CALIFICACIONES DEL EJERCICIO PARA LA CONSTITUCIÓN, A TRAVËS DE PRUEBAS SELECTIVAS, DE DOS RELACIONES DE ASPIRANTES AL DESEMPEÑO DE PUESTOS DE TRABAJO DE TËCNICO SUPERIOR DE DEPORTE, UNA PARA LA FORMACIÓN, EN SITUACIÓN DE SRVICIOS ESPECIALES, Y OTRA PARA LA CONTRATACIÓN TEMPORAL (RESOLUCION 121/2011, DE 24 DE ENERO, DEL DIRECTOR GENERAL DE LA FUNCIÓN PÚBLICA)

RESULTADOS DE LA PRIMERA PRUEBA: COMENTARIO SOBRE UN ARTÍCULO (HASTA UN MÄXIMO DE 50 PUNTOS):

1) Criterios de calificación:
   - Resumen del artículo (hasta 20 puntos)
   - Comentario crítico (hasta 20 puntos)
   - Posibles líneas futuras de investigación (hasta 10 puntos)
2) Calificación:
   - Examen número 1: **0** puntos
   - Examen número 2: **10** puntos
   - Examen número 3: **10** puntos
   - Examen número 4: **10** puntos
   - Examen número 5: **20** puntos
   - Examen número 6: **10** puntos
   - Examen número 7: **12** puntos
   - Examen número 8: **10** puntos
   - Examen número 9: **17** puntos
   - Examen número10: **18** puntos
   - Examen número 11: **10** puntos
   - Examen número 12: **15** puntos
   - Examen número 13: **10** puntos
   - Examen número 14: **20** puntos
   - Examen número 15: **14** puntos
   - Examen número 16: **10** puntos
   - Examen número 17: **17** puntos
   - Examen número 18: **40** puntos

RESULTADOS DE LA SEGUNDA PRUEBA: 5 PREGUNTAS RELATIVAS A LOS TEMAS (HASTA UN MÄXIMO DE 50 PUNTOS):

3) Criterios de clasificación:
   - Pregunta número 1:
     i. Lenguaje científico: 1 p
     ii. Distinción ácido láctico-lactato: 1 p
     iii. Citar H+: 1p
     iv. Valores aproximados de lactato (sangre y músculo): 1p

v. Cinética de los valores de recuperación: 1p
vi. Órganos que utilizan lactato: 2p
vii. Diferencia resistencia-fuerza: 2p

- Pregunta número 2:
  i. ¿Dónde se forma durante el ejercicio?: 1p
  ii. Ciclo de las purinas, xantina, hipoxantina: 2p
  iii. Evolución muscular: 8p
- Pregunta número 3:
  i. Definir OBLA: 1p
  ii. Definir MLSS: 1p
  iii. Definir IAT: 1p
  iv. Definir VT: 1p
  v. Definir Tegtbur: 1p
  vi. Análisis crítico: 5 p
- Pregunta número 4:
  i. Evolución gráfica de curva de desplazamiento: 1p
  ii. Evolución gráfica de curva de velocidad: 1p
  iii. Evolución gráfica de curva de aceleración: 1p
  iv. Aplicación a ejemplo de movimiento deportivo en protocolo de test de fuerza máxima y descripción correcta: 7p
- Pregunta número 5:
  i. Aportaciones realizadas: 8p
  ii. Análisis crítico: 2p

4) Calificación:
- Examen número 19: **1** punto
- Examen número 20: **2** puntos
- Examen número 21: **0** puntos
- Examen número 22: **0.5** puntos
- Examen número 23: **7.75** puntos
- Examen número 24: **0.5** puntos
- Examen número 25: **0** puntos
- Examen número 26: **0.1** puntos
- Examen número 27: **2** puntos
- Examen número28: **2** puntos
- Examen número 29: **9.95** puntos
- Examen número 30: **8.5** puntos
- Examen número 31: **0** puntos
- Examen número 32: **2.5** puntos
- Examen número 33: **0.7** puntos
- Examen número 34: **1** punto
- Examen número 35: **37** puntos
- Examen número 36: **3.2** puntos

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11

The Modified D_{max} Method is Reliable to Predict the Second Ventilatory Threshold in Elite Cross-Country Skiers

Nicolas Fabre,[1] Filippo Balestreri,[1] Barbara Pellegrini,[1] and Federico Schena[1,2]

[1]*CeBiSM, Center of Bioengineering and Motor Science, Rovereto (TN), Italy; and*
[2]*Faculty of Exercise and Sport Science, University of Verona, Italy*

Abstract

Fabre, N, Balestreri, F, Pellegrini, B, and Schena, F. The modified D_{max} method is reliable to predict the second ventilatory threshold in elite cross-country skiers. *J Strength Cond Res* 24(6): 1546–1552, 2010—This study was designed to evaluate, in elite cross-country skiers, the capacity of the D_{MAX} lactate threshold method and its modified version ($D_{MAX\ MOD}$) to accurately predict the second ventilatory threshold (VT2). Twenty-three elite cross-country skiers carried out an incremental roller-ski test on a motorized treadmill. Ventilation, heart rate (HR), and gas exchanges were continuously recorded during the test. Blood was sampled at the end of each 3-minute work stage for lactate concentration measurements. The VT2 was individually determined by visual analysis. The D_{MAX}, $D_{MAX\ MOD}$ points also with the 4 mmol·L^{-1} fixed lactate concentration value (4 mM) were determined by a computerized program. Paired *t* tests showed nonsignificant differences between HR at VT2 and HR at $D_{MAX\ MOD}$, between HR at VT2 and HR at 4 mM, and between HR at $D_{MAX\ MOD}$ and HR at 4 mM. HR at D_{MAX} was significantly lower than HR at VT2, $D_{MAX\ MOD}$, and at 4 mM ($p < 0.001$). HR at VT2 was strongly correlated with HR at 4 mM ($r = 0.93$, $p < 0.001$), HR at D_{MAX} ($r = 0.97$, $p < 0.001$) and especially with HR at $D_{MAX\ MOD}$ ($r = 0.99$, $p < 0.001$). Bland-Altman plots showed that HR at D_{MAX} underestimated HR at VT2 and permitted to observe that the D_{MAX} method and particularly the $D_{MAX\ MOD}$ method had smaller limits of agreement as compared with the 4 mM method. Our results showed that the $D_{MAX\ MOD}$ lactate threshold measurement is extremely accurate to predict VT2 in elite cross-country skiers.

Key Words anaerobic threshold, lactate, respiratory compensation threshold, roller-ski

Address correspondence to Nicolas Fabre, CeBiSM, fabre.nicolas@aliceadsl.fr.

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Introduction

The capacity of an athlete to utilize an important part of his maximum oxygen uptake is a key issue for performance in long duration sports. This capacity, also called endurance, can be evaluated during laboratory or field incremental tests, determining the anaerobic threshold of an athlete. Thus, the work intensity corresponding to this threshold seems like one of the most important parameter to determine during a testing session. Then, knowing precisely this intensity, in terms of speed (ie, for runners), power (ie, for cyclists), and/or heart rate (HR) (ie, especially when speed and power are unusable like during cross-country ski activity because of snow conditions and field profile changes), athletes can perform some specific training sessions at this intensity to improve their endurance capacity and, therefore, their race performances.

The anaerobic threshold is principally determined examining, during an incremental test to exhaustion, the evolution of ventilatory parameters and/or blood lactate concentration. The ventilatory method, a noninvasive procedure, is used to determine the second ventilatory threshold (VT2, or ventilatory compensation point). Typically, the breakpoints of ventilatory equivalent of carbon dioxide ($\dot{V}_E/\dot{V}CO_2$), ventilatory equivalent of oxygen ($\dot{V}_E/\dot{V}O_2$), tidal partial pressure of carbon dioxide ($PetCO_2$) and minute ventilation ($\dot{V}_E$) changes over time are determined by visual analysis (15,22,23). This method could be criticized for its lack of objectivity (4) because generally based on visual analysis. However, several reviewers with serious experience in this kind of evaluation can easily solve this issue, making VT2 as a standardized, validated, reliable, and individualized method for the determination of the anaerobic threshold. Moreover, VT2 seems as an useful training indicator and as a key factor of performance in endurance sports (1,7,13–15,17,22).

The estimation of the anaerobic threshold through the measurement of blood lactate concentration is more discussed and an important number of more or less valid methods has already been reported in the literature. Today, many trainers still use the training intensity corresponding to the fixed 4 mmol·L^{-1} lactate concentration value (12,21) to monitor the training of their athletes, whereas this method received many criticisms. Indeed, it does not take into consideration the individual variation of the lactatemia, and lactate concentrations are dependent on external factors such as test protocol or alimentation (9,20). The observation of 2 breakpoints in the lactate concentrations changes over the time during an incremental test (12,18) could resolve the problem of the individualization of the determination. However, this method required a sufficient number of points and for some authors, the blood lactate concentration increase as a continuous function in progressive exercise making impossible the observation of breakpoints (11). Finally, the D_{MAX} method (5) has been proposed in cyclists (2) and later in runners (19). This method involves calculating the point that yields the maximal perpendicular distance to the straight line formed by the 2 end data points of the lactate vs time or workload curve. This method seemed like more sensitive and most strongly related to the performance when compared with the previous cited methods. Indeed, it seemed that the speed at the D_{MAX} point was not significantly different from mean 10 km velocity and was more strongly correlated to 10 km velocity than the speed at the 4 mmol·L^{-1} lactate concentration point (19). During cycling (2), the power at D_{MAX} point was highly correlated to 1-hour cycling performance and provided the best estimate 1-hour race pace in trained female.

Aforementioned, the D_{MAX} method and its modified version ($D_{MAX\ MOD}$) (2,8) have only been validated in activities like running (19) and cycling (2,5), but to our knowledge, no data are available for cross-country skiing activity. We hypothesized that one of these lactate threshold measurements (ie, D_{MAX} and/or $D_{MAX\ MOD}$) could be valid and reliable for cross-country skiers. If this is confirmed, cross-country skiers, coaches, and/or practitioners could have an individualized and objective method for the determination of the anaerobic threshold, which could be easily and confidently used in complement (in the case of doubts with the visual analysis of VT2) or instead of the ventilatory method.

Thus, the present study was mainly designed to compare, in elite cross-country skiers, the capacity of the D_{MAX} and $D_{MAX\ MOD}$ methods to accurately predict VT2. Moreover, because the fixed 4 mmol·L^{-1} lactate concentration point still remains the most commonly indicator used by trainers for monitoring training, we also compared results obtained with VT2, D_{MAX}, and $D_{MAX\ MOD}$ methods with those corresponding to the 4 mmol·L^{-1} lactate threshold.

Methods

Experimental Approach to the Problem

This study was carried out to compare the capacity of 2 individualized descriptors of the lactate threshold (D_{MAX} and $D_{MAX\ MOD}$ points) to accurately predict the VT2 which can be considered as a good predictor of the competitive intensity in elite cross-country skiers, but which requires a consistent experience for its determination. To do this, the the D_{MAX} and $D_{MAX\ MOD}$ points plus the fixed 4 mmol·L^{-1} lactate concentration point, determined through a customised written program, were compared with the VT2 point determined by visual analysis, by examining 1-way analysis of variance (ANOVA) for repeated measurements results and, their relationships were evaluated using the Pearson correlation. Finally, Bland-Altman plots (3) were used to assess the agreement between the measurements.

Subjects

Twenty-three elite cross-country skiers (12 males and 11 females) from the national Italian ski team involved during winter in European and/or World Cup cross-country ski races, were evaluated. Their mean ± *SD* age was 22 ± 4 years, height was 173 ± 8 cm, body mass was 65.1 ± 10.1 kg, and $\dot{V}O_{2peak}$ was 66.7 ± 5.1 ml·min·kg^{-1}. They were asked to refrain from ingesting caffeine or alcohol for at least 12 hours before testing, to eat a light meal 3 hours before testing and to not plan an exhaustive training session for at least 48 hours before testing. The study protocol complied with the declaration of Helsinki for human experimentation and was approved by the University ethical committee for human research. Possible risks and benefits were explained, and written informed consent was obtained from each subject before participation.

Procedures

The skiers carried out an incremental cross-country roller-ski test with the diagonal stride technique. This test was performed during roller skiing on a large motor-driven treadmill (belt dimensions of 2.5 m × 3.5 m, Rodby, Sodertalje, Sweden) with a constant speed of 9 km·h^{-1} for females and 10 km·h^{-1} for males. The start slope was fixed at 2° and increased by 1° every 3-minute work period until exhaustion. This study took place during October when skiers had already reached a high volume of training especially in cross-country roller-skiing. During the test, subjects used the same pair of roller-skis (Ski Skett Nord CL, Sandrigo, Italy) and their own poles for the classical technique.

At the beginning of the test, the skier was secured by a safety harness, which was connected to an emergency brake suspended from a metal bracket above the treadmill. Each skier was fully familiarized with roller skiing on treadmill.

Physiological Measurements

Ventilatory Measurement. Values of minute ventilation ($\dot{V}_E$), tidal partial pressure of carbon dioxide ($PetCO_2$), carbon dioxide output ($\dot{V}CO_2$) and oxygen uptake ($\dot{V}O_2$) were continuously measured by a portable breath-by-breath gas exchange measurement system (Cosmed K4b^2, Rome, Italy). Gas analyzers were calibrated before each test with ambient air (O_2: 20.93 % and CO_2: 0.03 %) and a gas mixture of known composition (O_2: 16.00 % and CO_2: 5.00 %). An O_2 analyzer with a polarographic electrode and a CO_2 analyzer with an infrared electrode sampled expired gases at the mouth. The Cosmed K4b^2 system is lightweight (800 g) with the main sample unit attached to the chest and the battery pack on the

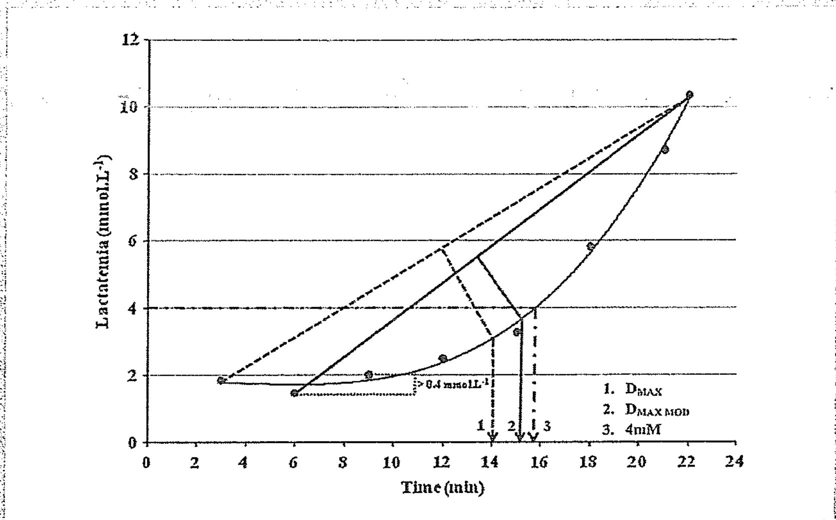

Figure 1. The 3 methods used to determine lactate threshold: 4 mM, the 4 mmol·L^{-1} fixed blood lactate concentration (10); D_{MAX}, individualized lactate threshold measurement identified as the point on the third order polynomial curve that yielded the maximal perpendicular distance to the straight line formed by the 2 end data points; $D_{MAX\ MOD}$, a modified D_{MAX} method, identified as the point on the third order polynomial curve that yielded the maximal perpendicular distance to the straight line formed by the first point preceding an increase of lactate concentration greater than 0.4 mmol·L^{-1} and the final lactate point. Schematic figure based on data from a subject of the study.

back. The facemask, that had a low dead space (70 mL), was equipped with a low resistance, bidirectional digital turbine (28 mm diameter). This turbine was calibrated before each test with a 3-L syringe (Cosmed, Rome, Italy). Facemasks allowed subjects to simultaneously breathe with mouth and nose, for more comfort. Heart rate was continuously measured via a wireless Polar-monitoring system (Polar Electro Oy, Kempele, Finland) and synchronized with the Cosmed system.

Lactate Measurement. Finger-tip capillary blood (20 μL) was sampled in the last 20 s of each 3-min work stage following a puncture made using a lancet (Heinz-Herenz, Germany), without stopping the treadmill and immediately at the end of the incremental test. During the sample, the skier placed his/her left hand on the lateral hand-bar of the treadmill continuing to ski with only 1 pole (ie, the right one). The blood sample was then immediately mixed with a lysing stabilizing agent in a safe-lock vial. Blood lactate concentration was determined using a Biosen C-Line Sport Analyser (EKF Diagnostics, Magdeburg, Germany). Before blood analysis, the analyzer was calibrated with standard 12 mmol·L^{-1} solution.

Table 1. Relevant physiological results observed (mean ± *SD* [min–max], $n = 23$).

Parameter	HR (bpm)	Lactatemia (mmol·L^{-1})
VT2	180 ± 8.0*	4.16 ± 0.8 [2.40–5.53]*
$D_{MAX\ MOD}$	180 ± 8.0*	3.94 ± 0.6 [2.94–4.91]*
4 mM	180 ± 8.2*	4.00 ± 0.0 [4.00–4.00]*
D_{MAX}	176 ± 7.6	3.03 ± 0.5 [1.65–4.14]

*Significantly different from the D_{MAX} method ($p < 0.001$).
HR = heart rate; VT2 = ventilatory threshold.

Data Analysis

Ventilatory Threshold Determination. Two blinded and experienced investigators determined individually the second VT2 (or ventilatory compensation point) by visual analysis of the breakpoints of ventilatory equivalent of carbon dioxide ($\dot{V}_E/\dot{V}CO_2$), ventilatory equivalent of oxygen ($\dot{V}E/\dot{V}O_2$), tidal partial pressure of carbon dioxide ($PetCO_2$) and minute ventilation ($\dot{V}_E$) changes over time, with an increase in both $\dot{V}_E/\dot{V}CO_2$ and $\dot{V}E/\dot{V}O_2$ and a decrease in $PetCO_2$ (15,22,23). If a difference was observed between the results of the 2 investigators, a third 1 was asked to do the analysis.

Lactate Thresholds Determination. Three different descriptors (Figure 1) were determined thanks to a customised written program (LabView 7.1, National Instruments, Austin, TX, USA): (1) 4 mM, corresponding to the 4 mmol·L^{-1} fixed blood lactate concentration (10,2) D_{MAX}, identified as the point on the third order polynomial curve that yielded the maximal perpendicular distance to the straight line formed by the 2 end data points, and (3) $D_{MAX\ MOD}$, a modified D_{MAX} method, identified as the point on the third order polynomial curve that yielded the maximal perpendicular distance to the straight line formed by the point preceding an increase of lactate concentration greater than 0.4 mmol·L^{-1} and the final lactate point (2).

Statistical Analysis

Values presented are expressed as mean ± *SD*. They were checked for normal distribution using the Kolmogoroff-Smirnov test. A 1-way ANOVA for repeated measurements was chosen to test for differences between methods. If data distribution fails the normality and/or with unequal variance, a RM ANOVA on ranks was systematically performed. When overall difference was found, the Tukey post hoc test was used for specific comparisons. The Pearson product-moment zero-order correlation coefficient demonstrated any significant relationship between the VT2 and the various lactate thresholds. Finally, Bland-Altman plots (3) were used to assess the agreement between the measurement of HR at VT2 and HR at D_{MAX}, $D_{MAX\ MOD}$, and 4 mM. Difference between the values measured from 2 methods on *y* axis was plotted against their averages on *x* axis. Limits of agreement involved the mean difference between 2 methods ± 2 *SD*. Statistical significance was accepted at $p \leq 0.05$. Data were analyzed with the software package SigmaStat version 3.5 (SPSS Inc., Chicago, IL, USA)

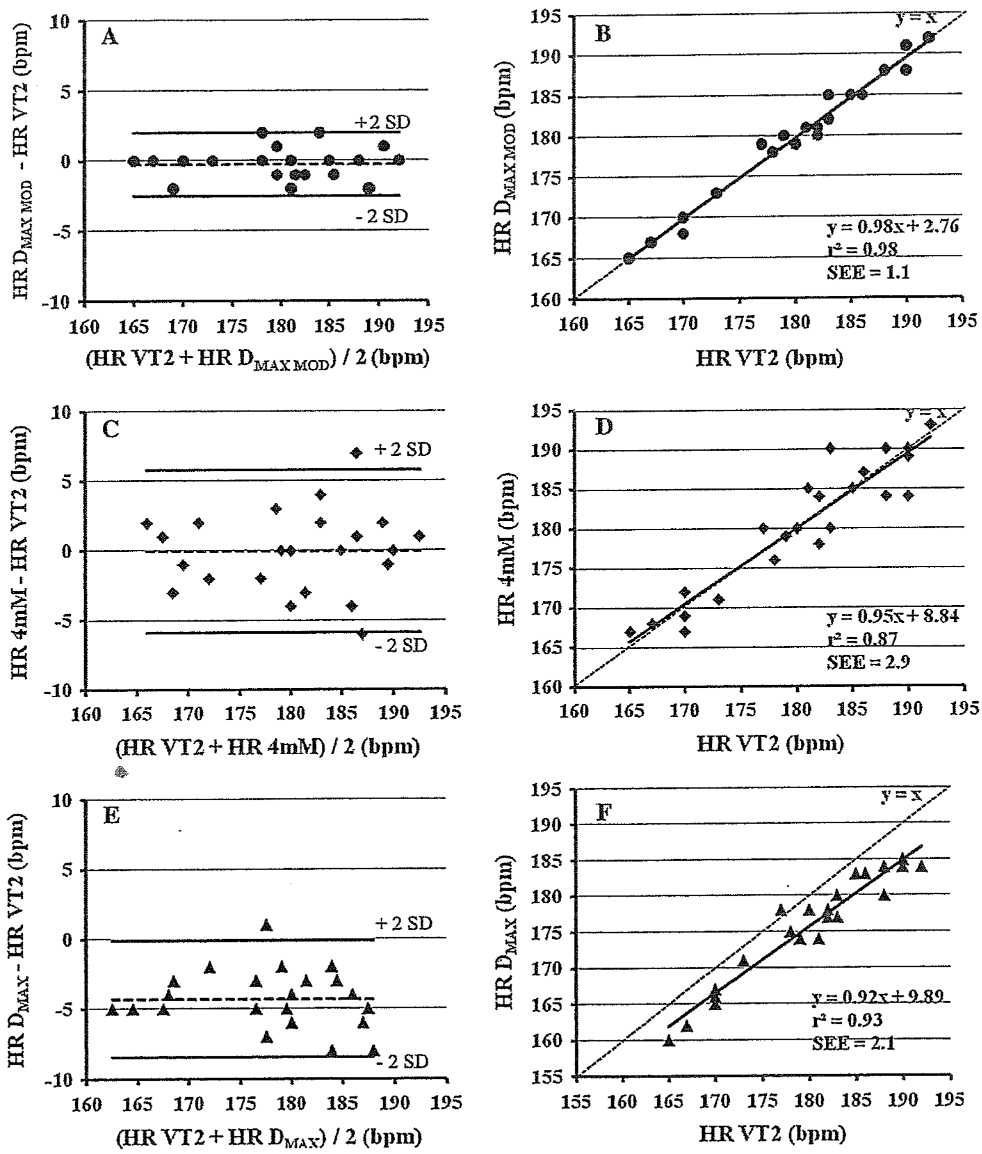

Figure 2. Heart rate measured at the second VT2 compared with heart rate measured at $D_{MAX\ MOD}$ (A and B), 4 mM (C and D) and D_{MAX} (E and F). Plots B, D, and F represent the regression analyses with the line of identity (dotted diagonal) and the regression line (thick line). Plots A, C, and E represent Bland-Altman (3) plots with the dashed line showing mean difference (systematic bias) between methods and the 2 extreme lines showing the limits of agreement (2 *SD* around the mean). Note that the between-method limits of agreement were narrower for the $D_{MAX\ MOD}$ method (panel A). *SEE* = standard error of the estimate; VT2 = ventilatory threshold.

Results

Mean data for the relevant physiological data observed are presented in Table 1.

VT2 was detected in 100% of the subjects. Both independent researchers were in agreement for VT2 detection in 21 (91%) of the tests. In those 2 cases where the opinion of a third observer was assessed for VT2 detection, there always existed agreement with 1 of the 2 other researchers. VT2 was then detected based on this agreement.

Comparisons Between Measurements

The 1-way RM ANOVA showed significant difference for HR between the measurements ($p < 0.001$). The Tukey multiple comparison procedure revealed that HR at D_{MAX} (176.1 ± 7.6 bpm) was significantly lower than HR at VT2, at $D_{MAX\ MOD}$ and at 4 mM ($p < 0.001$). Nonsignificant differences were found between HR at VT2 (180.4 ± 8.0 bpm) and HR at $D_{MAX\ MOD}$ (180.1 ± 8.0 bpm, $p = 0.953$), between HR at VT2 and HR at 4 mM (180.3 ± 8.2 bpm, $p = 1.000$) and between HR at $D_{MAX\ MOD}$ and HR at 4 mM ($p = 0.972$).

In the same way, a statistical significant difference was found for blood lactate concentration between the measurements ($p < 0.001$). The post hoc tests revealed that the blood lactate concentration corresponding at D_{MAX} (3.03 ± 0.5 $mmol{\cdot}L^{-1}$) was lower than the lactatemia observed with the three other methods ($p < 0.001$). The blood lactate concentration corresponding at VT2 (4.16 ± 0.8 $mmol{\cdot}L^{-1}$) was not significantly different with $D_{MAX\ MOD}$ (3.94 ± 0.6 $mmol{\cdot}L^{-1}$, $p = 0.250$) and with 4mM (4.00 ± 0.0 $mmol{\cdot}L^{-1}$, $p = 0.539$).

Relationships and Agreement Between Measurements

As shown in Figure 2, HR at VT2 was strongly correlated with HR at 4mM ($r = 0.93, p < 0.001$), HR at D_{MAX} ($r = 0.97, p < 0.001$) and especially with HR at $D_{MAX\ MOD}$ ($r = 0.99, p < 0.001$). However, despite the strong correlation between HR at VT2 and HR at D_{MAX}, Figure 2F also revealed that data do not fit with the line of identity. Bland-Altman plot (Figure 2E), showed that HR measured with D_{MAX} method underestimated HR measured with the VT2 method. Finally and more interestingly, the Bland-Altman plots permitted to observe that the D_{MAX} method and particularly the $D_{MAX\ MOD}$ method had consistently and appreciably smaller limits of agreement (2 *SD* −0.2 to −8.5 bpm and −2.5 to 2.0 bpm, respectively) as compared with the 4 mM method (2 *SD* −5.9 to 5.8 bpm), underlining an important variability in the HR measurement with the 4 mM method when this method is compared with the VT2 method.

Discussion

The aim of this study was to compare the capacity of mainly designed to compare the capacity of the D_{MAX} method and its modified version ($D_{MAX\ MOD}$) to accurately predict the second VT2 in elite cross-country skiers. This threshold, also named ventilatory compensation threshold, can be identified as the second breakpoint in the ventilation response mainly explained by an acidosis (pH decrease) as bicarbonate is overwhelmed by the growing production of lactate (22). After the publication of Wasserman and McIlroy (23), the use of ventilation and gas exchange techniques to determine the onset of metabolic acidosis has become widespread in the literature and has an obvious attraction in cardiorespiratory evaluations as noninvasive and useful index of exercise performance (15,16,22). Thus, we choose the second VT2 as a reference to evaluate the suitability of different lactate threshold measurements, especially the D_{MAX} and $D_{MAX\ MOD}$ methods. One could say that detection of VT2 is too much subjective to be valid (4), however, more than 1 reviewer with serious experience in this kind of evaluation (many years of practice in athletes testing) help to solve this issue.

Otherwise, in most of the protocols that were carried out regarding the determination of the anaerobic threshold and its utility for training, intensity was often set according to the speed or the power corresponding to the anaerobic threshold. But, giving the particularity of the cross-country skiing activity during which skiers are unable to determine their training intensity using speed (as, for example, a runner on a track might) because of variations of snow conditions and field profile, HR and/or exercise perception are the only parameters available for setting training intensity at or near anaerobic threshold. In this way, we choose to compare methods according to the HR value corresponding to the different points measured.

The main finding of this study was that among the 3 lactate threshold measurements tested, the $D_{MAX\ MOD}$ method seemed like the more reliable to predict the VT2 in elite cross-country skiers. However and whatever the method used, HR was highly correlated (with still the higher r-value for $D_{MAX\ MOD}$ method) with HR at VT2. But, the Bland-Altman analysis revealed that, (1) the D_{MAX} method underestimated the HR at VT2 (mean HR difference of about 4 bpm) but had narrow limits of agreement and that, (2) despite the same HR mean value, the 4 mM method provided consistently and appreciably larger limits of agreement compared with the $D_{MAX\ MOD}$ and D_{MAX} methods. This last point implies that using the HR corresponding to the 4 mM point to individually monitor athletes training, trainers run the risk of making important errors, even though no significant differences in mean HR values compared with VT2 and a strong relationship with HR at VT2 are present. Indeed, fixed levels of blood lactate concentrations can vary widely inter and intrasubject (Table 1, the high range of lactate values obtained with the individualized threshold measurements). These variations in lactate levels may be induced by factors including nutrition, prior stress, and muscle fibre distribution (6). Consequently and as shown in the present study, it is more effective for training monitoring and/or for performance predicting, to use a method derived from lactate kinetics than from absolute values.

Our results underlining a better precision of an individualized vs fixed lactate concentration method to predict anaerobic threshold are consistent with the studies that previously tested these methods (2,8,19). However and unlike the present study, Bishop et al. (2) observed a stronger relationship to the performance with D_{MAX} than with $D_{MAX\ MOD}$. This discrepancy could be explained by the fact that the performance test carried out in the study of Bishop et al (2) was a 1-hour time trial which corresponds to a lower exercise intensity than the intensity at VT2 (intensity usually maintained no longer than 50 minutes (7)). The intensity at D_{MAX} point effectively is always lower than the intensity at $D_{MAX\ MOD}$ point. In the same way, Nicholson and Sleivert (19) showed no significant difference between the running speed at the D_{MAX} point and the speed on a 10-km running time trial. The training level of the subjects tested may be an explicative reason for this difference with our result. In fact, Nicholson and Sleivert (19) have tested subjects "actively engaged in running" with a middle-ranking regional running level (ie, mean 10-km velocity of 3.77 $m \cdot s^{-1}$ equivalent to a total time of 44 minutes to cover the distance), whereas we tested elite skiers regularly engaged in international competitions, thus, physiologically and psychologically more suited to enduring high exercise intensities.

In summary, this study has shown that the $D_{MAX\ MOD}$ lactate threshold measurement is extremely accurate to predict the second VT2 in elite cross-country skiers. Thus, this method can be easily and confidently used by practitioners in complement (in the case of doubts with the visual analysis of ventilatory parameters) or instead of the VT2 determination. The D_{MAX} method underestimate the HR at VT2 and so, seems like not valid for monitoring training at or near VT2 intensity but could remain a good marker of aerobic endurance because of its strong relationship with VT2 and the narrow limits of agreements when compared with VT2. Finally, the fixed lactate concentration method (4 mM) should be cautiously applied as proposed by Vallier et al (22), because of its not negligible error risk for a precise individualized monitoring training in elite athletes.

Practical Applications

From a practical point of view, a precise determination of the intensity close to competitive intensity is needed for skiers and/or coaches to optimize training load and increase race performances. Indeed, the determination of this intensity is useful for skiers and/or coaches because it is a key factor of performance in elite endurance athletes (15). This intensity represents the capacity of the athletes to utilize an important part of their maximum oxygen consumption (ie, endurance). To improve their endurance capacity and, therefore, their race performances, skiers have to perform some specific training sessions (usually interval training sessions) precisely at the intensity corresponding to VT2 (14) to obtain significant training-induced adaptations (ie, shift in VT2 toward higher workload). Now, it seems that this intensity can precisely and individually be determined using the $D_{MAX\ MOD}$ method in good to high level skiers, without using expensive gas exchange analyzers. Moreover, the determination of the $D_{MAX\ MOD}$ point is not human related, thus the error-risk to precisely determinate this point is reduced and requires less experience than for the determination of VT2.

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SEGUNDA PRUEBA

Desarrollar por escrito, durante un periodo máximo de dos horas, las siguientes 5 preguntas :

1) Destino del ácido láctico durante los 30 primeros minutos de recuperación después de realizar un ejercicio que provoca el agotamiento en 1 minuto. ¿Existe alguna diferencia si se trata de un ejercicio de fuerza o si se trata de uno de resistencia ?
2) Metabolismo muscular del ácido úrico durante el ejercicio intenso.
3) Análisis crítico de las determinaciones del OBLA (Onset of blood lactate accumulation), MLSS (Maximal lactate steady state), IAT (Individual anaerobic threshold), VT (Ventilatory threshold) y del test de Tegtbur, como indicadores de la resistencia aeróbica,
4) Describa gráficamente y explique la evolución de las principales magnitudes físicas (desplazamiento, tiempo, velocidad y aceleración) durante la realización de un test de fuerza dinámica máxima.
5) Haga un análisis crítico de las aportaciones científicas que usted ha realizado al conocimiento actual de los temas que figuran en el temario de esta segunda prueba.