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Paul Berthon · Nicole Fellmann · Mario Bedu · Bruno Beaune
Michel Dabonneville · Jean Coudert · Alain Chamoux

A 5-min running field test as a measurement of maximal aerobic velocity

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Abstract Based on a theoretical approach from world record running data, we have previously calculated that the most suitable duration for measuring maximal aerobic velocity (v_{amax}) by a field test was 5 min ($v_{\mathrm{amax(5)}}$). The aim of this study was, therefore, to check this hypothesis on 48 men of various levels of physical fitness by comparing ($v_{\mathrm{max(5)}}$) with (v_{amax}) determined at the last step of a progressive treadmill exercise test when the subject felt exhausted ($v_{\mathrm{amax(t)}}$) and during a test on a running track, behind a cyclist (following an established protocol) ($v_{\mathrm{amax(c)}}$). For each test, ($\dot{V}O_{2\mathrm{max}}$) was also measured by a direct method on a treadmill ($\dot{V}O_{2\mathrm{max(t)}}$) and calculated by an equation for field tests ($\dot{V}O_{2\mathrm{max(5)}}$ and $\dot{V}O_{2\mathrm{max(c)}}$). The $V_{\mathrm{amax(5)}}$ [17.1 (SD 2.2) $\mathrm{km \cdot h^{-1}}$] and ($v_{\mathrm{amax(c)}}$) [(18.2 (SD 2.4) $\mathrm{km \cdot h^{-1}}$] were significantly higher than ($v_{\mathrm{amx(t)}}$) [16.9 (SD 2.6) $\mathrm{km \cdot h^{-1}}$; $P < 0.001$]. The ($v_{\mathrm{amax(t)}}$) was strongly correlated with ($v_{\mathrm{amax(5)}}$) ($r = 0.94$) and ($v_{\mathrm{amax(c)}}$) ($r = 0.95$) ($P < 0.001$). The best identity and correlation between ($v_{\mathrm{amax(5)}}$) and track performances were found in the runners ($n = 9$) with experience over a distance of 3,000 m. The $\dot{V}O_{2\mathrm{max(5)}}$ and ($\dot{V}O_{2\mathrm{max(c)}}$) were higher than $\dot{V}O_{2\mathrm{max(t)}}$ (+ 5.0% and + 13.7%, respectively; $P < 0.001$) and $\dot{V}O_{2\mathrm{max(t)}}$ was highly correlated with $v_{\mathrm{amax(5)}}$ ($r = 0.90$; $P < 0.001$). These results suggest that the 5-min field test, easy to apply, provided precise information on v_{amax} and to a lesser degree on $\dot{V}O_{2\mathrm{max}}$.

Key words Maximal oxygen consumption · Running performances · Léger test · Blood lactate · Energy cost of running

P. Berthon (✉) · M. Dabonneville
Laboratoire Performance Motrice,
UFR STAPS, Université Blaise Pascal,
B.P. 104, F-63172 Aubière Cédex,
France

A. Chamoux
Laboratoire de Médecine du Travail,
Université d'Auvergne,
F-63000 Clermont Ferrand,
France

N. Fellmann · M. Bedu · B. Beaune · J. Coudert
Laboratoire de Physiologie-Biologie du Sport,
Université d'Auvergne,
F-63000 Clermont-Ferrand,
France

Introduction

Performance in many sports has been shown to depend largely on *aerobic qualities* including maximal oxygen consumption ($\dot{V}O_{2\mathrm{max}}$), economy of running and the fractional utilisation of $\dot{V}O_{2\mathrm{max}}$ (di Prampero et al. 1986), which are determinants for training and during recovery. Performance cannot indeed be explained only in terms of ($\dot{V}O_{2\mathrm{max}}$). In the laboratory, during direct $\dot{V}O_{2\mathrm{max}}$ measurements, maximal aerobic velocity (v_{amax}) (di Prampero 1987) has been defined as the speed reached by the subject on a treadmill at the last stage corrected by the time spent at this stage (Lacour et al. 1989). On the track, coaches and physical education instructors must take v_{amax} into account to establish training programmes. Various field tests have been proposed, consisting of maximal running tests of different durations, distances and stages and they can be continuous or discontinuous. All these tests evaluate physical fitness but few of them attempt to measure v_{amax}.

Léger and Boucher (1980) have developed and validated an indirect continuous running multistage field test providing an indirect determination of $\dot{V}O_{2\mathrm{max}}$ (Université de Montréal Track Test, UMTT). This test is based on the assumption that the subjects will reach their $\dot{V}O_{2\mathrm{max}}$ during the last stage of the test. More recently, Lacour et al. (1991) have demonstrated with runners from regional to international level that the UMTT provides a value of v_{amax} as accurately as a treadmill measurement. Moreover v_{amax} has been shown to correlate well with the best performance maintained over 1,000 m (Montmayeur and Villaret 1990), 1,500 and 3,000 m (Lacour et al. 1989). However, this test is not valid for $\dot{V}O_{2max}$ estimation from v_{amax} using the equation of Léger and Mercier (1983). The $\dot{V}O_{2max}$ has been shown to be overestimated when compared with $\dot{V}O_{2max}$ measured by a direct method on a treadmill, and this difference was more marked in the less fit subjects (Lacour et al. 1989). This discrepancy may result from several factors. Firstly, an energy cost of running which is different from the value used by Léger and Mercier (1983) (210 ml $O_2 \cdot kg^{-1} \cdot km^{-1}$) for establishing their equation, would introduce an error. Secondly, v_{amax} measured by UMTT could be overestimated because the velocity sustained during the last stage of this field test could exceed the actual v_{amax} corresponding to the maximal aerobic capacity. In fact the time duration of the stages is different in laboratory and field tests. In the Brue protocol (Brue et al. 1986), v_{amax} corresponds to the last wholly completed stage maintained for only 30 s (time duration of each step), whereas the time of the running period is 3 or 4 min during treadmill measurements. Depending on the studies, the duration of the running performance which is maintained at 100% v_{amax}, a concept of "Tlim at MAS" developed by Billat (1994a,b), varies from 5 min to 8 min (4.95 min – Montmayeur et Villaret 1990; 5 min – Londeree 1986; 5.12 min – Billat et al. 1994a; 5.23 min – Billat et al. 1994b; 7 min – Costill and Fox 1969; Peronnet and Thibault 1989; 4.6 min – Léger et al. 1986). These values have been shown to correspond to the best track performance over 1,500 to 3,000 m. According to Katch et al. (1973), it is not necessary to run for more than 5 min at a steady pace to improve significantly the correlation between $\dot{V}O_{2max}$ measured in the laboratory and running performance. Brikci and Dekkar (1989) have demonstrated a significant correlation between the 5-min running test and $\dot{V}O_{2max}$ (r = 0.93; n = 38), but these authors did not compare the field test performance to v_{amax} because the laboratory tests were performed on a cycle ergometer. More recently, we have demonstrated by a critical approach to world record running data that a 5-min long maximal test is the most suitable duration for measuring v_{amax} (Chamoux et al. 1996).

Therefore, in order to check whether a 5-min maximal continuous running test allows the accurate measurement of v_{amax} and correlates with $\dot{V}O_{2max}$, the results of this field test were compared with v_{amax} and $\dot{V}O_{2max}$ determined in the laboratory on a treadmill and during the UMTT (Léger and Boucher 1980, modified by Brue et al. 1986). In addition, these field velocities were compared to the athlete's best performances of the corresponding track season over 800 m, 1,500 m, 3,000 m, 5,000 m, 10,000 m and half-marathon.

Methods

Subjects

A group of 51 men, who volunteered for the study were informed before the tests about the risks and constraints involved and gave their written consent to participate. All the subjects had a medical examination including an electrocardiogram and a complete medical history was taken. This examination led us to exclude three subjects from the experimental programme. Finally 48 men [mean age 27.9 (SD 6.9) years, range 18.2–46.1 years; mean height 178.0 (SD 5.2) cm, range 169–190 cm; mean body mass 71.2 (SD 7.4) kg, range 56.5–85.5 kg] performed the three tests in random order within a maximal period of 2 weeks. They had different physical fitness levels varying from sedentary subjects to sportsmen in individual or collective sports, and runners at local or national level.

Measurement of $\dot{V}O_{2max}$ by a direct method and of v_{amax}

The $\dot{V}O_{2max}$ was measured during a graded continuous treadmill test (Gymrol Super 2500) ($\dot{V}O_{2amx(t)}$). The duration of each step was 3 min with a gradient of 1%. The magnitude of the gradient was chosen for two reasons:

1. It is easier to maintain a running posture on a treadmill with a slight gradient and
2. To compensate for the wind resistance during running which occurs on the track but not on a motor driven treadmill (Davies 1980).

The speed increment was 1.5 $km \cdot h^{-1}$. Each subject performed five or six steps until he felt exhausted. The first step lasted 5 min as a warm-up and the corresponding speed was fixed according to the physical fitness of the subject [70% of the theoritical maximal heart rate (220- age in years) as defined by Astrand and Rythming 1954]. Expired gas was collected in a Douglas bag for the last 30 s of each running stage. Subsequent volume determination was carried out in a Tissot spirometer. The mean O_2 and CO_2 fractions of expired air were determined by Morgan analysers.

The $\dot{V}O_{2max}$ measurement was considered valid if three of the following criteria were satisfied: exhaustion of the subject, respiratory exchange ratio equal to or greater than 1.10, blood lactate concentration equal to or greater than 8 $mmol \cdot l^{-1}$ or actual maximal heart rate (HR_{max} greater than at 95% of the maximal theoretical heart rate) (Astrand et al. 1973; Lacour and Flandrois 1977).

The maximal aerobic velocity on the treadmill ($v_{amax(t)}$) was calculated using the equation proposed by Kuipers et al. (1985): $v_{amax(t)} = v + a. n/b$ where v (in kilometres per hour) is the velocity maintained before the last stage, a (kilometres per hour) is the value of the speed increment between two stages, n is the number of seconds run in the last stage and b the theoretical number of seconds of the last stage.

The running energy cost was calculated using the equation proposed by Lacour et al. (1991) at submaximal velocity just before the last stage: running energy cost ($mlO_2 \cdot kg^{-1} \cdot km^{-1}$) = [oxygen uptake ($\dot{V}O_2$) at the stage ($ml \cdot kg^{-1} \cdot min^{-1}$) −5($ml \cdot kg^{-1} \cdot min^{-1}$)/ velocity ($km \cdot min^{-1}$). The 5 $ml \cdot kg^{-1} \cdot min^{-1}$ value corresponded to resting $\dot{V}O_2$ (Medbo et al. 1988).

Université de Montréal track test

The UMTT was performed within the week preceeding or following the other two tests. On the track, without warm-up, the athletes (5 maximum) followed a cyclist whose pedalling rate was paced by a tape recorder. This technique, proposed by Brue et al. (1986), provided a regular increase in velocity (v). The v of the first stage was approximately 6.4 $km \cdot h^{-1}$ and it increased about 0.30 $km \cdot h^{-1}$ every 30 s. The cyclist was informed by a whistle blast about the right intermediate time. The v maintained during the last wholly completed stage was considered as the subject's v_{amax} in the test ($v_{amax(c)}$).

The $v_{amax(c)}$ was converted into theoretical $\dot{V}O_{2max}$ ($\dot{V}O_{2max(c)}$) using the equation of Léger and Mercier (1983) which has been established for treadmill and track performances obtained from data in the literature as follows:

$\dot{V}O_{2max(c)} = 1.353 + 3.163\,v + 0.0122586\,v^2$ where $\dot{V}O_{2max}$ is in millilitres per minute per kilogram and v in kilometres per hour.

A 5-min maximal running test

The procedure was as follows:

1. A 5–10 min warmup at 70% HR_{max} which allowed the subject to start at his maximal potential
2. A constant pace which was necessary to obtain maximal performance
3. No rests during the test to avoid the effect of the recovery process on physiological responses
4. The shuttle-run technique was excluded because this method introduces additional factors (muscle strength, nervous reactivity) which modify performance.

After a 10-min warm-up at approximately 70% HR_{max} evaluated from heart rate monitoring, the subjects were asked to run the maximal distance in 5 min on the track. The subjects were informed that steady running was needed for the best performance. A sound signal was given every minute. A count down was given for the last 10 s. Intermediate times were written down every 100 m.

The maximal aerobic velocity [$v_{amax(5)}$ (in kilometres per hour)] was calculated by multiplying the running distance (d) by 12 (1 h = 5 min × 12): $v_{amax(5)}$ (km · h^{-1}) = 12 d (km run in 5 min).

As for UMTT, the equation of Léger and Mercier (1983) was used to estimate $\dot{V}O_{2max(5)}$.

Throughout the three tests, heart rate (HR) was recorded with a heart rate monitor (Sport Tester TM PE 4000, Polar Electro), and blood samples for lactate concentration measurement ($[La^-]_b$) were obtained by micropuncture of the ear lobe within the 3 min following the completion of the tests. The ($[La^-]_b$) were measured with a lactate analyser (Analox LM5).

Track performances

Out of the 48 subjects, the best performances (expressed as a velocity, metres per second) achieved by the experienced runners of the group studied during the track season (over a period of 6 months before and after the tests) were obtained over 800 m (n = 8), 1,500 m (n = 12), 3,000 m (n = 9), 10,000 m (n = 12) and half-marathon (n = 13). Each subject could run from one to five different distances.

Statistics

The ANOVA was used for overall comparisons of (HR), $[La^-]_b$, $\dot{V}O_{2max}$ and v_{amax} for all the three tests (Stat View 4.02). Subsequent post-hoc analysis by using a Scheffé test was performed to identify the location of significant differences. The relationships between variables $\dot{V}O_{2max}$, v_{amax}, track performances) were analysed using linear regression analysis. The significant level was fixed at $P < 0.05$.

Results

Data from treadmill and track measurements are listed in Table 1. The $[La^-]_b$ and HR_{max} were no different between the three tests.

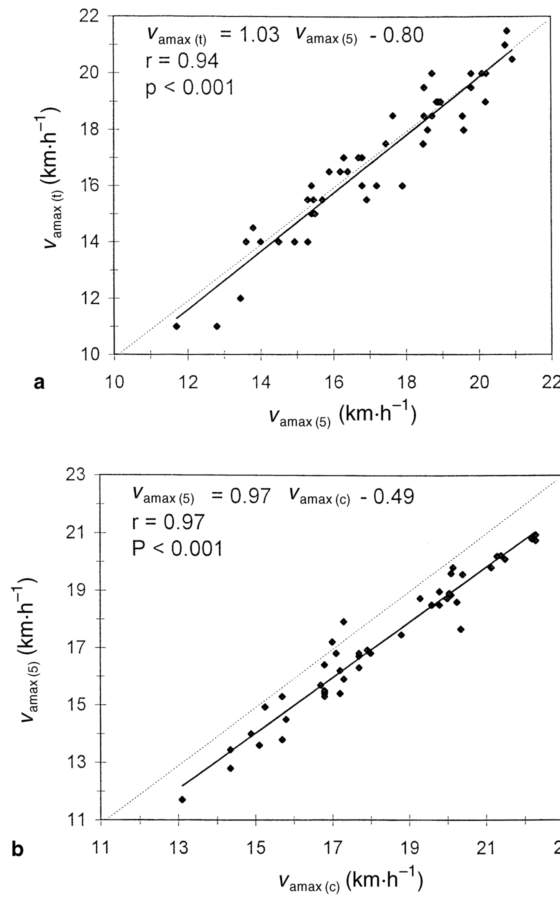

Fig. 1 Relationships between the maximal aerobic velocity, as measured on a treadmill $v_{amax(t)}$ and the running velocity maintained during the 5-min field test $v_{amax(5)}$ **a** between $v_{amax(5)}$ and the running velocity maintained during the last completed stage of the Université de Montréal Track Test with Brue protocol $v_{amax(c)}$ **b** *Dotted line* line of identity

Table 1 Maximal parameters obtained during laboratory test (treadmill) and field tests: Université de Montréal Track Test with Brue protocol (UMTT) and 5-min test. HR_{max} Maximal heart rate, v_{amax} maximal aerobic velocity, $\dot{V}O_{2max}$ maximal oxygen consumption

Test		HR_{max} (beats · min^{-1})		Lactate (mmol · l^{-1})		v_{amax} (km · h^{-1})		$\dot{V}O_{2max}$ ml · min^{-1} · kg^{-1}	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Treadmill		192.0	7.5	9.1	2.2	16.9	2.5	55.6	8.2
	Range	175–208		5.8–14.9		10.0–21.4		33.5–71.0	
UMTT		192.6	7.7	9.2	2.6	18.2	2.3***	63.1	8.4***
	Range	177–210		5.2–14.6		13.1–22.3		45.8–78.1	
5-min		191.8	8.1	9.9	2.1	17.1	2.3***	59.2	8.3***
	Range	175–210		5.6–14.8		11.7–20.9		40.0–72.9	

*** $P < 0.001$ Significantly different from treadmill test

Maximal aerobic velocity

The $v_{amax(c)}$ and $v_{amax(5)}$ were significantly higher than $v_{amax(t)}$. The mean differences were + 1.4 $km \cdot h^{-1}$ (+ 8.3%) ($P < 0.001$) and + 0.3 $km \cdot h^{-1}$ (+ 1.8%) ($P < 0.001$), respectively. The three v_{amax} were significantly correlated with each other ($P < 0.001$): $v_{amax(t)}$ and $v_{amax(5)}$ ($r = 0.94$) (Fig. 1a); $v_{amax(c)}$ and $v_{amax(5)}$ ($r = 0.97$) (Fig. 1b) and $v_{amax(t)}$ and $v_{amax(c)}$ ($r = 0.95$).

Maximal oxygen uptake

The calculated $\dot{V}O_{2amx(c)}$ and $\dot{V}O_{2max(5)}$ were both significantly higher than direct $\dot{V}O_{2max(t)}$: + 7.6 $ml \cdot min^{-1} \cdot kg^{-1}$ (+ 13.7%) and + 2.8 $ml \cdot min^{-1} \cdot kg^{-1}$ (+ 5.0%) ($P < 0.001$), respectively. There were significant correlations between $\dot{V}O_{2max(t)}$ and $v_{amax(5)}$ ($r = 0.90$, $P < 0.001$) (Fig. 2) and between $\dot{V}O_{2max(t)}$ and $v_{amax(c)}$ ($r = 0.92$, $P < 0.001$). Consequently, significant relationships were also found between $\dot{V}O_{2max(t)}$ and $\dot{V}O_{2max(5)}$ ($\dot{V}O_{2max(t)} = 0.88\ \dot{V}O_{2max(5)} + 3.35$, $r = 0.90$ $P < 0.001$) and $\dot{V}O_{2max(t)}$ and $\dot{V}O_{2max(c)}$ ($\dot{V}O_{2max(t)} = 0.89\ \dot{V}O_{2max(c)} - 0.54$, $r = 0.92$ $P < 0.001$).

The energy cost of running calculated from the treadmil data was 182 (SD 14) ml $O_2 \cdot kg \cdot km^{-1}$ (range 166–221 ml $O_2 \cdot kg^{-1} \cdot km^{-1}$).

Track performances

Strong correlations between $v_{amax(5)}$ and track performance were found over all distances except for 800 m for which the linear regression line was not significant (Table 2). The best relationship with $v_{amax(5)}$ was obtained for 3,000 m (Fig. 3). Whatever the runner's level, the velocity at 1,500 m was systematically higher than $v_{amax(5)}$ whereas the velocity corresponding to 5,000 m, 10,000 m and half-marathon were lower (Fig. 3).

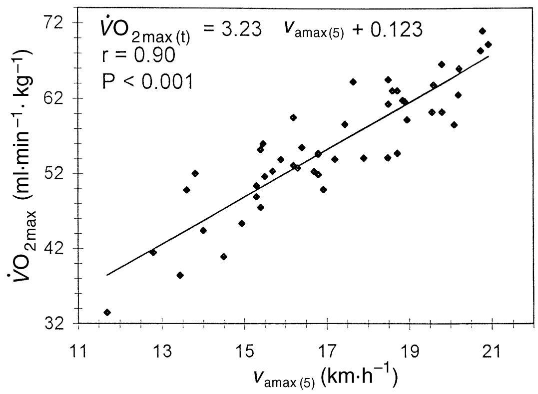

Fig. 2 Relationships between maximal oxygen uptake ($\dot{V}O_{2max}$) measured on treadmill $\dot{V}O_{2max(t)}$, and $V_{amax(5)}$. For other definitions see Fig. 1

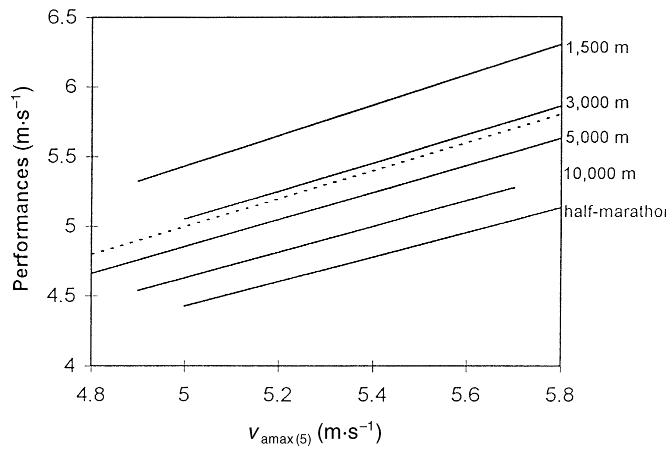

Fig. 3 Relationships between the average velocity maintained during the best performances of the season over 1,500 m ($n = 12$), 3,000 m ($n = 9$), 5,000 m ($n = 9$), 10,000 m ($n = 12$), half-marathon ($n = 13$) and $v_{amax(5)}$, maximal aerobic velocity determined during the 5-min field test. *Dotted line,* line of identity. For other definitions see Fig. 1

Table 2 Relationships between $v_{amax(5)}$ and $v_{amax(c)}$, and the velocity achieved during the best track performances ($v_{track\ performance}$) over various distances. $v_{amax(5)}$ (in metres per second) Maximal aerobic velocity determined during the 5-min field test, $v_{amax(c)}$ (in metres per second) maximal aerobic velocity determined during the last stage of the Université de Montréal Track Test with Brue protocol, v (in metres per second) velocity corresponding to the best $v_{track\ performances}$ in competitions over 800m, 1,500m, 3,000m, 5,000m, 10,000m and half-marathon

Distances	Relationships $v_{amax(5)}$ $v_{track\ performance}$	Relationships $v_{amax(c)}$ $v_{track\ performance}$
800 m	NS	$v_{800} = +1.02 + 0.98\ v_{amax(c)}$
$n = 8$		r = 0.64; $P < 0.01$
1,500 m	$v_{1,500} = -0.92 + 1.26\ v_{amax(5)}$	$v_{1,500} = -0.32 + 1.08\ v_{amax(c)}$
$n = 12$	$r = 0.97$; $P < 0.0001$	$r = 0.93$; $P < 0.01$
3,000 m	$v_{3,000} = +0.21 + 0.97\ v_{amax(5)}$	$v_{3,000} = +0.63 + 0.85\ v_{amax(c)}$
$n = 9$	$r = 0.97$; $P < 0.0001$	$r = 0.94$; $P < 0.01$
5,000 m	$v_{5,000} = +0.10 + 0.96\ v_{amax(5)}$	$v_{5,000} = -1.27 + 1.13\ v_{amax(c)}$
$n = 9$	$r = 0.95$; $P < 0.0001$	$r = 0.81$; $P < 0.001$
10,000 m	$v_{10,000} = -0.74 + 1.07\ v_{amax(5)}$	$v_{10,000} = +0.33 + 0.82\ v_{amax(c)}$
$n = 12$	$r = 0.95$; $P < 0.0001$	$r = 0.78$; $P < 0.05$
half-marathon	$v_{half\text{-}marathon} = -1.73 + 1.20\ v_{amax(5)}$	$v_{half\text{-}marathon} = -0.23 + 0.87\ v_{amax(c)}$
$n = 13$	$r = 0.96$; $P < 0.0001$	$r = 0.80$; $P < 0.05$

Discussion

If $v_{amax(t)}$ is considered as the reference for analysing the runner's performance (Lacour et al. 1991), the 5-min field test provides a good assessment of v_{amax}. Although the mean $v_{amax(5)}$ value was significantly higher than $v_{amax(t)}$ (+ 0.30 $km \cdot h^{-1}$, + 1.8%), this differences was smaller than that observed between $v_{amax(c)}$ and $v_{amax(t)}$ (+ 1.4 $km \cdot h^{-1}$, + 8.3%). Moreover, a strong relationship existed between $v_{amax(t)}$ and $v_{amax(5)}$ (Fig. 1a).

These results could have been due to the specific procedure of the 5-min test. Firstly, the duration of 5 min would seem quite satisfactory for evaluating v_{amax}. Since velocity is closely linked to duration, v_{amax} varies according to the protocol used. The minimal duration depends on the time necessary to elicit the maximal aerobic component with a reduced anaerobic participation. But the total duration of the test which itself generates fatigue, must not exceed a certain limit. When velocity calculated from performance ranging from 100 m to the marathon (42,195 m) is related to the logarithm of the time, the intersection of "anaerobic and aerobic lines" has been found to result in a duration of 4.97 min (Chamoux et al. 1996). This mathematical approach is close to the experimental results of Montmayeur and Villaret (1990) who have determined a 4.95-min duration as the optimal time for v_{amax} measurement corresponding to 100% $\dot{V}O_{2max}$ behind a cyclist. This time corresponded to the performance over 1,500–2,000 m. Secondly, running was performed at a constant pace and the duration was the same for all subjects.

When the speed increment is fixed from the first step until exhaustion as has been proposed by Léger and Boucher (1980) and modified by Brue et al. (1986), a well-trained subject can run more than 25 min while a less fit one runs less than 10 min. Consequently, duration and intensity of the warm-up which corresponds to the first stages of the UMTT vary with physical fitness. The less trained a subject, the shorter and more intense the warming-up. Moreover the step duration of 30 s proposed by Brue et al. (1986) is too short: some athletes have been found to exceed the speed corresponding to their $\dot{V}O_{2max}$ during the completion of the last stage (Montmayeur and Villaret 1990). This could explain the higher v_{amax} reached during the UMTT compared with the treadmill protocol. However, the lack of significance between $[La^{-}]_b$ after the treadmill running, the 5-min-test and the UMTT did not support this assumption. The same observation has also been reported by Lacour et al. (1991) between the laboratory test and UMTT. It has also been suggested that when the athletes run grouped closely together following the cyclist while performing the UMTT, their motivation is enhanced and air resistance is reduced and this leads to an overestimate of v_{amax}. In contrast, running at a constant pace without the stimulation of a cyclist simulates *normal* race strategy more accurately. Finally, the procedure of the 5-min test was easier to achieve than the UMTT because it did not need an experienced cyclist to regulate speed accurately. In contrast, the 5-min test could disadvantage less fit subjects who do not know how to choose the maximal velocity that they can maintain as regularly as possible throughout the test.

The correlation coefficients between track performances and $v_{amax(5)}$ were better than those obtained with $v_{amax(c)}$ (Table 2). The best relationships were found with 1,500 m ($v_{amax(c)}$) and 3,000 m ($v_{amax(5)}$) and confirm previous results obtained by Lacour and Candau (1990) and Lacour et al. (1991) using UMTT. A high fraction of v_{amax}, close to 100%, is involved when performing over longer distances. It would be surprising if the 5-min field test provided the most accurate assessment for velocity sustained over 3,000 m. The fastest runner needed 8.14 min to cover this distance whereas 5 min is closer to the 1,500-m performance which varied from 3.80 to 4.79 min in this study. This unexpected result could be explained by two factors. Firstly, the runners were probably more motivated during competition than during the field test evaluation. Consequently, they could exceed v_{amax} in these particular running conditions. Secondly, the 5-min field test was performed during the period corresponding to the resumption of training. Thus, the physical fitness level was probably lower than that during the competition period. Nevertheless, in spite of high correlation coefficients between $v_{amax(5)}$ and track performance, the 5-min field test was not precise enough to differentiate among runners over a small range of performances.

The 5-min test provides also an indirect estimation of $\dot{V}O_{2max}$ from v_{amax} using the equation proposed by Léger and Mercier (1983). The $\dot{V}O_{2max(5)}$ were well correlated with $\dot{V}O_{2max(t)}$. The same result has been found by Bricki and Dekkar (1989) between 5-min test performance and $\dot{V}O_{2max}$ measured by a direct method on a cycle ergometer. But $\dot{V}O_{2max(5)}$ was also significantly higher than $\dot{V}O_{2max(t)}$, and as for $\dot{V}_{amax(5)}$, this difference was smaller than that found between $\dot{V}O_{2max(c)}$ and $\dot{V}O_{2max(t)}$ (Table 1). It is unlikely that these results could be due to an underestimation of $\dot{V}O_{2max}$ on the treadmill. The $[La^{-}]_b$ and HR_{max} were no different from the levels reached at the end of the 5-min test and UMTT. The better $\dot{V}O_{2max}$ estimation by the 5-min test than UMTT was partly due to a more accurate v_{amax} assessment which is taken into account in the $\dot{V}O_{2max}$ calculation. Moreover, this is all the more interesting since the runners studied exhibited a wide range of physical fitness (33.5–71.0 $ml \cdot min^{-1} \cdot kg^{-1}$) and running energy cost (166–221 ml $O_2 \cdot kg^{-1} \cdot km^{-1}$, ie. 33% difference). When we used the equations proposed by Bricki and Dekkar (1989) established on 38 athletes [$\dot{V}O_{2max}$ ($ml \cdot min^{-1} \cdot kg^{-1}$) = 2.27 v ($km \cdot h^{-1}$) + 13.3 for a velocity lower than 20 $km \cdot h^{-1}$ and $\dot{V}O_{2max}$ ($ml \cdot min^{-1} \cdot kg^{-1}$) = 8.67 v ($km \cdot h^{-1}$) – 113 for a velocity higher than 20 $km \cdot h^{-1}$], we found an underestimation of $\dot{V}O_{2max(5)}$ compared with $\dot{V}O_{2max(t)}$ (– 2.8 $ml \cdot min^{-1} \cdot kg^{-1}$). From our own values of $\dot{V}_{amax(5)}$ and $\dot{V}O_{2max(t)}$, we established a predictive equation for $\dot{V}O_{2max}$ from $\dot{V}_{amax(5)}$: $\dot{V}O_{2max}$ ($ml \cdot min^{-1} \cdot kg^{-1}$) = 3.23 $v_{amax(5)}$ + 0.123. This could be simplified as $\dot{V}O_{2max}$ = 3.23 $v_{amax(5)}$. Since the velocity is equivalent to 12 d (d representing the distance in kilometer covered during the 5-min test), the equation becomes: $\dot{V}O_{2max}$ ($ml \cdot min^{-1} \cdot kg^{-1}$) = 39 d (km). For our group of runners, the error was lower than 5% when $\dot{V}O_{2max(t)}$ was taken as the reference.

In conclusion, the 5-min test provided valuable information on v_{amax} which was close to and highly correlated with treadmill results and track performances especially over 3,000 m. This test could also be used for $\dot{V}O_{2max}$ evaluation. Nevertheless, the simple equation that we proposed to calculate $\dot{V}O_{2max}$ from the distance covered during 5-min running needs to be validated on a greater number of subjects of both sexes, from sedentary to experienced runners with a wide range of performances.

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