Original article

Validity of blood lactate measurements between the two LactatePro versions

Iñaki Arratibel-Imaz[1], Julio Calleja-González[2], Nicolás Terrados[3]

[1]Laboratorio de Análisis del Rendimiento Deportivo. Departamento de Educación Física y Deportiva. Facultad de Educación y Deporte. Universidad del País Vasco, Vitoria, Alava. Tolosa Kirol Medikuntza, Tolosa, Guipuzkoa. [2]Laboratorio de Análisis del Rendimiento Deportivo. Departamento de Educación Física y Deportiva. Facultad de Educación y Deporte. Universidad del País Vasco, Vitoria, Alava. Fakulty of Kinesiology of Zagreb, Croacia. [3]Unidad Regional de Medicina Deportiva del Principado de Asturias-Fundación Deportiva Municipal de Avilés y Departamento de Biología Funcional. Universidad de Oviedo.

Summary

Introduction: The blood lactate concentration to measure the exercise intensity in the lab or in the field is very usual in the exercise physiology and training control. The main aim was to measure the validity and the concordance in the measurement between two lactate-pro models in the market.

Methods: 34 voluntary sportmen (3 cyclist, 17 rowers, 10 long distance runners and 4 mountains runners) performed a staggered, progressive, intervallic, maximal test of effort. Constant increases of intensity (every 3 min) were done. The peripheral blood lactate was measured at the same time in both models by a heparinized capilar during the 10 next second after the step.

Results and Conclusion: A high correlation between devices was presented ($r = 0,991$ and $r^2 = 0,983$; $p < 0.001$), with a high concordance for the medium results (0,31 mmol/l), being a little beat higher in the model LactatePro LT-1710. The stretch of values (0 – 5,0 mmol/l) presented a high correlation between devices ($r = 0,965$ and $r^2 = 0,931$; $p < 0.001$). The stretch of medium values (5,1 – 10,0 mmol/l) determined a high correlation between them ($r = 0,921$ and $r^2 = 0,848$; $p < 0.001$) and high concordance (0,54 mmol/l). In the stretch (10,1 – 20,0 mmol/l) the correlation is high, similar than the medium group ($r = 0,926$ and $r^2 = 0,858$). The concordance in this group is for the mean results (0,40 mmol/l). For high [La⁻] (>10 mmol/l), the correlations and the concordance are high. The measurements of the [La⁻] values by the old model LactatePro LT-1710 versus the new one LT 1730 (Akray Factory Inc. KDK Corporation, Siga, Japan) is possible, given that the correlation and the concordance for the total data as well as groups are high.

Estudio de la validez en la medición de los valores de lactato sanguíneo entre los dos modelos existentes de LactatePro

Resumen

Introducción: La medición de la concentración de lactato sanguíneo ([La-]) para el control de la intensidad del esfuerzo, tanto en laboratorio como sobre el terreno, es muy habitual en la fisiología del ejercicio y en el control del entrenamiento. El objeto de este estudio es analizar la validez y concordancia en la medición de [La-] entre los dos modelos existentes de LactatePro en el mercado.

Métodos: Han participado 34 deportistas voluntarios (3 ciclistas, 17 remeros, 10 corredores de larga distancia y 4 de montaña), los cuales llevaron a cabo un test Escalonado Progresivo Incremental Máximo (EPIM) con escalones de 3 minutos hasta el agotamiento subjetivo, con toma de una muestra sanguínea con un capilar heparinizado, la cual se analizó simultáneamente ambos modelos.

Resultados y conclusión: El análisis mostró una alta correlación entre aparatos ($r = 0,991$ y $r^2 = 0,983$; $p < 0.001$), con concordancia alta para la media de resultados (0,31 mmol/l), siendo ligeramente más alta en el modelo LactatePro LT-1710. El tramo (0 – 5,0 mmol/l) muestra una alta correlación entre aparatos ($r = 0,965$ y $r^2 = 0,931$; $p < 0,001$). El tramo de lactato medios (5,1 – 10,0 mmol/l) determina una alta correlación entre ambos ($r = 0,921$ y $r^2 = 0,848$; $p < 0,001$) y concordancia alta (0,54 mmol/l). En el tramo de valores de lactato (10,1 – 20,0 mmol/l) la correlación es alta, similar a la del tramo medio ($r = 0,926$ y $r^2 = 0,858$). La concordancia en este grupo es alta para la media de los resultados (0,40 mmol/l). Para los de [La⁻] mayor (>10 mmol/l) la correlación y la concordancia son altas. El cambio en la medición de los valores de [La⁻], sustituyendo el modelo antiguo de LactatePro LT-1710 por el nuevo LT 1730 del mismo fabricante (Akray Factory Inc. KDK Corporation, Siga, Japan), es posible dada la alta correlación y concordancia tanto para todo el conjunto como para los grupos.

Correspondence: Iñaki Arratibel Imaz
E-mail: inaki.arratibel@ehu.eus

Introduction

The use of measuring blood lactate concentration values ([La-]) to control the intensity of exercise, both in the laboratory and in the field, is a very habitual practice of the physiology of exercise[1-6]. These measurements of the [La-] are necessary in both phased and constant efforts. Their validity, reliability and precision are a fundamental part of the control of training[7,8]. For this reason, any appearance in the market of a more modern version of measuring apparatus for the same biological variable as a preceding one requires an assessment study of the results, so that the change in its use does not entail a significant alteration in the controls performed[9].

Diverse studies have analysed the possible difference that may exist in the [La-] values analysed using the different portable measuring devices available on the market: Lactate Pro, Accusport, Analox GM7, Kodak Ektachem lactate, Lactate Scout, Lactate Plus, Lactate Pro2, Lactate Scout+, Xpress™, Edge[9-13]. As such, the substitution of the lactate analyser from the manufacturer Akray Factory Inc. (KDK Corporation, Siga, Japan) Lactate Pro LT-1710 for the new version called Lactate Pro2 LT-1730 requires an assessment of the concordance of the lactate values measures with both apparatus, given that until now and to our knowledge, no studies have been published that analyse the validity of this instrument. Therefore, the aim of this study is to analyse the validity and concordance in the measurement of blood lactate values between the two existing LactatePro models on the market.

Material and method

Participants

34 voluntary athletes participated in the study (3 cyclists, 17 rowers, 10 distance runners and 4 distance fell runners). The characteristics of the subjects can be seen in Table 1. During the study, all the subjects carried out the complete training programme. The athletes were informed about the experimental protocols and the possible risks and benefits of the project, which was approved by the local ethics committee, which granted its written consent in accordance with the Helsinki Declaration and the Organic Act 15/1999, 13th December, governing personal data protection, as well as after having explained to them the details of the study and after having received their written consent.

Method

The blood test samples were performed in the ergometric tests carried out by athletes of different levels, taken in the Sports Medicine Centre Tolosa Kirol Medikuntza. The tests were performed in different ergometers: 17 on rowing ergometers, 3 on cycle-ergometers, 10 on treadmills with speed protocol, and 4 on treadmills with gradient protocol (Table 1). In all the cases, the athletes carried out a Maximum Incremental Progressive Phasing test (MIPT), with phases of 3 minutes, until subjective exhaustion was reached.

Table 1. Anthropometric data of the athletes.

	Height	Weight	BMI	% Fat	Age
Average	176.4	74.3	23.8	11.6	32.7
SD	8.6	12.0	3.3	4.1	10.1
Max.	191.5	114.1	38.1	26.4	54.0
Min.	151.0	46.5	18.6	7.1	19.0

During the performance of the habitual ergometric tests, the same blood samples were analysed simultaneously with the two models of LactatePro, Lactate Pro LT-1710 and Lactate Pro2 LT-1730. For this, in each of the effort test phases, performed by 40 athletes that attended their habitual controls, the blood tests were taken with a heparin-containing capillary, so that the time of the blood test was the same.

There were 269 blood samples, which were measured a maximum of 10 seconds after taking them, with the two lactate analysers of the study used simultaneously.

The blood extractions were taken from the earlobe and the collection did not take more than 10 seconds, with the aim of discovering the precise [LA] level.

Lactate analysers

Both analysers (Lactate Pro LT-1710 (LP1) and Lactate Pro2 LT-1730 (LP2)) used the oxidase lactate enzyme electrode method. The LT-1710 model requires 5 μl of blood, whilst the LT-1730 model only requires 0.3 μl. An important difference, though it does not influence the results obtained, is that the first model requires 60 seconds to obtain the results, whilst the second gives the results in 15 seconds. The measurement range is of 0.8-23.3 mmol/l for the LactatePro LT-1710 model, and 0.5-25.0 for the LactatePro LT-1730[7] model.

Statistical analysis

A descriptive analysis was carried out of the data, describing average ± standard deviation (SD), including range, typical error of the average and minimum and maximum values. The Normality test was analysed using the Kolmogorov-Smirnov test. All the variables revealed a standard distribution. Therefore, we used parametric tests. Likewise, an analysis of the homogeneity was also carried out with the ANOVA analysis of Levene, with a signification of $p = 0.000$. The null hypothesis was rejected, as the p value associated with the result observed is the same or less than the level of established signification ($p < 0.05$). The result of the size of the effect analysis produced an r = 0.44, therefore the size of effect is medium. Considering that the sample measures were obtained in progressive ergometric tests, the [LA-] values obtained can be classified as low, medium and high, following the approach of the study performed by Bonaventura *et al*. (2014)[9]. In this study a global analysis was performed of all the data collectively. In a second phase, the same studies were carried out in each group of values, which have

been divided into low 0-5.0 mmol/l; medium 5.1-10.0 mmol/l; high > 10.0 mmol/l, which according to the measurements is between 10 and 20 mmol/l.

To get information about the agreement observed and regarding the presence of systematic differences between the measurements, the Concordance Correlation Coefficient (CCC) by Lin[14] was applied, following the method developed by Bland and Altman, which is based on the analysis of the differences between the individual measurements[15], studying the trend as well as the concordance limitations for 95%. For the statistical analysis, the computing package IBM SPSS Statistics21.0 (Chicago IL, USA) was used. The signification was calculated using an analysis of variance and was established for $p <0.05$.

Results

The application of the Pearson Correlation Coefficient displays high correlation between both apparatus ($r = 0.991$ and $r^2 = 0.983$) with a probability of $p <0.001$. The regression equation between both methods in this range was LP2 = 0.936 LP1 + 0.080 (Figure 1).

The analysis of the concordance between the results obtained with the two methods studied reveals that this concordance is high for the average results (0.31 mmol/l), being slightly higher in the measurements with the previous model (LactatePro LT-1710). The margin for the values to 95%, limited by the double Standard Deviation (±2SD), is positioned between +1.65 and -1.03 mmol/l which entails a difference of 2.68 mmol/l (Figure 2a). If the margin for the values to 95% is calculated with direct Standard Deviation (±SD), the same way it appears in the study by Bonaventura and collaborators[9], it is positioned between +0.98 and -0.31 mmol/l, which entails a difference of 1.34 mmol/l (Figure 2b).

Values between 0 and 5 mmol/l

In the section of low lactate values (0 – 5.0 mmol/l) the application of Pearson's Correlation Coefficient reveals a high correlation between both apparatus ($r = 0.965$ and $r^2 = 0.931$; $p <0.001$), but less than in the

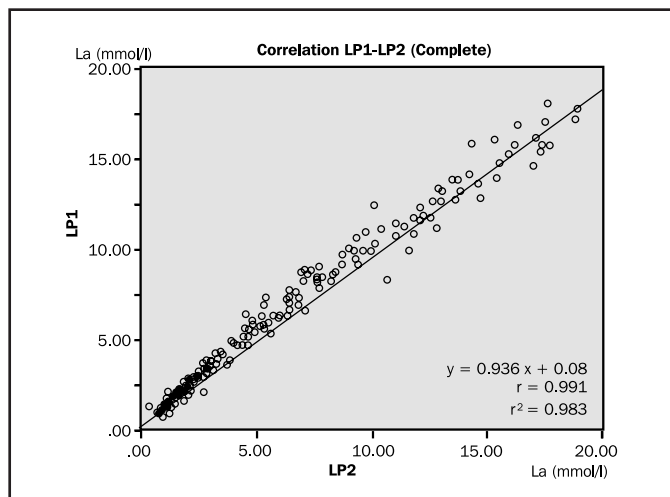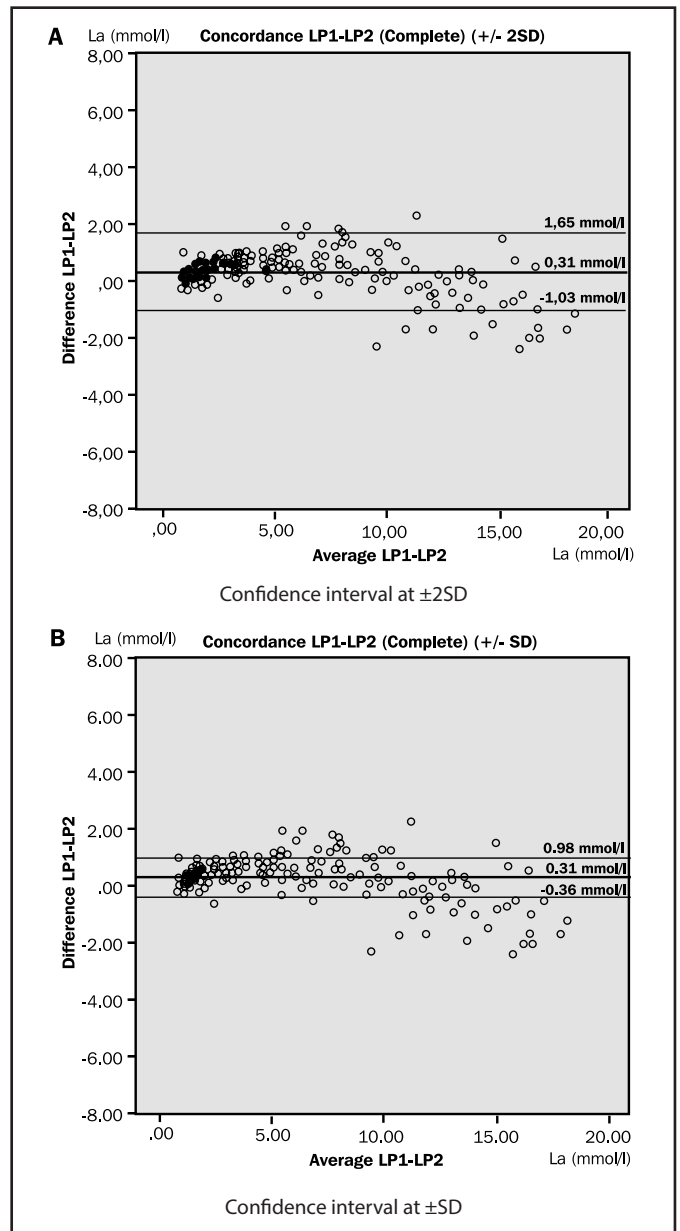**Figure 1. Correlation between LactatePro LT-1710 and LactatePro LT-1730.**

Figure 2. Concordance between LactatePro Lt-1710 and LactatePro Lt-1730.

Confidence interval at ±2SD

Confidence interval at ±SD

case of the values as a whole. The regression equation between both methods in this range was LP2 = 1.093LP1 + 0.023 (Figure 3).

In this section of values the concordance analysis is high for the average of the results (0.39 mmol/l), similar to that obtained in the collection of data as a whole, and slightly higher in the measurements with the previous model (LactatePro LT-1710). The margin for the values to 95%, limited by the double Standard Deviation (±2SD), is positioned between +0.95 and -0.17 mmol/l, which entails a difference of 1.12 mmol/l, slightly lower than when compared to the collection of data as a whole (Figure 4a). Upon establishing the reliability margins with ±SD, they are positioned between +0.67 and +0.11 mmol/l, which is a difference of 0.56 mmol/l (Figure 4b).

Figure 3. Correlation between LactatePro LT-1710 and LactatePro LT-1730 for the values between 0 and 5.0 mmol/l.
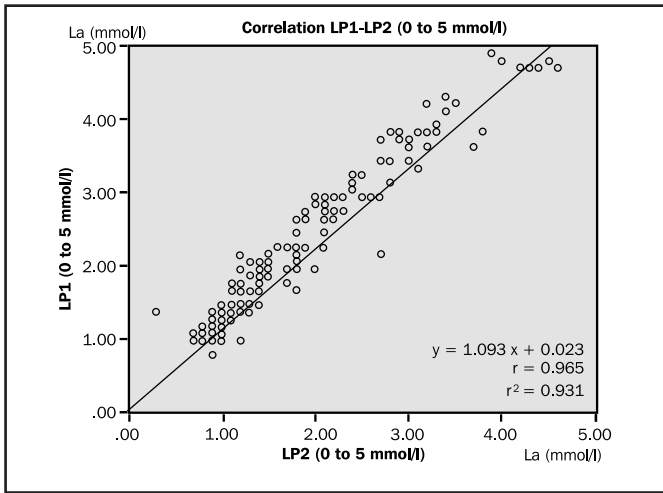

Figure 5. Correlation between LactatePro LT-1710 and LactatePro LT-1730 for the values between 5.1 and 10.0 mmol/l.
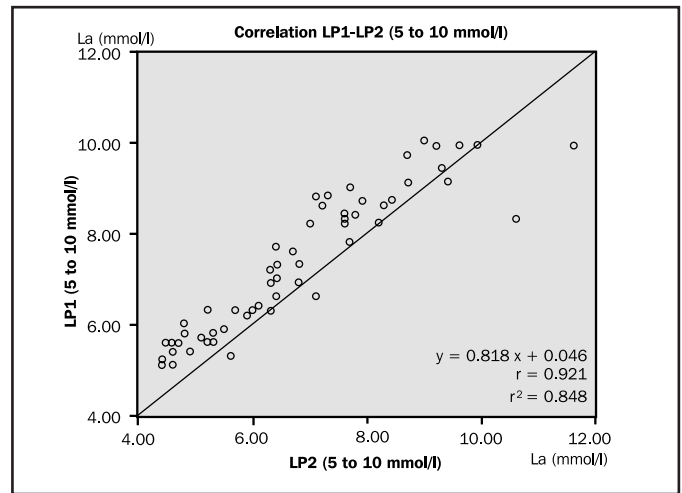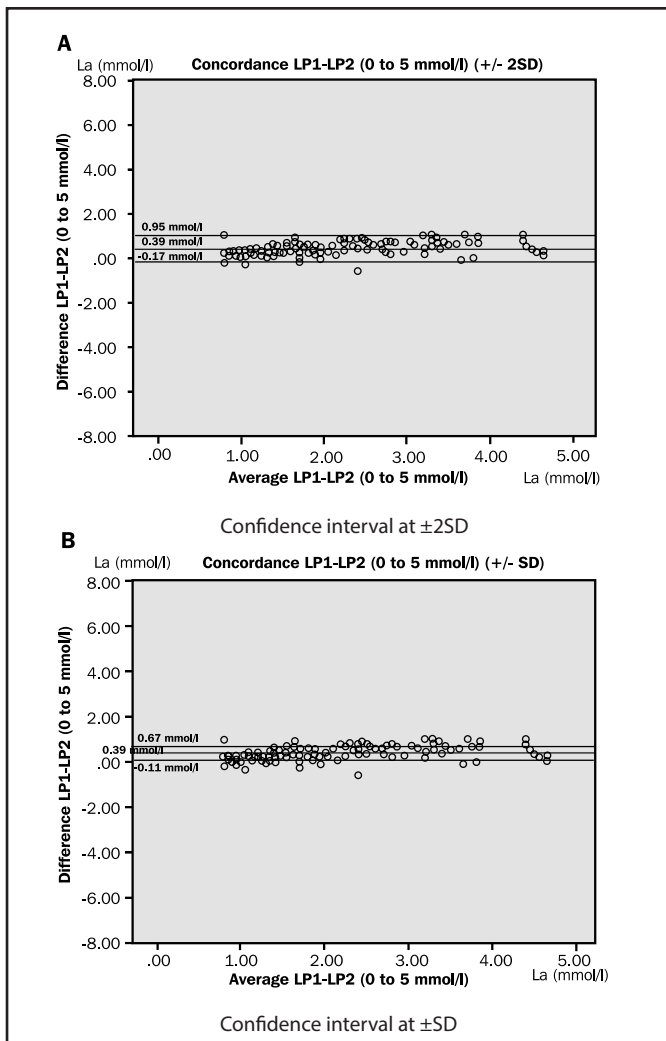

Figure 4. Concordance between LactatePro LT-1710 and LactatePro LT-1730 for the values between 0 and 5 mmol/l.

Values between 5 and 10 mmol/l

The section of medium lactate values (5.1 – 10.0 mmol/l) reveals a high correlation between both apparatus (r = 0.921 and r^2 = 0.848; p <0.001), but it is even less than in that observed for the section of low values and logically less than in the collection of data as a whole. The regression equation between both methods in this range was LP2 = 0.818LP1 + 0.046 (Figure 5).

The analysis of the concordance for this group reveals that it is high for the average of the results (0.554 mmol/l), though somewhat less than in the low group and in the data overall, in any case the highest being the measurements with the previous model (LactatePro LT-1710). The margin for the values to 95%, limited by the double Standard Deviation (±2SD), is positioned between +1.87 and -0.81 mmol/l which entails a difference of 2.68 mmol/l (Figure 6a). With reliability margins of ±SD, they are positioned between +1.21 and -0.13 mmol/l, which is a difference of 1.34 mmol/l (Figure 6b). In both cases it is exactly the same in the collection of data as a whole.

Values between 10 and 20 mmol/l

In this section of high lactate values (10.1 – 20.0 mmol/l) the correlation is high, similar to the section of medium values (r = 0.926 and r^2 = 0.858), less than in the section of low values and logically less than in the total of the data. The regression equation between both methods in this range was LP2 = 0.761LP1 + 0.480 (Figure 7).

The concordance in this group reveals that this is high for the result average (0.40 mmol/l), but in this case the measurements with the previous model (LactatePro LT-1710) are lower than those of the new model (LactatePro LT-1730). When the margin for 95% is calculated with ±2SD, it is positioned between +1.68 and -2.48 mmol/l, which involves a difference of 4.16 mmol/l (Figure 8a), much higher than that obtained in all the previous analyses. Using the ±SD, the margins are positioned between +0.64 and -1.44 mmol/l, which is a difference of 2.08 mmol/l (Figure 8b). Also above the previously analysed sections.

Figure 6. Concordance between LactatePro LT-1710 and LactatePro LT-1730 for the values between 5.1 and 10.0 mmol/l.
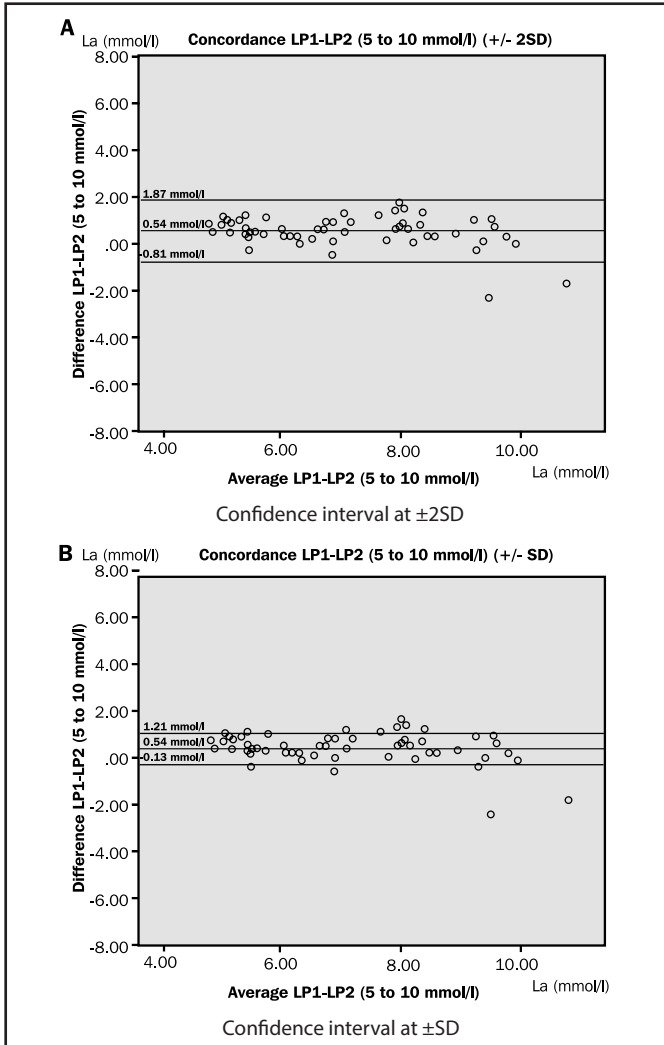

Confidence interval at ±2SD

Confidence interval at ±SD

Figure 8. Concordance between LactatePro LT-1710 and LactatePro LT-1730 for the values between 10.1 and 20.0 mmol/l.

Confidence interval at ±2SD
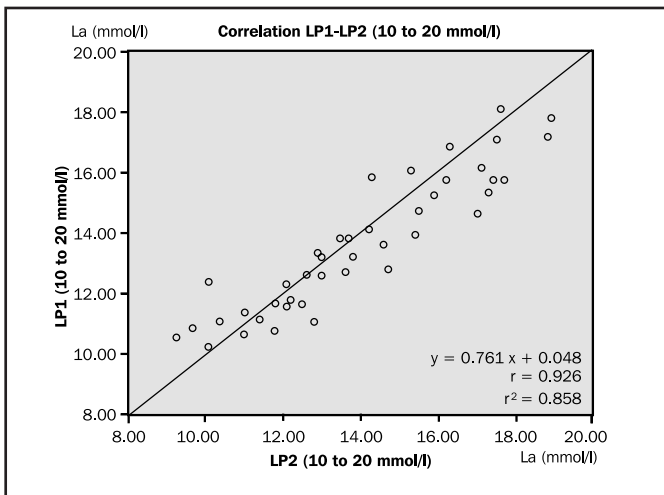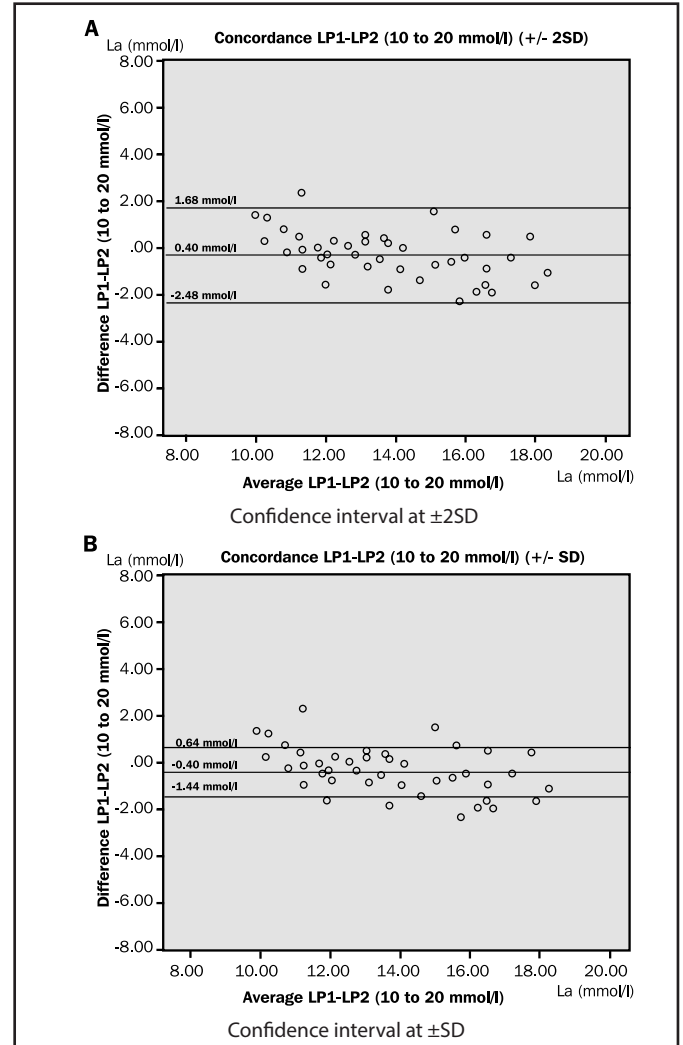
Confidence interval at ±SD

Figure 7. Correlation between LactatePro LT-1710 and LactatePro LT-1730 for the values between 10.1 and 20.0 mmol/l.

Discussion

To the best of our knowledge, this is the first study to analyse the concordance in the measurement of blood lactate values just between the two models studied, and only between them, based on the lactate analyser LactatePro. The results of this study indicate that the change in the measurement of the [La-] values carried out with the former LactatePro LT-1710 model, with those performed using the new LactatePro LT 1730 model by the same manufacturer (Akray Factory Inc. KDK Corporation, Siga, Japan) is possible, given that a high correlation and concordance was observed, both for the entire collection of data as well as for the groups of low (0 – 5.0) and medium (5.1 – 10.0) [La-]. For the high [La-] data (>10 mmol/l) both the correlation and concordance remain high, but in lesser measure than in the previous groups.

These results align with those obtained by Bonaventura *et al.*[9], who observed similar results for the two analysers compared in this study,

though in their case, the comparison between the two LactatePro models is included in a comparison with more portable lactate analysers. Just as in this study, in the high concentrations there is a greater dispersion of the results, which could be explained by the high LA in a low blood volume[9], which in the case of the LT-1730 model is very low (0,3 μl) compared to the 5.0 μl of the previous model, with an increased possible difference in the measurements carried out

Our results indicate that the change in the previous model (LT-1710) for the new one (LT-1730) should not generate differences in the calculation of the different lactate thresholds: Aerobic Threshold (LT), Individual Anaerobic Threshold (IAT) or Fixed Threshold of 4 mmol/l (OBLA), as the high concordance of the measurements in the low or medium [La-] groups is high. This aligns with the results of Bonaventura *et al.* who did not find significant differences in the calculation of the thresholds for both analysers[9].

For a precise transfer of the results, the regression equations will be:

For all the measurement margins: LP2 = 0.936LP1 + 0.080

For values between 0 and 5 mmol/l: LP2 = 1.093LP1 + 0.023

For values between 5 and 10 mmol/l: LP2 = 0.818LP1 + 0.046

For values between 5 and 10 mmol/l: LP2 = 0.761LP1 + 0.480

Conclusions

Considering that there is a vast biological variability in the lactate concentrations, the results of our study suggest that the results in the calculation of the training intensities and in the interpretation of the results of an ergometer, obtained with the measurements performed with the new LactatePro model (LT-1730), are interchangeable with those performed using the previous model (LT-1710).

Acknowledgements

Bibliography

1. Billat VL. Use of Blood Lactate Measurement for Prediction of Exercise Performance and for Control of Training. *Sport Med.* 1996;22(3):157-75.

2. Bosquet L, Léger L, Legros P. Methods to determine aerobic endurance. *Sports Med* [Internet]. 2002 Jan;32(11):675–700. Disponible en: http://www.ncbi.nlm.nih.gov/pubmed/12196030

3. Beneke R, Hütler M, von Duvillard S, Sellens M, Leithäuser RM. Effect of Test Interruptions on Blood Lactate during Constant Workload Testing. *Med Sci Sports Exerc.* 2003;35(9):1626-30.

4. Arratibel-Imaz I, Calleja-Gonzalez JR, Emparanza JI, Terrados N, Mjaanes JM, Ostojic SM. Lack of concordance amongst measurements of Individual Anaerobic Threshold and Maximal Lactate Steady State on a cycle ergometer. *Phys Sportsmed* [Internet]. 2015;3847(December 2015):00913847.2016.1122501. Disponible en: http://www.tandfonline.com/doi/full/10.1080/00913847.2016.1122501

5. Melloh M, Theis J, Beneke R. Variability of blood lactate during and between given constant prolonged cycling power. *J Sports Med Phys Fitness.* 2012;52(6):575-82.

6. Hoppe M, Baumgart C, Sperlich B, Ibrahim H, Jansen C, Willis S, *et al.* Comparison between three different endurance tests in professional soccer players. *J Strength Cond Res.* 2013;27(1):31-7.

7. Billat VL, Sirvent P, Py G, Koralsztein J-P, Mercier J. The concept of maximal lactate steady state: a bridge between biochemistry, physiology and sport science. *Sports Med* [Internet]. 2003 Jan;33(6):407-26. Disponible en: http://www.ncbi.nlm.nih.gov/pubmed/12744715

8. Beneke R, Leithäuser R, Ochentel O. Blood lactate diagnostics in exercise testing and training. *Int J Sports Physiol Perform.* 2011;6(1):8-24.

9. Bonaventura JM, Sharpe K, Knight E, Fuller KL, Tanner RK, Gore CJ. Reliability and accuracy of six hand-held blood lactate analysers. *J Sport Sci Med.* 2015;14(1):203-14.

10. Mc Naughton L, Thompson D, Philips G, Backx K, Crickmore L. A comparison of the lactate Pro, Accusport, Analox GM7 and Kodak Ektachem lactate analysers in normal, hot and humid conditions. *Int J Sports Med.* 2002;23(2):130-5.

11. Bishop P, Smith J, Kime J, Mayo J, Tin Y. Comparison of a manual and an automated enzymatic technique for determining blood lactate concentrations. *Int J Sports Med.* 1992;13(1):36-9.

12. Pyne D, Boston T, Martin D, Logan A. Evaluation of the Lactate Pro blood lactate analyser. *Eur J Appl Physiol.* 2000;82(1-2):112-6.

13. Tanner R, Fuller K, Ross M. Evaluation of three portable blood lactate analysers: Lactate Pro, Lactate Scout and Lactate Plus. *Eur J Appl Physiol.* 2010;109(3):551-9.

14. Cortés-Reyes E, Rubio-Romero J, Gaitán-Duarte H. Métodos estadísticos de evaluación de la concordancia y la reproductibilidad de pruebas diagnósticas. *Rev Colomb Obstet Ginecol.* 2010;61(3):247-55.

15. Bland J, Altman D. A note on the use of the intraclass correlation coefficient in the evaluation of agreement between two methods of measurement. *Comput Biol Med.* 1990;20(5):337-40.

POSTGRADOS OFICIALES:
SALUD Y DEPORTE

UCAM UNIVERSIDAD CATÓLICA DE MURCIA

Espíritu
UCAM
Espíritu **Universitario**

Miguel Ángel López
Campeón del Mundo en 20 km. marcha (Pekín, 2015)
Estudiante y deportista de la UCAM

- **Actividad Física Terapéutica** (2)

- **Alto Rendimiento Deportivo:**

  Fuerza y Acondicionamiento Físico (2)

- **Performance Sport:**

  Strength and Conditioning (1)

- **Audiología** (2)

- **Balneoterapia e Hidroterapia** (1)

- **Desarrollos Avanzados**

  de Oncología Personalizada Multidisciplinar (1)

- **Enfermería de Salud Laboral** (2)

- **Enfermería de Urgencias,**

  Emergencias y Cuidados Especiales (1)

- **Fisioterapia en el Deporte** (1)

- **Geriatría y Gerontología:**

  Atención a la dependencia (2)

- **Gestión y Planificación de Servicios Sanitarios** (2)

- **Gestión Integral del Riesgo Cardiovascular** (2)

- **Ingeniería Biomédica** (1)

- **Investigación en Ciencias Sociosanitarias** (2)

- **Investigación en Educación Física y Salud** (2)

- **Neuro-Rehabilitación** (1)

- **Nutrición Clínica** (1)

- **Nutrición y Seguridad Alimentaria** (2)

- **Nutrición en la Actividad Física y Deporte** (1)

- **Osteopatía y Terapia Manual** (2)

- **Patología Molecular Humana** (2)

- **Psicología General Sanitaria** (1)

(1) Presencial   (2) Semipresencial

MÁS INFORMACIÓN:

📞 **968 27 88 01** · 🌐 **ucam.edu**