A Simple Assessment of Aerobic Fitness in Field Conditions
評核有氧適能的簡易方法

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Abstract

The conventionally accepted physiological criterion of aerobic fitness (AF) is VO_{2max}. When VO_{2max} is not directly measured, it can be estimated from performance motor tests. The using of motor tests for indirect determination of VO_{2max} is based on dependence between the energy cost of exercise and exercise intensity. In submaximal range of intensities the linear equations may be used to relate intensity of physical activity to VO_2. If we extrapolate linear relationships between VO_2 and exercise intensity to maximal exercise intensity, the inaccuracy of VO_{2max} determination resulting from the intensity of exercise increases by approximately 5%. The purpose of this study was to determine norms for the estimation of AF with regard to Czech standards and with regard to general relations between the mean velocity of the cyclical movement in a field conditions and an energy required for this activity. These norms were derived from a Czech sample, incorporating relations between speed of movement and energy required for this activity expressed indirectly by VO_2. The basic element of evaluating AF under field conditions is the mean velocity of walking or running on a 2000 m track, and/or cycling on a 5000 m distance, and/or swimming on a 300 m distance. The standards have been prepared for males and females aged 6-70 years, making it possible to estimate "poor", "good", and "excellent" levels of AF and physical performance. The error of assessment of VO_{2max} and thus AF level varies by about 15%.

Key words: Aerobic fitness, Motor tests, Running, Walking, Swimming, Cycling

摘 要

一般評估帶氧運動能力的方法，都是採用慣常的量度「最大攝氧量」。本文旨在探討可否使用較簡易而有效的評估辦法去取代複雜的傳統方法，利用捷克地區的數據來作測試，結果發現：簡易方法準確度互差約15%。

Introduction

Aerobic fitness (AF) is frequently considered the most important aspect of physical fitness (Haskell 1995). The generally accepted physiological criterion of AF - maximal oxygen uptake (VO_{2max}), is only a predisposition for physical performance (Armstrong & Welsman, 1994). A high VO_{2max} does not guarantee good physical performance, since technique of motion and psychological factors may have an influence either positively or negatively. In work and exercise where the body is lifted, oxygen uptake should be related to the subject's body mass. In this case, the individual's VO_{2max} provides a measure of the "motor effect" (Astrand & Rodahl, 1986; Armstrong & Welsman, 1994; Bunc, 1994). With this parameter the subject's ability to move her or his body can be evaluated. In practice this means that if we wish to characterise fitness level, we must evaluate VO_{2max} and physical performance at the same time.

When VO_{2max} is not directly measured, estimation can be made from performance tests. Although a minimal 10 % prediction error exists (Bunc, 1994; Cooper 1968; Kline et al. 1987), these tests estimate aerobic fitness with less risk and are particularly useful for estimating large samples in a short time. The predicted group mean values of VO2max are similar to the directly measured values, but individual estimates may be less precise (Astrand & Rodah,l 1986; Cooper 1968).

The data for indirect determination of VO_{2max} with a motor test - running test 1.5 miles (2.4 km) were first published by Balke (1963). An adaptation of the test was later published by Cooper (1968). The walking test one-mile for assessment of CF was first used by Kline et al. (1987) and in Europe a 2000 m walking test was developed by Oja et al. (1991). Often, the walking tests are not recommended for subjects under 20 years of age. On the other hand the number of individuals who are not able to run over 2000 m is very large.

Because the motivation plays very important role in all tests with maximal effort, it is necessary to select a such form of exercise, which is for the subjects most suitable and acceptable, and in which the adaptation to the load will be high. From this point of view, for any successful exercise testing it is preferable to offer to the subjects a choice of exercise test.

The purpose of this study was to determine norms for estimation of AF with regard to Czech standards and with regard to the general relationship between the mean velocity of the cyclical movement in a field conditions and an energy required for this activity. The basic element of evaluating AF under field conditions is the mean velocity of walking or running on a 2000 m track, and/or cycling on a 5000 m distance, and/or swimming on a 300 m distance.

Methods

For this study, 2501 men and 1778 women of various in ages (age ranged from 14 to 70 years) and training condition (the criterion of training state - maximal oxygen uptake ranged in men from 20 to 63 $ml.kg^{-1}.min^{-1}$, and in women from 19.5 to 57.5 $ml.kg^{-1}.min^{-1}$) were tested in the laboratory, and in the field. In the laboratory a graded exercise test to the point of voluntary exhaustion was used.

In the field testing conditions 47% of men and 49% of women were tested in a walking test (2000 m walk on a flat terrain, mainly on the track), 29% of men and 27% of women on a running test (2000 m run at a flat terrain, mainly on the track), 15% of men and 14% of women on a cycling test (5000 m track test on a flat terrain, 80 to 100 revolutions per min), 9% of men and 10% of women on a swimming test (300 m in the swimming pool).

Subjects were selected from healthy population without any systematic physical training. The assessment of AF in laboratory - VO_{2max}, determination - was made on the treadmill. After two warm-up loads at intensities ranging from 50 to 65% VO_{2max}, each lasting 4 min, the initial intensity of graded exercise was about 60% VO_{2max}. The exercise intensity was increased every minute by 1 $km.h^{-1}$. The cardiorespiratory variables were assessed using an open system with a Jaeger apparatus and/or TEEM 100.

The author agrees with Astrand and Rodahl (1986) and Pugh (1970) in believing that the model relating energy cost of cyclical exercise should be as simple as possible. Therefore, only linear equations were used to relate intensity of physical activity to oxygen uptake. These relationships are linear in the submaximal range of 20-80% VO_{2max} (Astrand & Rodahl, 1986).

The VO_{2max} in the field may be predicted from the values of mean moving speed. In literature, general equations for determination of VO_{2max} from mean speed of moving that are independent of training state, age, body mass, and speed were used by Astrand and Rodahl (1986), Balke (1963), Bunc et al. (1986), Bunc and Heller (1990), and Pugh (1970). The basic element of evaluating AF under field conditions is the mean velocity of walking or running on a 2000 m track, and/or cycling on a 5000 m distance, and/or swimming on a 300 m distance.

The field tests were conducted within one week of the laboratory evaluation. Values of VO_{2max}, by age, which were not directly determined in the laboratory were calculated with linear interpolation.

Results

The subjects did not experience any health or serious fatigue symptoms that would limit their running and/or walking. The majority of subjects, over 90% reported no symptoms. Among the most frequently reported symptoms was pain in lower limbs, and/or in swimming in the upper extremities.

The values of VO_{2max} determined from our measurements in groups of untrained subjects are presented for men in Table 1 and for women in Table 2. The norms for AF were divided into three groups. "Good" level of AF was determined as the mean values from all data for each particular age. "Excellent" values were calculated as the mean plus one standard deviation - SD, and "Poor" values were constructed as the mean minus one SD.

The same Table contains values for a physical performance, which may be realised from the above mentioned oxygen uptakes. The missing data for performance were calculated from oxygen uptake, assuming a general dependence between VO_{2max} and mean speed of moving in the relevant test.

Discussion

Physical fitness, and thus aerobic fitness, is not understood solely in terms of a potential for tolerating physical stress. Often it is viewed as one of the dimensions of health.

The presented standards of maximal oxygen uptake and thus of AF do not significantly differ from the data of European population samples. The physical performance in younger groups (younger than 25 years) is similar to the data from other European countries but performance for older subjects is slightly lower than in other European studies. These differences are increasing with an increasing of age. The reason for this is probably connected with the amount of physical activity, which significantly decreases with increasing age - from 4. 7 hours of physical activity per week in young subjects (younger than 20 years) to 2.1 hours per week in older groups.

The use of the Table presented for assessment of aerobic fitness in practice is similar to the original system developed by Cooper (1968). In practice, this method is simpler than Cooper's original system because only one parameter (time) must be monitored.

The mean speed during the motor tests can characterise the level of physical performance, and may be used for indirect determination of aerobic fitness in the field conditions. The reliability of VO_{2max} assessing and thus the determination of the aerobic fitness from the mean speed of motion varies around 15%.

These differences may seem to be large, but one should note that the errors of cardiorespiratory measurements during exercise testing are about 5 %. From this point of view it is legitimate to assume that the Table presented for the assessment of aerobic fitness in the field conditions is valid. Motivation has a similar influence on the results in this test as in other methods which use the maximal parameters.

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Table 1. Standards of Aerobic Fitness and Physical Performance for Men Determined on a Treadmill and during a 2000 m Track (w - walking, r - running), and/or 5000 m cycling - c, and/or 300 m swimming - s.

Age	Poor					Good					Excellent				
	Speed				$VO_{2max}.kg^{-1}$	Speed				$VO_{2max}.kg^{-1}$	Speed				$VO_{2max}.kg^{-1}$
Yrs	km/h c	km/h w	m/s s	km/h r	ml/kg.min	km/h c	km/h w	m/s s	km/h r	ml/kg.min	km/h c	km/h w	m/s s	km/h r	ml/kg.min
14	28.6	8.2	0.94	12.4	44.4	33.1	9.1	1.15	14.8	53.2	37.7	10.0	1.35	17.1	61.9
20	26.5	7.7	0.84	11.4	40.6	31.3	8.7	1.06	13.8	49.7	35.8	9.6	1.27	16.2	58.4
25	25.4	7.5	0.80	10.8	38.5	30.1	8.5	1.01	13.2	47.4	34.6	9.4	1.21	15.5	56.0
30	23.8	7.2	0.72	10.0	35.4	28.4	8.1	0.93	12.4	44.2	33.0	9.0	1.14	14.7	53.0
35	23.2	7.1	0.69	9.7	34.2	27.8	8.0	0.90	12.0	43.0	32.4	8.9	1.12	14.4	51.9
40	22.3	6.9	0.65	9.2	32.4	26.8	7.8	0.86	11.5	41.0	31.4	8.7	1.07	13.9	49.9
45	21.2	6.7	0.60	8.7	30.3	25.8	7.6	0.81	11.0	39.1	30.4	8.5	1.02	13.4	48.0
50	20.2	6.5	0.56	8.2	28.7	24.9	7.4	0.77	10.6	37.5	29.4	8.3	0.98	12.9	46.1
55	19.4	6.3	0.52	7.7	26.9	24.0	7.2	0.73	10.1	35.7	28.4	8.1	0.93	12.4	44.2
60	18.4	6.1	0.48	7.3	25.1	23.1	7.1	0.69	9.6	34.0	27.7	8.0	0.90	12.0	42.8
65	17.6	5.9	0.44	6.8	23.4	22.1	6.9	0.64	9.1	32.1	26.7	7.8	0.85	11.5	40.9
70	16.6	5.8	0.39	6.3	21.6	21.1	6.7	0.60	8.6	30.1	25.6	7.6	0.80	10.9	38.8

Table 2. Standards of Aerobic Fitness and Physical Performance for Women Determined on a Treadmill and during a 2000 m Track (w - walking, r - running), and/or 5000 m cycling - c, and/or 300 m swimming - s.

Age	Poor					Good					Excellent				
	Speed – **Rychlost**				$VO_{2max}.kg^{-1}$	Speed				$VO_{2max}.kg^{-1}$	Speed				$VO_{2max}.kg^{-1}$
Yrs	km/h c	km/h w	m/s s	km/h r	ml/kg.min	km/h c	km/h w	m/s s	km/h r	ml/kg.min	km/h c	km/h w	m/s s	km/h r	ml/kg.min
14	21.7	7.6	0.85	10.0	38.7	25.2	8.3	1.00	12.0	45.2	28.6	9.0	1.17	13.9	51.7
20	20.2	7.2	0.78	9.2	35.8	24.0	8.0	0.96	11.3	43.0	27.2	8.7	1.11	13.1	49.0
25	19.3	7.0	0.73	8.7	34.1	22.7	7.8	0.89	10.6	40.5	26.3	8.5	1.07	12.6	47.4
30	18.4	6.8	0.69	8.1	32.3	21.7	7.5	0.85	10.0	38.6	25.6	8.4	1.03	12.2	46.1
35	17.6	6.7	0.65	7.7	30.9	20.9	7.4	0.81	9.6	37.2	24.5	8.2	0.98	11.6	44.0
40	16.1	6.4	0.58	7.4	28.1	19.5	7.1	0.74	8.8	34.5	23.0	7.8	0.91	10.8	41.2
45	15.5	6.2	0.55	7.1	26.8	18.8	6.9	0.71	8.4	33.1	22.1	7.6	0.87	10.3	39.5
50	14.6	6.0	0.51	6.9	25.1	18.0	6.8	0.67	8.0	31.7	21.4	7.5	0.83	9.9	38.1
55	13.2	5.7	0.45	6.5	22.6	16.7	6.5	0.61	7.6	29.1	19.9	7.2	0.76	9.0	35.3
60	12.4	5.6	0.41	6.3	21.1	15.9	6.3	0.57	7.3	27.6	19.2	7.0	0.73	8.5	33.9
65	11.8	5.4	0.38	6.0	19.9	15.1	6.1	0.54	7.1	26.2	18.6	6.9	0.70	8.3	32.8
70	11.1	5.3	0.35	5.7	18.6	14.3	6.0	0.50	6.8	24.7	17.8	6.7	0.66	7.8	31.3

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