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Validity of a 2-km Walk Test in Predicting the Maximal Oxygen Uptake in Moderately Active Hungarian Men

Géza Zakariás, M. Petrekanits, and R. Laukkanen

The present study examined whether prediction models based on the 2-km UKK Walk Test (UWT) are valid for predicting the maximal oxygen uptake or maximal aerobic power (VO_{2max}) in moderately active Hungarian men. Eighty-seven 24–62 year old, non-athletic, sedentary or moderately physically active men were studied. Maximal aerobic power was measured in a maximal uphill walk exercise test on a treadmill. The walking tests were performed on a 400-m outdoors athletic track. The subjects walked 2 km (5 laps) as briskly as they could. VO_{2max} was predicted with the formula as established in the original development study of the UWT. The total error of prediction and the correlation coefficient between the laboratory measured and UWT predicted VO_{2max} (ml · kg^{-1} · min^{-1}) were 4.6 and 0.85. The Bland-Altman analysis showed a good agreement between the methods, with the mean error of prediction 0.05 ml · kg^{-1} · min^{-1}. The results verify that the UWT can be used as a reasonably valid test for predicting maximal aerobic power in Hungarian men.

Key Words: maximal oxygen uptake, prediction of VO_{2max}, laboratory test, field test, moderately active men

Key Points:

- UKK 2-km Walk Test (UWT) has been developed and validated in Finnish and Singaporean adults with good results.
- This study evaluated validity of the UWT in Hungarian men.
- Total error of the prediction by UWT compared to the laboratory-measured aerobic power was 11%, indicating that the UWT is a valid test for this population sample.

Introduction

Cardiovascular diseases account for 52% of deaths in men in Hungary (24). The mortality rate is higher in the city of Gyõr (53.7%), which is the biggest industrial city in the northwest of Hungary (25). Low cardiovascular fitness has been shown to be a strong independent predictor of cardiovascular diseases and all-cause mortality (26). Measuring aerobic fitness is very important in order to evaluate the need for

G. Zakariás is with Széchenyi István University, Gyõr, Hungary. M. Petrekanits is with Semmelweis University, Hungary. R. Laukkanen is with the Department of Public Health Science and General Practise at the University of Oulu, Oulu, Finland.

fitness improvement and give guidance to increase physical activity and to monitor changes in fitness. The maximal aerobic power (VO_{2max}) is an accepted index of cardiorespiratory fitness. The measurement of VO_{2max} in laboratory settings with standard techniques requires expensive and complicated equipment as well as highly educated testing personnel; therefore, its widespread use is limited. Additionally, tests that require maximal effort of subjects can be a health risk for untrained or aged persons. For these reasons, low-cost, simple, submaximal, and more feasible tests are needed and have been developed for field use (6).

Some of the VO_{2max} prediction tests are based on heart rate response during submaximal work on a bike ergometer, such as the Åstrand-Ryhming test (1, 4) or WHO test (11), and during or after bench stepping, such as the Harvard Step Test (3) and the Canadian Home Fitness Test (9). Others, like the Cooper (5) and Leger (17, 18) tests, use running or shuttle running with maximal effort to estimate maximal oxygen uptake. These tests provide a good method of predicting VO_{2max} for fit individuals, but the result depends on motivation and running skills, and they are unsuitable for inactive or elderly people. A safe and suitable exercise for adults is walking (20, 23). Kline et al. (10) have developed a 1-mile walking test for the estimation of VO_{2max}. The variables in the prediction are age, body weight, walking time, and heart rate during the walk. Oja et al. (21) have developed a 2-km walking test named as the UKK Walk Test. There are separate prediction equations for women and men, and they include walking time, heart rate at the end of the walk, age, and body mass index. The criterion validity of the 2-km walking test has been studied in overweight adults (12) and moderately to highly active middle-aged adults (13, 14), with good results except for very fit men. The UKK Walk Test has also been validated in Singaporean adults (15) and shown to be valid in measuring change in aerobic fitness after walking training in middle-aged adults (16).

The UKK Walk Test was selected to be studied, because it is a simple and novel submaximal fitness test and recommended by the European Community Eurofit test battery for adults (22).

The aim of this work was to evaluate the validity of the UKK Walk Test in the Hungarian, non-athletic adult male population.

Subjects and Methods

Subjects

The subjects were selected based on a questionnaire. The goal was to recruit a minimum of 100 healthy (considered fit for brisk walking, with no cardiorespiratory or musculoskeletal disorders or medication) men, aged 24–64 years, currently working in the city of Gyõr. Currently, 300 non-athletic, less or moderately active men, were invited by letter, e-mail, and phone. One important inclusion criterion was the level of physical activity: maximal two training sessions or regular exercise weekly during the previous 2 years.

A total of 223 men responded to the invitation, and 107 volunteer men were invited to this study. Before the laboratory test, the subjects were invited to undergo a medical examination. Nine subjects were excluded for the following reasons: 4 because of high blood pressure, 3 because of abnormalities in resting ECG, 2 due to influenza infection. Eleven subjects did not perform both tests, and their results were therefore excluded. Thus, 87 subjects are included in the final results.

Table 1 Physical Characteristics of the Subjects (n = 87)

Characteristic	Mean ± *SD*
Age (years)	37 ± 11.2
Weight (kg)	77.7 ± 8.7
Height (cm)	178 ± 7.1
BMI (kg/m^2)	24.6 ± 2.5
Body fat (%)	22.5 ± 5.2
VO_{2max} ($L \cdot min^{-1}$)	3.3 ± 0.70
VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	43.3 ± 8.7
Maximal heart rate ($beats \cdot min^{-1}$)	186 ± 13.1
Maximal blood lactate ($mmol \cdot L^{-1}$)	10.8 ± 2.8
Maximal respiratory quotient (CO_2/O_2)	1.16 ± 0.05

Laboratory Test Procedure

All the laboratory tests were performed in the morning between 9–12 am. All subjects fasted and abstained from alcohol and caffeine for a minimum 2 hours before the test. They did not do any exercise in the 24 hours before the test. Anthropometric and performance characteristics of the subjects are presented in Table 1.

Body weight (Seca scale, Delta model 707, UK) and height (Holtain Ltd., Wales, UK) were measured in minimal clothing without shoes, and the subjects body mass index (BMI) was calculated. Body fat was estimated from 4 skinfolds (biceps, triceps, suprailiaca, subscapulare) measured with a skinfold calliper (Lange Ltd., Cambridge, USA) and calculated with the Durnin and Womersley method (7).

Maximal oxygen uptake (VO_{2max}) was determined during uphill walking to subjective maximum on a treadmill (LE 6000 Jaeger GmbH, Germany). Walking speed during the test varied between 4.5–5.5 km/h, and inclination increased 2.5% every 2 min. Expired gases were collected and analyzed continuously (Jaeger MJ Datascript, Germany) in successive 30-s periods. Heart rate was recorded by ECG (4 leads, Hellige Sigma Multiscript 3, Hellige GmbH, Germany) and by a telemetric heart rate monitor (Polar Vantage NV, Polar Electro Oy, Kempele, Finland) with 5-s intervals. Blood lactate was determined from the earlobe (Jaeger Dr. Lange Miniphotometer 8, Germany) at 2-min intervals during the test. Criteria for attaining VO_{2max} were as follows: heart rate at least 90% of the age-specific maximum (220 – age), respiratory quotient (RQ) over 1.00, and capillary lactate over 4 mmol/L. All subjects had to fulfill at least two of the criteria.

Walking Test Procedure

Within 5–9 days after laboratory testing, each subject walked a 2-km distance. The walks took place on a 400-m outdoor-track (covered by clay). The temperature during the test was between 21–24 °C, and humidity was between 62–68%. All subjects started individually every 60 s. The instruction for the walks was: "Walk the distance as fast as you can, but do not risk your health". Walking time was recorded on the finish line to the nearest second. Immediately after the walk and 1 min later, the heart rate was measured with Polar Pacer (Polar Electro Oy, Kempele, Finland) heart rate receiver fixed to a Polar handlebar transmitter.

Statistical Analysis

Estimations of VO_{2max} were based on regression equations, established by Oja et al. (22). The relationship between the anthropometric and walking test variables were calculated. The *t* test was used to evaluate the statistical significance of the correlation coefficients. A *p* value of less than .05 was considered significant. The validity of the prediction model in measured data was evaluated with two methods. At first, we examined the relationships between the laboratory measured and predicted VO_{2max} by the mean difference, the correlation coefficient, and the total error (E) according to Lohmann (20). Second, the data were analyzed using the principle presented by Bland and Altman (2). The total error E of the prediction was calculated as follows:

$$E = \sqrt{\frac{\sum(\hat{y}_i - y_i)^2}{n}}$$

where $\hat{y}_i$ is VO_{2max} predicted by the Walk Test, y_i is VO_{2max} measured in the maximal exercise test, and n is the number of observations.

Results

The mean walking time and speed of the group were 15.7 min and 127 m · min^{-1} (7.6 km · h^{-1}). The mean (*SD*) heart rate at the end of the test was 149 (19) beats · min^{-1} and corresponded to 81% of the maximal heart rate.

The single correlation between VO_{2max}, selected anthropometric measures, and the walking performance are presented in Table 2. The highest correlation was

Table 2 Correlation Coefficients Between Maximal Oxygen Uptake (VO_{2max}) and Selected Variables Included in the Prediction Model and Body Fat (*n* = 87)

Variable	VO_{2max} L · min^{-1}	VO_{2max} ml · kg^{-1} · min^{-1}
Age (years)	–0.39*	–0.53*
BMI (kg/m^2)	–0.02	–0.43*
Body fat (%)	–0.18*	–0.48*
Walking time (min)	–0.67**	–0.62**
HR[a] (bpm)	–0.12*	–0.21*

Note. [a]HR immediately at the end of the walk. **$p < .01$; *$p < .05$.

Table 3 Measured and Predicted VO_{2max}, Their Difference (Mean ± *SD*), Total Error (E), and Correlation Coefficient (*r*) for the Group in the Study (*n* = 87)

Variable	VO_{2max} $L \cdot min^{-1}$	VO_{2max} $ml \cdot kg^{-1} \cdot min^{-1}$
Measured VO_{2max}	3.33 ± 0.71	43.07 ± 8.81
Predicted VO_{2max}	3.34 ± 0.69	43.2 ± 8.6
Difference	0.01 ± 0.36	0.16 ± 4.6
E	0.34	4.6
r	0.86	0.85

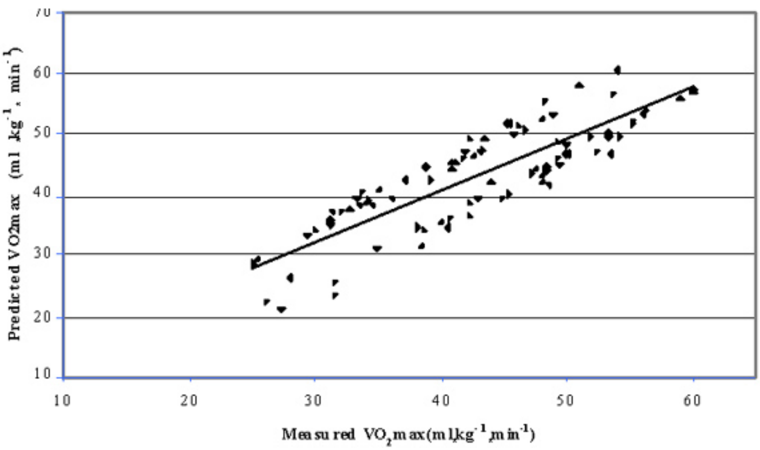

Figure 1 — Scatterogram for the measured and predicted maximal oxygen uptake values,VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$) values for the group in the study. Adjusted R^2 and SEE ($ml \cdot kg^{-1} \cdot min^{-1}$; *n* = 87).

found between the walking time and VO_{2max} (–0.62). Age, body mass index, and body fat correlated better to relative VO_{2max} value ($ml \cdot kg^{-1} \cdot min^{-1}$) than to absolute value ($L \cdot min^{-1}$). The correlation coefficient between the heart rate at the end of the walk and maximal aerobic power was the smallest (–0.21).

Table 3 shows the laboratory measured and UKK Walk Test predicted VO_{2max}, as well as the mean difference, total error, and correlation coefficient between them. The mean difference between the laboratory-measured and UKK Walk Test–predicted absolute and relative VO_{2max} were 0.01 $L \cdot min^{-1}$ and 0.16 $ml \cdot kg^{-1} \cdot min^{-1}$ and the total error 0.34 $L \cdot min^{-1}$ and 4.6 $ml \cdot kg^{-1} \cdot min^{-1}$, respectively. Figure 1 shows the measured regression between the walk time and for each subject, adjusted R^2 of

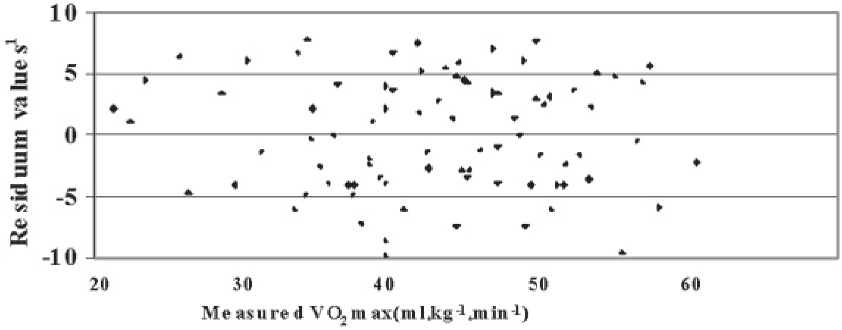

Figure 2 — Scatterogram showing the association between the laboratory-measured and UKK Walk Test–predicted maximal aerobic power. Mean of methods and limits of agreement (±2*SD*).

0.73, and standard error of estimate (SEE) of 4.58 ml · kg^{-1} · min^{-1}. In Figure 2, the difference of methods (UKK Walk Test predicted vs. laboratory measured VO_{2max}) is presented against the mean of the methods. The mean error of prediction was 1.89 ml · kg^{-1} · min^{-1}, with ±2*SD* limits of agreement (41.64–44.84 ml · kg^{-1} · min^{-1}).

Discussion

When compared to moderately active men in the earlier studies (13, 16, 21), the subjects of the present study had about the same mean fitness level. It must be noted that these subjects included a few former endurance athletes (long distance runners, cyclists, and kayak competitors) and some persons with very low levels of physical activity. Therefore, the range of VO_{2max} in this group is very large: from 25 to 60 ml · kg^{-1} · min^{-1} in measured VO_{2max}. However, the UKK Walk Test prediction did not show any systematic under- or overestimation of maximal aerobic power in unfit or fit individuals (Figure 1).

There is an interaction between the walking time and HR in the UKK Walk Test prediction equation. In this study, the mean walking time was a half minute faster than in earlier studies on moderately active men (13, 21) and 2 min 20 s slower than that of moderately and highly active men, respectively, in previous studies (13, 16). The subjects in this study did reach a lower heart rate in the walking test than moderately active men (81% vs. 87% of HR_{max}) in earlier studies (16, 21). The exertion level or walking speed was, however, high enough for the UKK Walk Test (14).

The total error of the VO_{2max} prediction in this group was smaller (11% vs. 13%) compared with an earlier study on Finnish men (13). The correlation coefficients between the predicted and measured VO_{2max} were high for both absolute and relative VO_{2max}.

There were 14 overweight men (BMI > 25 kg/m^2) in this study. Their mean (*SD*) walking time and heart rate were 16.1 (1.5) min and 150 (16) bpm. The mean (*SD*) measured VO_{2max} for this subgroup was 38.6 (8.7) ml · kg^{-1} · min^{-1}, and the predicted VO_{2max} was 36.7 (9.1) ml · kg^{-1} · min^{-1}. The total error (E) was 4.8 ml · kg^{-1} · min^{-1}. Compared with an earlier study on overweight men (12), we found better prediction accuracy with the same walking times and heart rates in our study.

Conclusion

From the results, we conclude that the UKK Walk Test developed in Finland is a reasonably valid field test for estimating aerobic fitness of healthy and moderately physically active Hungarian adult men.

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About the Authors

G. Zakarias is a Ph.D. student at Semmelweis University, Physical Education and Sport Sciences Faculty, in Budapest. He works for Széchenyi University, Gyõr as a PE teacher. He has been published at the fields of evaluation of cardiovascular fitness training and coaching of top athletes.

Dr. Máté Petrekanits is an exercise physiologist at HUMET-R clinic in Budapest. He has been published in the fields of exercise physiology and hemodynamics during exercise. He teaches at Semmelweis University, Physical Education and Sport Sciences Faculty, in Budapest. He is a member of the Hungarian Society of Sport Science.

Dr. Raija Laukkanen received her PhD at the University of Kuopio in 1993. Dr. Laukkanen has acted as a docent in health-related fitness at the University of Oulu, Department of Medicine, since 1999. She has been published in the fields of cardiovascular training and dose-response issues as well as in evaluation of cardiovascular fitness. Dr. Laukkanen is a fellow of the American College of Sport Medicine and a member of European College of Sport and Science.