Estimation of the maximum blood lactate from the results in the Wingate test

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Received: 23.08.2017
Accepted: 08.05.2018

Summary

Muscle energy is provided by three mechanisms acting simultaneously, with differences in their power and capacity: alactacid anaerobic, lactacid anaerobic and aerobic. In efforts leading to exhaustion in less than two minutes, and in the initial and final stages of the efforts of medium and long duration, lactacid anaerobic mechanism has a fundamental role. The determination of lactacid anaerobic capacity is very important to estimate the performance capacity in many sports and physical activities. This paper proposes an indirect method to determine the maximum lactatemia, by the use of average performance in the Wingate test. The results of the Wingate test were transformed into lactate levels by a proposed formula, and were compared to the actual measurement of maximum blood lactate post maximum effort in field trials for different sport modalities. The method was tested in 185 athletes (103 men and 82 women) from different national teams from Venezuela, which practiced 18 sports (males) and 17 sports (females). Direct lactate measurements did not differ from levels calculated from the results of the Wingate test (men: 19.60 ±1.49 in Wingate test *vs.* 18.80±1.70 mmol.l^{-1}, in field measurement; women: 16.10 ± 1.47 *vs.* 14.82 ± 1.64, respectively). Direct correlation between the lactate levels obtained by measurement and by calculation was highly significant (all subjects r= 0.86, p<0.000000). In conclusion, calculation of lactacid anaerobic capacity with a formula that uses the result of Wingate test, may be a non invasive, non expensive, simple and reliable method.

Key words:
Lactacid anaerobic capacity. Wingate test. Physical performance. Exercise.

Estimación de la concentración máxima de lactato en sangre a partir de los resultados en la prueba de Wingate

Resumen

La energía muscular es proporcionada por tres mecanismos que actúan simultáneamente, con diferencias en su potencia y capacidad: anaeróbico alactácido, anaeróbico lactácido y aeróbico. En los esfuerzos que llevan al agotamiento en menos de dos minutos y en las etapas inicial y final de los esfuerzos de mediano y largo plazo, el mecanismo anaeróbico lactácido juega un papel fundamental. La determinación de la capacidad anaeróbica lactácida es muy importante para estimar la capacidad de rendimiento en muchos deportes y actividades físicas. Este artículo propone un método indirecto para determinar la lactatemia máxima, mediante el uso del rendimiento promedio en el test de Wingate. Los resultados de la prueba de Wingate se transformaron en niveles de lactato mediante la fórmula propuesta y se compararon con la medición real del lactato sanguíneo máximo después de un esfuerzo máximo en pruebas de campo para diferentes modalidades deportivas. El método fue probado en 185 atletas (103 hombres y 82 mujeres) de diferentes equipos nacionales de Venezuela, que practicaban 18 deportes (hombres) y 17 deportes (mujeres). Las mediciones directas del lactato no difirieron de los niveles calculados a partir de los resultados de la prueba de Wingate (hombres: 19,60 ± 1,49 en la prueba de Wingate frente a 18,80 ± 1,70 mmol.l^{-1}, en la medición de campo; las mujeres: 16,10 ± 1,47 frente a 14,82 ± 1,64 mmol.l^{-1} respectivamente). La correlación entre los niveles de lactato obtenidos por medición directa y la obtenida por cálculo fue altamente significativa (todos los sujetos r = 0,86, p <0,000000). En conclusión, la determinación de la capacidad anaeróbica lactácida con una fórmula que utiliza el resultado de la prueba de Wingate, puede ser un método no invasivo, económico, simple y confiable.

Palabras clave:
Capacidad anaeróbica lactácida. Prueba de Wingate. Rendimiento físico. Ejercicio.

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Introduction

Anaerobic source of energy, and more specifically the lactacid mechanism, is critical to the performance in efforts leading to exhaustion in less than two minutes, as well as at the start and the end of long duration efforts[1,2].

Lactacid capacity mechanism is closely linked to the ability of lactate production. In this sense it is important to know it, in order to evaluate the anaerobic capacity and its response to training.

Although some methods have been developed for the indirect determination of blood lactate[3-6], as far as we know, there is no evidence for the indirect determination of blood lactate from the Wingate test.

This paper proposes a method to estimate lactate production from average performance in the Wingate test, avoiding the direct determination by the extraction of capillary blood samples.

Material and method

Subjects

Subjects included were 103 men and 82 women, all members of various sport teams of national and international category of Venezuela, who voluntarily agreed to participate in this study. They were asked to sign a written consent; in underage cases this was done by their legal representatives. Biometric characteristics of the groups are presented in Table 1. Male subjects practiced 18 different sports and female subjects 17 sports (Table 2). Most of them were on the pre competitive period of their training program.

Wingate test

All subjects performed two Wingate tests[7,8] of 30 seconds duration with a charge equivalent to 7.5% of their body weight on a Monark cycle ergometer model 894 Ea, with a recovery period of 180 minutes between the two tests. The best result was used for the comparison with that of the field test.

Field Test

Forty eight hours after the Wingate test, the athletes performed various field exercises, according to the practiced sport of each subject. In those who were in aquatic sports, two 100-meter freestyle swimming tests were applied. Cyclists in their specialties performed twice 750 meters at the speed track. Skaters and ski sports did two 750 meters tests at the skating rink with skates. All others performed two 400-meter races at the track. In all cases the athletes were requested to undertake maximum efforts. The interval between tests was 10 minutes. After each test, blood samples were taken from the earlobe, previously cleaned and dried, at 1, 3, 5, 7 and 10 minutes. Sampling was interrupted when a measurement was obtained at a figure lower than the preceding assessment.

Blood lactate concentration was assessed by a miniphotometer (Miniphotometer Plus LP20, Dr Lange, Berlin, Germany). The best value in any of the measurements was considered for statistical analysis.

Table 1. Biometric data.

Subjects	Age (years)	Height (cm)	Weight (kg)
Men	23.2 ± 6.62	173.1 ± 7.13	73.68 ± 11.34
Women	20.63 ± 4.11	158.5 ± 8.24	56.23 ± 8.78

Table 2. Distribution of the athletes in different sports.

Sports	Men	Women
Athletics	14	2
Basketball	5	7
Boating	8	1
Boxing	4	-
Cycling	8	6
Hockey turf	-	10
Judo	-	1
Karate	-	2
Kempo	5	2
Modern pentathlon	6	1
Nordic skiing	2	-
Olympic wrestling	6	-
Rhythmic gymnastics	-	4
Rowing	1	-
Rugby	-	5
Sailing	-	2
Synchronized swimming	-	14
Skating	2	-
Soccer	7	-
Softball	-	3
Surfing	4	-
Table tennis	6	-
Triathlon	4	3
Volleyball	17	6
Water polo	2	13
Wushu	2	-
Total	103	82

Transformation of the results of Wingate test into lactate levels

A formula was developed to transform the average power in watts Wingate test (Wa) in energy units (Kcal), then the result is converted to lactate values (mmol), taking as reference the caloric equivalent of lactate (0.222 Kcal/g)[9-11]. In order to calculate the lactate concentration in mmol/l, it is necessary to know the total lactate production, for which the body water volume must be calculated, since lactate is evenly distributed in all body fluids except in the transcellular fluid (synovial, cerebrospinal fluid, vitreus humor…), reaching similar concentrations 3-5 minutes after the activity[12,13]. The water content of the body depends on the body fat content, so the body fat percentage was determined in all subjects[14]. The lean body weight was determined and based on this value; a water fraction of 0.70 was assumed. All of the subjects studied

had a percentage of fat between the limits accepted for age and sex, and even a relevant percentage of the subjects studied had values lower than the normal lower limit, particularly in endurance sports.

Parameters were expressed in the following terms:

$$La\ (mmol.l^{-1}) = [(Wa \times 0{,}06 \times 50{,}045) / (Wt \times 0{,}7)] / 2$$

Where:
Wa = Wingate average value (watts).
Wt = Fat free body weight (kg)

Statistical analysis

Values are expressed as mean and standard deviation. Comparison between the determined and the calculated lactate levels was done with paired Student t test. Pearson method was used to calculate correlations between variables. Levels of $p<0.05$ were considered significant.

Results

The comparison between the measured levels of lactate after the field test and the calculation form the result of the Wingate test are shown in Table 3. The differences were neither significant in the male nor in the female group.

The correlation between the calculated value in the Wingate test and the values obtained with the measurement of blood lactate in the field test, in the different exercises performed by subjects were: male $r = 0{,}85$; $p< 0{,}000000$ (Figure 1); women $r = 0{,}74$; $p< 0{,}000000$ (Figure 2); the whole value for the 185 subjects tested was $r = 0{,}86$; $p< 0{,}000000$ (Figure 3).

Discussion

The Wingate test is a test widely used in the evaluation of athletes during the four last decades, and has been shown to be a good measure of the anaerobic alactacid and lactacid power, but it is also a good indicator of the lactácid capacity of the subjects.

The relationship between lactic acid production and muscle exercise was established more than 200 years ago[15]. And there is an obvious link between the maximum capacity of lactic acid production and the capacity of performance in efforts that lead to exhaustion between 30 and 120 seconds. Different lactate responses have been taken in relation to physical exercise to establish training criteria such as the lactic threshold (LT) and the maximum level of lactate in steady state (MLSS)[15]. These facts motivated us to present a non-invasive method for estimating the maximum lactate concentration.

The indirect tests that have been developed, have done so in order to calculate the critical speed in cycling in which the minimum level of lactate is reached, , which is the concentration that expresses the balance between the production and elimination of blood lactate, and others to determine the exercise intensity or running speed, or swimming that corresponds to the MLSS, as well as in other situations that

Table 3. Lactate levels calculated from the Wingate Test and measured at field (mmol.l^{-1}).

Subjects	Wingate	Field
Men	19,60 ± 1,49	18,80 ± 1,70
Women	16,10 ± 1,47	14,82 ± 1,64

Figure 1. Correlation of lactate values calculated form the Wingate test and the levels measured after the field test in 103 men.

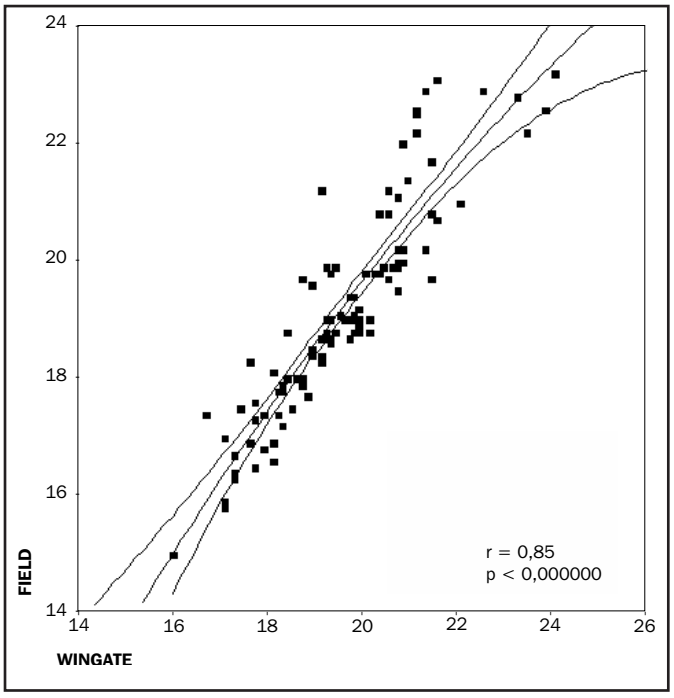


Figure 2. Correlation of lactate values calculated form the Wingate test and the levels measured after the field test in 82 women.

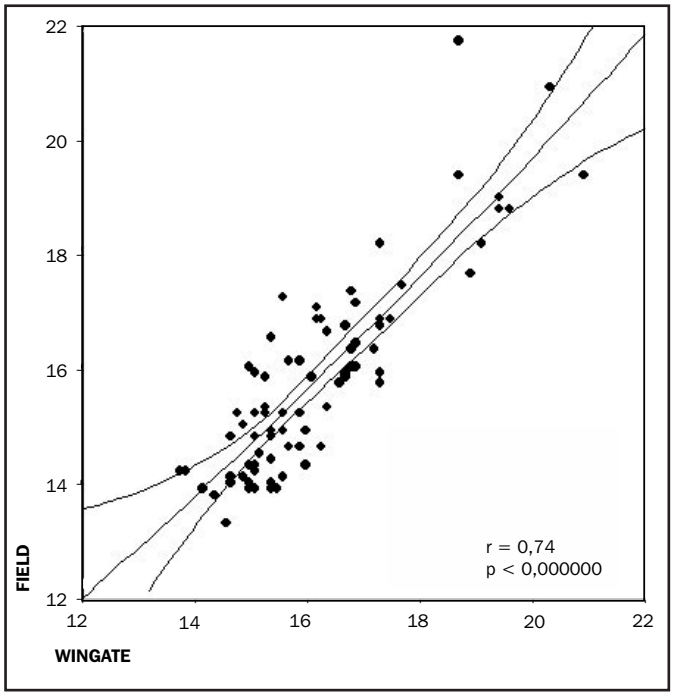
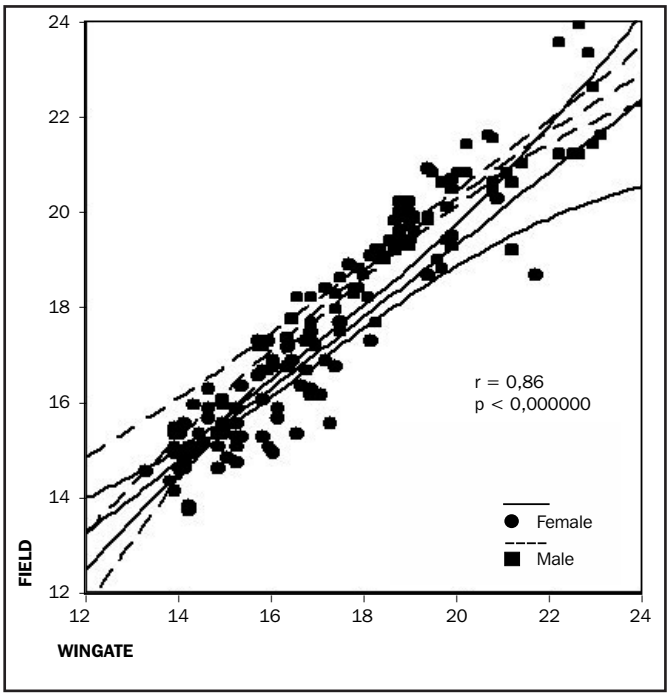


Figure 3. Correlation of lactate values calculated form the Wingate test and the levels measured after the field test in 185 athletes.



provide important information that allow to dose, control and evaluate the training with scientific criteria, which has a great practical interest. In this regard we invite groups of researchers interested in the subject to continue developing methods to estimate maximum lactatemia in various situations and with different procedures. This in addition to enrich the knowledge in the area would allow to contrast the results with the proposal that we present.

This study included male athletes from 18 sports and females that practice 17 different sports, all with more than three years of continuous practice on their relevant sports. The level of all participants was national or international category, forming very homogeneous groups in their respective sports. All of them had previously performed the Wingate test in one or more opportunities, so that their characteristics were known and familiar to them.

The presented method offers the possibility of estimating the maximum value of lactate by the transforming the average power obtained in the Wingate test (Wa) into blood lactate concentration (mmol.l^{-1}).

The results of the present study are limited to the group studied. It will be necessary to apply the formula to other groups, including less experienced athletes and hierarchy, to verify if the proposed procedure provides results similar to those obtained in the present work.

In conclusion a formula based in the results of the Wingate test is proposed to calculate capacity of lactate production in subjects that practice different sports. The method is simple, practical, non invasive and economical, and possibly a good predictor of lactacid anaerobic capacity.

Acknowledgment

We wish to express our appreciation and gratitude to Dra. Sonia H. Torres for her collaboration in the revision and correction of the text. Similary our thanks to Dr. Bepsi Collazo for her collaboration in the realization of the graphics.

Conflict of interest

The authors do not declare a conflict of interest.

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