STUDY

Prediction of race walking performance via laboratory and field tests

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ABSTRACT

It may be useful to be able to predict race walking performance based on relationships between standard race velocities and physiological variables such as blood lactate (B_{lac}) or maximum oxygen uptake (VO_2max), however laboratory tests for this purpose are impractical in most situations. The aim of this study was to develop a method to predict competition performance and/or physiological variables from performances in other distances and/or field based tests such as a time trial. Laboratory treadmill tests were conducted on 68 athletes to find B_{lac}, VO_2max and race walking economy (ml O_2/kg/km). Twenty-one of the same subjects then completed a 2000m full-effort time trial for calculation of their race velocity (km/h). The values obtained were compared and combined with the performances of the athletes over standard race walking distances and the performances of elite athletes to produce a nomogram (a diagram representing the relations between three or more variable quantities) that could be used to predict any of the variables if one or more of the values was known. The findings support the use of time trials to predict velocity at VO_2max and show there is a link between laboratory and performance variables that can be used in coaching.

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Introduction

Previous studies of race walking (DRAKE et al. 2003; HAGBERG & COYLE, 1983; YOSHIDA et al. 1989) have concluded that success in this discipline is probably related to the ability to attain and sustain a high race walking velocity without accumulation of blood lactate (B_{lac}). Therefore, it may be useful for coaches, athletes and others to be able to predict performance based on the relationships between standard race velocities and B_{lac} or other physiological variables such as maximum oxygen uptake (VO_2max). Although it is often impractical to perform laboratory tests for this purpose, it could be efficacious to predict race walking performance and/or physiological variables from performances in other distances and/or a field based test such as a time trial.

For example MERCIER et al. (1986) developed a nomogram to predict performance equivalence for distance runners; and BILLAT et al. (1994) and BERTHON et al. (1997) developed field based tests to calculate velocity at maximum oxygen uptake (v-VO_2max). DABONVILLE et al. (2003) found that the five-minute running test of BERTHON et al. (1997) was reliable for estimating v-VO_2max from only one trial. BILLAT et al. (1994) found that the duration of running performance that could be maintained at v-VO_2max was 5:21 ± 1:23. BERTHON et al. (1997) found running v-VO_2max correlated best with performance over 3000m, which varied from 8:08 to 15:36 ($r = 0.97$, $p < 0.05$, $n = 9$ male runners); and DANIELS (1998) described v-VO_2max as representative of the speed of a running race lasting between 10 and 15 minutes, therefore a 2000m race walk would compare time wise with a 3000m run performance. Moreover laboratory-, performance- and field-based variables could be combined to construct the interrelationships between them, e.g. to create a nomogram to predict VO_2max, v-VO_2max, 2000m time trial performance and 3000m, 5000m, 10km, 20km and 50km race walk performance if one or more of the values was known.

The purpose of this study was to develop a nomogram (a diagram representing the relations between three or more variable quantities) to predict performance equivalence for race walking, which would enable coaches and athletes to predict competition performance and/or physiological variables from performances in other distances and/or a field based tests such as a time trial.

Methods

Subjects

Forty-five male and twenty-three female race walkers participated in this study, which had Coventry University's ethical approval. The mean age, height, body mass and maximum oxygen uptake was 27 ± 8 years; 1.73 ± 0.08m; 64.3 ± 9.8kg; and 62.9 ± 11.3 ml/kg/min respectively.

Laboratory test: treadmill protocol

The athletes completed between six and nine four-minute stages of race walking on a motorised treadmill. All tests began at a 1% gradient, increasing by 0.5km/h each stage, with a starting speed 2.0km/h below the current race speed for 10km of the subject. On completion of each stage a 20µl arterialised capillary blood sample was obtained from the ear lobe for the determination of B_{lac} values used to identify lactate turn point (LTP). Expired air was collected into a Douglas bag for the last 60 seconds of each stage to determine oxygen uptake (VO_2) and race walking economy (ml O_2/kg/km). When heart rate (HR) exceeded 95% of the predicted maximum or B_{lac} exceeded 4mmol/l the treadmill gradient was increased by 1% every 60 seconds. The test continued until volitional exhaustion for the determination of maximum oxygen uptake (VO_2max). The velocity at lactate turn point (v-LTP) was the race walking speed at which there was an abrupt and exponential increase in B_{lac} values. The velocity at VO_2max (v-VO_2max) was resolved by linear regression on sub-maximal race walking speed and VO_2 values.

Field test: 2000m time trial

Thirteen male and eight female race walkers from the main subject group (above) also race walked an all out 2000m time trial on a 400m Mondo surface athletics track for calculation of v-2km (km/h). The time trial was undertaken within 24 hours of completing the discontinuous incremental treadmill test described above. Subjects were informed they should race walk as fast as possible and to treat the time trial as a race effort. Time trials began after subjects had completed a 20 minute warm-up. Tests were undertaken on windless days when the track was dry. Subjects completed their time trials alone on the track to avoid creating a competitive environment. The mean ± SD age, height, body mass and VO_2max of the 2000m time trial group was 22 ± 9 years; 1.75 ± 0.07m; 62.3 ± 9.1kg; and 55.6 ± 8.9ml/kg/min respectively.

Construction of interrelationships between variables

The value for v-2km was compared to v-VO_2max identified in the laboratory and race walk performances over 3000m, 5000m, 10km, 20km and 50km by the athletes taking part in the present studies. Moreover, race walk performances over 3000m, 5000m, 10km, 20km and 50km attained by athletes ranked in the world, British or Italian top 50 between 1999 and 2003 were combined to create a nomogram to predict VO_2max, v-VO_2max, 2000m time trial performance and 3000m, 5000m, 10km, 20km and 50km race walk performance if one or more of the values was known.

Results

2000m time trial

The 2000m time trial performance time was 554 ± 65s. The v-2km was compared to v-VO_2max and race walk competition performances over 3000m, 5000m, 10km, 20km and 50km recorded within four weeks pre- or post-laboratory test. The v-2km (13.2 ± 1.6km/h) was 0.2% higher than v-VO_2max (13.1 ± 1.5km/h) ($p > 0.05$); and 10.9% higher than v-LTP (11.7 ± 0.7km/h) ($p < 0.05$). The v-VO_2max accounted for 94% of the variance in 2000m time trial performance when analysed by multiple stepwise linear regression. The relationship between v-VO_2max and v-2km was resolved by following the “field-laboratory” equation in Table 1 (R2 = 0.96, n = 21). To test whether the distribution of the VO_2max, v-VO_2max and v-2km data measured were significantly different from the normal distribution a Kolmogorov-Smirnov test (D) was used (FIELD, 2005). The distribution of the VO_2max val-

Table 1: Relationships between paired race distances analysed using linear regression, where 3000m, 5000m, 10km, 20km and 50km = hh:mm:ss (Predictive equations were established from World, British and Italian top 50 ranked performances 1999 – 2003, which were not significantly different (p >0.05) from the present study. #linear regression not performed due to n = 2.)

Field-laboratory	Common race walking economy	Performance-field
v-2 km (km/h) = 1.1042 v-VO_2max (km/h) – 1.4011 r = 0.96*, R2 = 0.96, n = 21	VO_2 (ml/kg/min) = 5.2482 treadmill speed (km/h) – 12.334 r = 0.85*, R2 = 0.996, n = 68	v-3 km (km/h) = 0.8624 v-2 km (km/h) + 1.6626 r = 0.93*, R2 = 0.76, n = 21

Paired race distances (h:mm:ss) used to construct nomogram			
3000m - 5000m	5000m - 10 km	10km - 20km	20km - 50km
5000m = 1.4468 3000m + 0.0024 R2 = 0.90, n = 31	10 km = 2.0906 5000m – 0.0002 R2 = 0.92, n = 44	20 km = 2.1031 10 km – 0.0009 R2 = 0.87, n = 44	50 km = 2.8868 20 km – 0.0039 R2 = 0.74, n = 63
Paired race distances (h:mm:ss) from present study for comparison			
3000m - 5000m	5000m - 10 km	10km - 20km	20km – 50km
5000m = 1.463 3000m + 0.0025 R2 = 0.82, n = 30	10 km = 1.8573 5000m + 0.0034 R2 = 0.87, n = 34	20km = 2.2811 10km - 0.0064 R2 = 0.86, n = 28	n = 2#

ues, ($D(21) = 0.12$ ($p > 0.05$)), v-VO_2max values ($D(21) = 0.21$ ($p > 0.05$)) and v-2km values ($D(21) = 0.16$ ($p > 0.05$)) indicated a normal distribution.

Interrelationships between variables

Data from the present study was combined to resolve the relationship between race walking speed and VO_2, i.e. "common race walking economy" (Table 1, R2 = 0.996, n = 68); and the "performance-field" based relationship between v-2km and v-3km was resolved from race performances completed by the athletes who completed the 2000m time trial (Table 1, R2 = 0.76, n = 21). The model construct was completed from analysis of 182 paired race walk times of athletes over the 3000m, 5000m, 10km, 20km and 50km distances (Table 1). The construct from the interrelationship between laboratory-, performance- and field-based variables was the nomogram (Figure 1) that can be used to predict performance in race walking events and VO_2max.

Present study v ranking data

The linear regression equations from Table 1 predict small differences in performance. For example, the VO_2max of the male athletes who completed a 2000m time trial was 55.6 ± 8.9ml/kg/min with a corresponding v-VO_2max of 13.2 ± 1.6km/h (Table 2), equating to v-2km of 13.2km/h ("field-laboratory" equation, Table 1) that is used to compute 3000m performance from 2000m time ("performance-field" equation, Table 1), i.e. v-3000m of 13.02km/h. The linear regression equations from Table 1 predict a 1.6 % difference between 5000m performances (22:26 derived from ranking data versus 22:47 derived from present study); a 1.3% difference between 10km performances (46:37 derived from ranking data versus 47:13 derived from present study); and a 1.8% difference between 20km performances (1:36:44 derived from ranking data versus 1:38:30 derived from present study). The relationships between paired performances from the present study compared to the ranking data are shown in Figure 2.

Discussion

Certain assumptions were inherent in the construct of the nomogram, e.g. the relationship between race walking speed (km/h) and VO_2 max (ml/kg/min). The regression equation created a curve that assumes common race walking economy; however the common curve ignores the differences in economy and the differences in VO_2max. In the race walking nomogram an athlete completing a 2000m time trial in 8:00 would be predicted as having a v-VO_2max of 15.0km/h and a VO_2max of about 66.0ml/kg/min, however in reality a v-VO_2max of 15.0km/h may be attained by an athlete with a lower VO_2max but superior race walking economy or by an athlete with a higher VO_2max but inferior race walking economy, i.e. a race walker using the nomogram to predict VO_2max may find a different value predicted to that which could be measured completing the discontinuous incremental treadmill race walking protocol.

MERCIER et al. (1986) developed a nomogram to predict performance equivalence for distance runners and proposed a number of uses for such a tool, which are also applicable to the nomogram presented here. Race walk performance may be predicted by interpolation or extrapolation, e.g. an athlete completing a 2000m time trial in 8:00 s and 10km time trial in 44:06 would be predicted to race walk 5000m in 21:14; the performances of an athlete completing a 2000m time trial in 7:21 and a 10km time trial in 41:04 could be extrapolated to predict to 50km in 3:59:58. A further use for the nomogram could be to determine the prerequisites to achieve a certain level of performance, such as a qualifying time, e.g. the "A" standard qualifying time for the Men's 20km at the 2008 Olympic Games was 1:23:00: an athlete seeking to attain this level of performance would have had to be able to complete time trials at 2000m in 7:08 or 3000m in 10:57, 5000m in 19:18 or 10km in 40:03.

In previous studies (DRAKE et al. 2003; HAGBERG & COYLE, 1983; YOSHIDA et al.

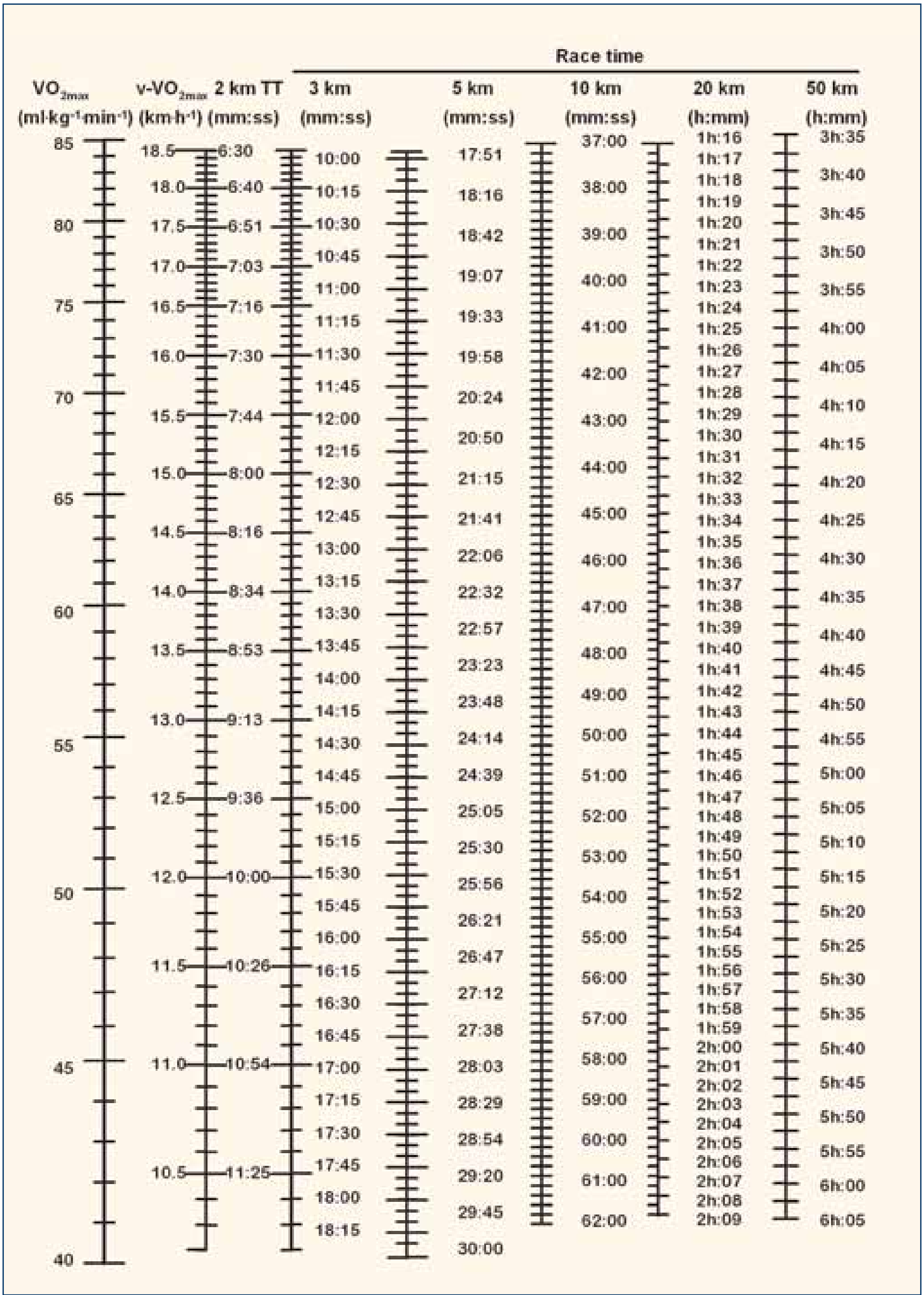

Figure 1: Nomogram to predict race walking performance at distances from 2000m to 50km (VO_2max is predicted by passing a horizontal line through the 2000m time trial (TT) performance. The line that describes the race walking performance of an athlete at two distances allows prediction of performance at a third distance.)

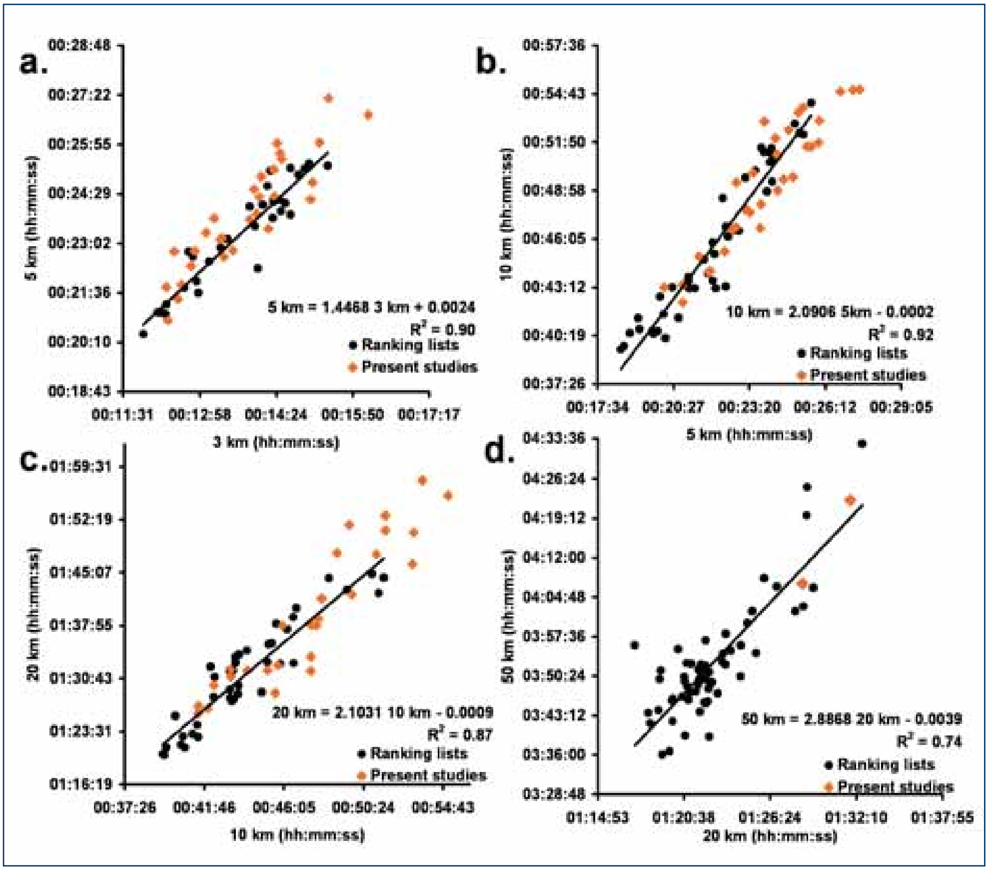

Figure 2: Relationships between paired performances from the present study compared to the ranking data used (a. 3000m – 5000m; b. 5000m – 10km; c. 10km – 20km; and d. 20km – 50km) (Performances by athletes ranked in the World, British or Italian top 50 between 1999 and 2003 were used to construct the model (n = 56 male, 37 female) – www.iaaf.org; www.ukathletics.org.uk; and www.fidal.it).

1989) the relationships between several physiological variables and athlete performance suggested that success in race walk competition was largely related to aerobic endurance, i.e. the ability to attain and sustain a high race walking velocity for a long period of time. However the present study did not establish the validity of the laboratory based methods compared to the field based 2000m time trial to determine the relative importance of the different variables in performance prediction, e.g. laboratory based threshold values versus time trial performance.

Conclusions

The 2000m time trial provided information on v-VO_2max: v-2km and v-VO_2max were not statistically significantly different from each other ($p > 0.05$) and r = 0.98 ($p < 0.05$). Furthermore the 2000m time trial and nomogram could be used for VO_2max evaluation and to identify prerequisite levels of performance required to achieve goals such as attaining championship qualifying times. Even so, the 2000m time trial warrants validation with more subjects to strengthen the interrelationships with laboratory- and performance-based variables.

Recommendations

The present study supports the use of a field based 2000m race walking time trial as a predictor of velocity at maximum oxygen uptake in athletes competing in race walking events. Moreover, the 2000m time trial provides a useful link between laboratory and performance variables in the construct of the race walking nomogram, which is an easy to use coaching tool for athletes and coaches.

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