subjects. If the purpose of the test is to show the population that their fitness is low, thus motivating them to improve it, the falsely high value that subjects obtain for themselves may have a reverse effect. Missing 2 pulse beats in the 10 seconds during which the heart rate was counted would lead to a heart rate error of 12 beats/min and a $\dot{V}O_2$ max overprediction of as much as 25%.

Bailey, Shephard and Mirwald[2] attributed the errors in heart rate counts in part to the noise and excitement of a mass testing program. In our study the large counting error persisted despite a quiet laboratory that subjects had visited on two or more previous occasions and despite the individual instruction, practice and checking of the subject's ability to count the resting heart rate. Perhaps repeated testing with practice in counting postexercise heart rates might eventually reduce this error to an unimportant value, but how are people to obtain this instruction at home, and how are they to learn whether their counts are correct?

Another source of error we found was failure to maintain the proper stepping cadence. Many of the subjects had problems with this and needed to be helped back into step by the observer. Who is to monitor this at home? The phonograph record might be improved by a calling out of the cadence every 30 seconds rather than just at the beginning of each stage, as it is now.

We examined the stepping frequencies produced by attendance to the record and they did not conform to the designers' statements.[3,4] These rates and the oxygen requirements for each stage are shown in Table IV. For some reason the stepping rates of stages 1 to 3 are faster for women. In addition, the maximal load of the step test requires only 37.9 mL/kg•min of oxygen, hardly a challenge for fit subjects.

Table IV—Stepping rates and calculated oxygen requirements produced by following the record of the Canadian Home Fitness Test (CHFT) with steps 20.3 cm high

Stage no.	No. of ascents/min		Oxygen cost (mL/kg·min)	
	Males	Females	Males	Females
1	11	12	17.0	18.2
2	14	15	20.7	21.9
3	17	18	24.2	25.7
4	20	20	28.1	28.1
5	23	21	31.8	29.3
6	25	23	34.3	31.8
7	28	—	37.9	—

Table V—Maximal heart rates permitted for designation "recommended personal fitness" (from CHFT record jacket) and predicted $\dot{V}O_2$ max values for these rates calculated from the stepping cadences of the record

Age group (yr)	Maximal heart rate for "fit" person (beats/min)	Required $\dot{V}O_2$ max (mL/kg·min)	
		Males	Females
20–29	150	51.8	45.3
30–39	144	46.1	44.4
40–49	138	39.0	39.0
50–59	132	32.2	32.2
60–69	132	23.4	27.6

Predicted $\dot{V}O_2$ max values, calculated from the stepping rates and postexercise heart rates permitted for persons in the "recommended personal fitness" level, are shown in Table V. According to the CHFT men and women should have the same aerobic power from age 40 to 59 years, and women a greater aerobic power after the age of 60 years. This would seem to be another error in the test and is definitely out of line with known measurements of greater muscle mass, cardiac stroke volume and hemoglobin values for men.

Step tests hardly require validation as laboratory predictors of $\dot{V}O_2$ max. Such validation was done 23 years ago by Astrand and Ryhmming,[1] as well as by other workers.[8-10] As with all predictive tests, there are large standard errors in the prediction of $\dot{V}O_2$ max from step tests and ECG heart rates, such that even with accurate heart rate counts the prediction of $\dot{V}O_2$ max and fitness from submaximal tests can be questioned.

In most population studies, as in ours, the coefficient of variation of $\dot{V}O_2$ max has been about 20%. Thus the mean value for the $\dot{V}O_2$ max of the population can be assigned to all subjects, and for 67% this value will be within 20% of their actual value. After doing the CHFT only 61% of our subjects predicted their fitness within 20% of the mean value. On this basis it can be argued that the subjects had a poorer idea of their fitness after doing the CHFT than before. It is possible to make arbitrary adjustments to expected population mean values for $\dot{V}O_2$ max by allowing for physical activity and body weight; for example, subjects regularly taking part in vigorous physical activities can be given a bonus of 3 mL/kg•min, while subjects 15 kg overweight can have 3 mL/kg•min subtracted. When such manipulations were carried out with our population the resultant fitness values (in terms of $\dot{V}O_2$ max) were much superior in predicting actual maximal treadmill performance than were the results from the CHFT.

Such "armchair estimates" of fitness are likely superior to estimates that the population might achieve at home with the CHFT, but admittedly these estimates have no promotional value. While the main purpose of the CHFT may be to promote fitness and not to measure fitness, a minimum standard of accuracy is surely required, and the CHFT may fail to meet this minimum standard.

There are some reasonable home fitness tests available that do not require the counting of one's pulse. For the person under 30 years of age or 30 to 60 years of age who is accustomed to intense exercise the Cooper run[11] is an excellent "home" fitness test (Appendix A). For the sedentary middle-aged person the Cooper run is potentially dangerous, but fitness can safely be gauged by walking about 3 km at increasing speeds for 1 to 2 weeks (Appendix B).

The record of the CHFT, with its catchy tune, does have the appeal of novelty and may help motivate some people to increase their fitness. Any new "home" fitness test will be tried by some people, but many such persons are likely already of above-average fitness. Whether such tests can improve the fitness of a population remains to be seen.

Bailey and colleagues[2] reported that the mean heart rates in the period 5 to 15 seconds after exercise were significantly higher than the mean rates during exercise — an unexpected finding. Our results did not support this; heart rates were a few beats per minute higher during exercise than 5 to 15 seconds after exercise in all but a few subjects.

Borg's rating of perceived exertion offers an alternative to the counting of heart rate by the subjects in a home fitness test. We gave our subjects no help in selecting a Borg rating. Accuracy could be improved by describing symptoms for a few of the ratings or by elaborating on the descriptive terms. For a home test designed to estimate fitness roughly, the subjects could alternatively be asked to go through the exercise stages and stop when specific symptoms such as leg fatigue or shortness of breath reached an intensity of 2 on a scale of 4. Stages at which fit persons could perform without symptoms of this intensity would be easy to establish. This would eliminate heart rate counting, which makes the CHFT unsuitable as a home test for a great many Canadians.

Health and Welfare Canada perhaps should reconsider the "home" label they have put on this test unless information is provided to indicate that fitness can be measured more accurately than in the population studied in this investigation. If the CHFT is to be used to market fitness in group situations the same problems with heart rate counting are likely to be encountered unless heart rates are obtained individually by trained observers.

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Appendix A: Cooper run[11]

This test is designed for well persons under 40 years of age. The person should find a running track in the neighbourhood or measure off 1.5 miles (2.4 km) with a car odometer, and time himself (or herself) running, jogging, or walking and jogging this distance. The "run" should be done at a comfortable pace two or three times; if no side effects other than fatigue have occurred, he should push himself and record his best time for this distance. His $\dot{V}O_2$ max likely lies within the ranges shown in Table A for the various times. An ideal "fitness" value is not known, but anything under 12 minutes is probably reasonable for adults 25 to 45 years of age.

Table A—$\dot{V}O_2$ max as predicted from time taken to complete the Cooper run

Time for 1.5 miles (2.4 km)(min)	Range of maximal oxygen uptake (mL/kg·min)
> 16.5	< 25
14.5 — 16.5	25 — 33
12.0 — 14.5	33 — 43
10.25— 12.0	43 — 51
< 10.25	> 52

Appendix B: Walking test

This test is designed for sedentary persons over 40 years of age. The oxygen cost (in millilitres per kilogram of body weight) of walking at various speeds is equal to 0.35 x V (velocity)^2 (in km/h) + 7.4 at age 55 to 65 years.[1] This allows the construction of Table B.

The person should measure 1 mile's distance from home and time himself or herself on a leisurely stroll covering this distance and returning. If the time were 40 minutes the oxygen cost would be about 16 mL/kg•min (Table B). The next day the person should increase the speed a little, and on successive days should try to walk a little faster each time. The best time before there is excessive fatigue and slight shortness of breath turns out to be 30 minutes; the maximal oxygen uptake is likely to be around 22.5 mL/kg•min (Table B). If the person is able to walk the 2 miles in under 28 minutes without distress, he or she may proceed to the Cooper test (Appendix A), walking and jogging at first, then jogging. After five or six trials, with very gradual increases in speed, a reasonable estimate of actual fitness is possible, and the gradual increase in exercise intensity should provide the necessary precautions.

Table B—Oxygen cost of walking at various speeds

Speed (km/h; miles per hour)	Time for 2 miles (min)	Oxygen cost (mL/kg·min)
3; 1.9	63	10.6
4; 2.5	48	13.2
5; 3.1	39	16.4
6; 3.7	32	20.4
7; 4.3	28	25.0
8; 5.0	24	30.4

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BOOKS

This list is an acknowledgement of books received. It does not preclude review at a later date.

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