Computer Software for Statistically Determined Blood Lactate Threshold for Sport Physiotherapists and Sport Trainers

Sporcu Fizyoterapistleri ve Sporcu Antrenörleri İçin İstatistiksel Olarak Kan Laktat Eşiği Belirleme Yazılımı

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Beta version of the software was introduced as a poster presentation at National Congress of Association of Turkish Physiological Sciences, August 31-September 3, 2004, Konya, Turkey. Bugs of the software were fixed between 2004 and 2010, software was developed and user interface was simplified. Stable version was presented as oral presentation in Asian Conference of International Association of Computer Science in Sports in 2010 Tokyo/Japan. In this paper software is presented with optimized algorithm which can be used for development of similar software for determination of blood lactate threshold.

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ABSTRACT Objective: Cardiovascular Fitness (CVF) reflects the ability of an athlete to endure an aerobic task like running, cycling and swimming. CVF level of an athlete can be determined by anaerobic threshold (AT). Blood lactate threshold (LTH) is an indicator of AT. The simplest method of determining the LTH is to use the point of nonlinear increase discerned by eye from a blood lactate-workload graph. Eye-examined LTH is a simple method but it includes problems related to inter-observer and intra-observer agreement. Statistical models can solve this problem but they involve complex statistical and mathematical procedures and can only be applied by using computer and statistical software. Moreover, they also need expertise on both statistics and mathematics. The purpose of this study is to develop user-friendly software to determine the LTH with an objective way by using linear and logarithmic models for non-statistician sport scientist like sport physiotherapist and sport trainers. **Material and Methods:** An algorithm was developed to determine LT by linear and logarithmic models at 4 mmol/L fixed lactate level. Software was developed under Visual Basic 6. **Results:** In this study software was developed which calculates and reports LTH by using statistical and mathematical models. The software directly calculates LTH in a single step for linear and logarithmic models. **Conclusion:** This application should be useful for both laboratory and field studies to obtain objective test results. This study can accepted as first step for a software on statistically and mathematically determined LTH. It can be concluded that the current study proposes a user-friendly software that overcomes the subjectivity and complexity problems related with mathematically and statistically determined LTH methods.

Key Words: Blood lactate threshold; mathematical and statistical models; computer software

ÖZET Amaç: Kardiyovasküler fiziksel uygunluk (CVF), bir sporcunun koşma, bisiklet sürme ve yüzme gibi aerobik bir iş ile ilgili dayanıklılığının göstergesidir. Bir sporcunun CVF seviyesi anaerobik eşik (AT) ile belirlenebilir. Kan laktat eşiği (LTH) ise AT'nin göstergelerinden biridir. LTH'ı belirlemenin en basit yolu, kan laktat- iş yükü grafiğinden, nonlineer artışın başladığı noktanın göz ile belirlendiği noktanın kullanılmasıdır. Göz ile belirlenen LTH basit bir yöntem olmasına karşın, gözlemciler arası ve gözlemci içi uyum ile ilgili test tekrar test sorunlarına sahiptir. İstatistiksel modeller bu sorunu çözebilir, ancak bunlar da karmaşık matematik ve istatistiksel prosedürlere sahip olup, bilgisayarlar ve istatistiksel programlar kullanılarak uygulanabilirler. Bu çalışmanın amacı, istatistikçi olmayan spor fizyoterapistleri ve antrenörler gibi spor bilimciler için LTH'ı lineer ve logaritmik regresyon modellerine göre, nesnel bir yolla belirlemek amacıyla kullanıcı dostu bir yazılım geliştirilmesidir. **Gereç ve Yöntemler:** 4 mmol/L sabit laktat seviyesinde, lineer ve logaritmik modellere göre kan laktat eşiğini belirlemek üzere bir algoritma geliştirilmiştir. Yazılım Visual Basic 6 altında geliştirilmiştir. **Bulgular:** Bu çalışmada LTH'ı istatistiksel ve matematiksel modellere göre hesaplayan bir yazılım geliştirilmiştir. Yazılım lineer ve logaritmik modellere göre LTH'ı tek aşamada doğrudan hesaplamaktadır. **Sonuç:** Bu yazılım hem laboratuarda hem de sahada nesnel test sonuçları elde etmek amacıyla kullanışlı olabilir. Bu çalışma istatistiksel ve matematiksel olarak LTH'ı belirlemede ilk aşama olarak kabul edilebilir. Bu çalışma sonucunda, kullanıcı dostu, öznellik ve matematik ve istatistiksel modellerin karmaşıklığı ile ilgili sorunların üzerinden gelebilecek bir yazılım önerilmiştir.

Anahtar Kelimeler: Kan laktat eşiği; matematiksel ve istatistiksel modeller; bilgisayar yazılımı

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Cardiovascular fitness (CVF) is defined as a health-related component of physical fitness that relates to ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity.[1] Cardiovascular endurance, aerobic fitness and cardio-respiratory fitness are the other terms that refer to CVF. In the perspective of sports sciences CVF reflects the ability of an athlete to endure an aerobic task like running, cycling and swimming.

CVF level of an athlete can be determined by both field and laboratory tests. Basically, all tests measure the physiological response (heart rate, oxygen consumption and blood lactate accumulation) to incremental aerobic exercise and work done by the athlete (or distance, speed). The tests can also be divided in two categories as direct and indirect measure of the physiological response.

Interpretation of the direct tests are done by interpolation of the acquired data in a two dimensional graph (like work/speed to blood lactate accumulation, oxygen consumption or heart rate) and investigation of special points which correlate to physiological performance. In work/speed versus VO_2 graph a plateau is investigated where the exercise intensity will increase but the oxygen consumption is constant. This point reflects the maximum aerobic exercise intensity that can be done by the athlete and called as maximum oxygen consumption.[2-4] In work/speed versus VO_2 and VCO_2 graph, an intersection point is investigated where VCO_2 curve intersects VO_2 curve. This point is called ventilator threshold (VT).[5] In work/speed versus blood lactate work/speed-heart rate graph a breaking point is investigated. The breaking point of blood lactate accumulation is called blood lactate threshold (LTH) and breaking point of heart rate is called as heart rate deflection point (HRDP).[6,7] LTH, VT and HRDP correlate each other and they are the different views of the same physiological phenomena called anaerobic threshold or metabolic acidosis.[7,8] Metabolic acidosis occurs when the aerobic energy supply to skeletal muscle is insufficient to corresponding exercise intensity and the energy deficit of the skeletal muscle is compensated by anaerobic pathway. Also, AT is defined as the highest $V0_2$ that can be attained during incremental exercise before an elevation in blood lactate is observed.[9]

AT is not only a theoretical definition, which explains a physiological phenomenon, but also important in athletic training. AT correlates with endurance performance and training loads can be prescribed and modulated according to it.[10] AT is the optimum exercise intensity to develop improvement in athletic performance.[11] AT can also be used as an outcome measure of aerobic fitness level resulting from training and it can be use to monitor the adaptation to training program.[12]

In the literature of LTH there are different terms, definitions and methods to define and measure the LTH. All of these approaches can be classified in two categories as; 1) conventional methods and 2) mathematical & statistical methods.[13-15] Both of these two groups can be divided in to two subgroups as; a) fixed blood lactate level based thresholds approaches and b) Individualized blood lactate threshold approaches (Figure 1a).[16-20]

Lactate threshold (LT), maximal steady state (MSS), lactate breaking point (LBP), individual anaerobic threshold (IAT) and onset of blood lactate accumulation (OBLA) are the terms that define LTH.[16,20-22] 4 mmol/L, Δ1 mmol/L (1 mmol/L increase from baseline during incremental exercise testing) and 2.5 mmol/L are some fixed blood lactate levels that are used to determine the LTH.[19,22,23] Linear model, logarithmic model, exponential model, second and third degree polynominal models are statistical models that are used to determine LTH.[16,23] Some statistical models use second derivatives to calculate inflection points as predictor of LTH. In derivatives a turn point is investigated without using a fixed lactate level. Also, combinations of these approaches are possible (e.g. 4 mmol/L fixed lactate level according to linear model) (Figure 1b).[17]

The simplest method of determining the LTH is to use the point of nonlinear increase discerned by eye from a blood lactate-workload graph. This is the simplest and common method but can be affected by personal factors and needs experience.

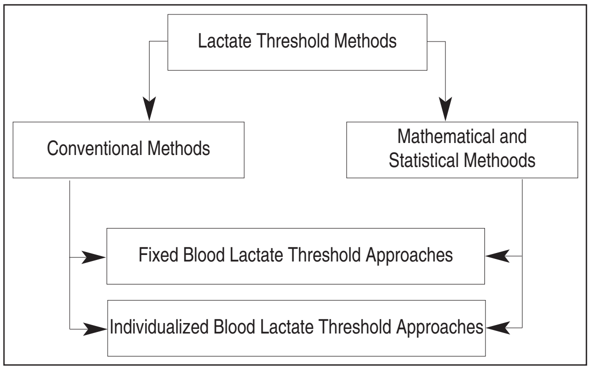

FIGURE 1a: General classification of LTH methods.

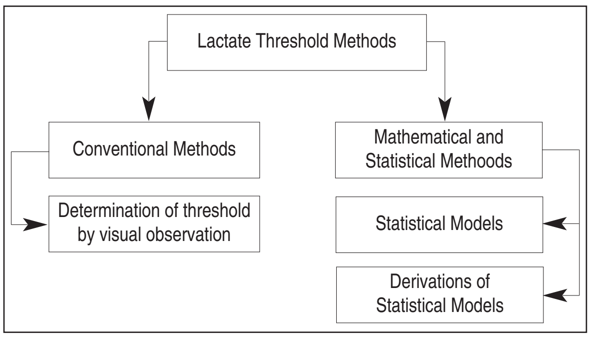

FIGURE 1b: Classification of LTH methods according to sub-categorical methods.

Personal factors that affect the result can be determined by inter-evaluator (test-retest reliability) and intra-evaluator agreement quaficient. Intra-evaluator agreement is the agreement of the same evaluator on the same test data in two different point of time. Inter-evaluator agreement is the agreement of different evaluators on the same test data. None of the current studies report 100% agreements on intra-evaluator and inter-evaluator agreements for visually detected LT methods.[24,25]

Statistical and mathematical methods are not affected by personal factors and result of them can be accepted as more objective.[15] For the same statistical & mathematical method the result is always same for the same test data. But they involve complex statistical and mathematical procedures and can only be applied by using computer and statistical software and they also need expertise on both statistics and mathematics.[17]

In the literature there are studies which are supported by computer software to obtain objective test results but it couldn't be succeed to find any study which focus on development of a user friendly software for sport scientists to calculate LTH by using statistical and mathematical models in an easy way.[15,17] The purpose of this study is to develop a software to determine the LTH with an objective way by using linear and logarithmic models.

MATERIAL AND METHODS

Linear and logarithmic models were used and LTH was determined at 4 mmol/L fixed lactate level.[16]

Regression equations and equation coefficients were shown on Table 1. The validty of the software was checked with the reference software SPSS 11. Regression equations were calculated both under the software developed and the reference software by using the same data set; the developed software was accepted valid when the same results were obtained.

RESULTS

The software consists of a Multi Document Interface Form (MDI Form) and 3 Child Forms. MDI form includes a 3 pull down menus for file manipulation, data management and help (Figure 2). The first child form is a welcome screen; the second is about dialog box. The third child form is the main form, all operations done.

Main form consists of list boxes for data manipulation and data screening, an image box for graph and a text box for report and a command box set. The blood lactate and workload data is simply input by "**blood_lactate_value; workload;**" syntax. After the input data saved and calculate command box clicked the graph and report will be built. In the graph, the sampled blood lactate

TABLE 1: Formulas that were used for calculation of regression equation.

$y = a + bx$	$= a + b\log(x)$
$b = \dfrac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\Sigma(x_i - \bar{x})^2}$	$b = \dfrac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\Sigma(x_i - \bar{x})^2}$
$a = \bar{y} - b\bar{x}$	$a = \bar{y} - b\bar{x}$
la= a + bx (Work Load)	log(la)= a + bxlog (Work Load)
la= a + bx (Speed)	log(la)= a + bxlog (Speed)

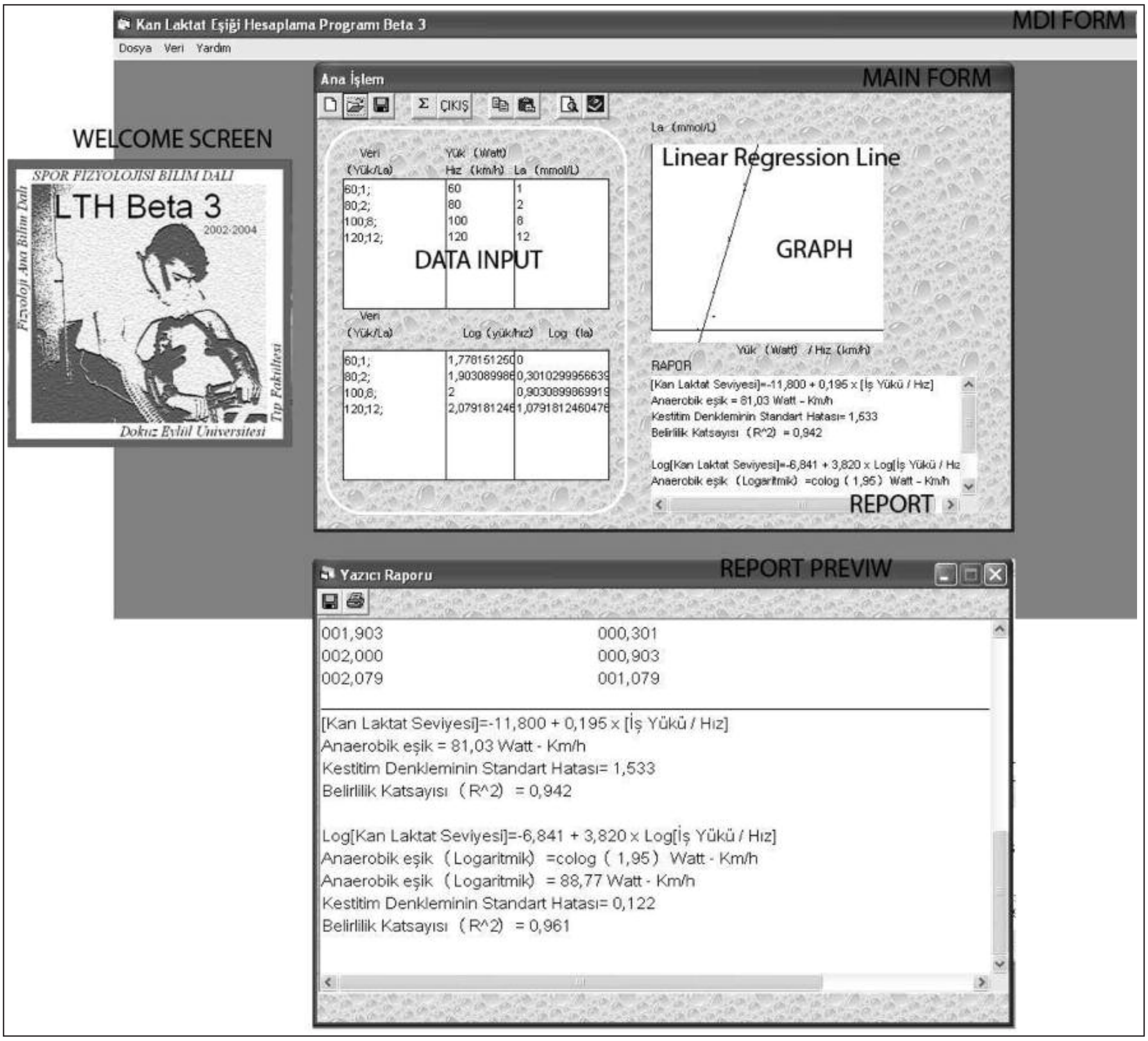

FIGURE 2: Multi Document Interface Form (MDI Form) with child forms.

and work load points are shown with linear regression line.

In the report sample data tables, model equations, standard error of estimate and R^2 coefficient are shown for linear and logarithmic model. The user interface was designed in Turkish Language.

An algoritm was developed and optimized to calculate regression equations and equation coefficients (Figure 3). The algorithm was implemented in Microsoft Visual Basic 6.

DISCUSSION

Eye examined LTH is a simple method but it includes problems related to inter-observer and intra-observer agreement. Statistical models can solve this problem but they involve complex statistical and mathematical procedures and can only be applied by using computer and statistical software. Moreover, sport scientists need to be expertise on both statistics and mathematics. In this study software was developed which calculates and reports LTH by using statistical and mathematical models in an easy way.

The software directly calculates LTH in a single step for linear and logarithmic models. This can be done by statistic software more then 3 steps (calculation of regression equation, calculation of inverse regression model and determination of lactate threshold) for each model.

There is also a graphical representation of linear regression model in the user interface, which

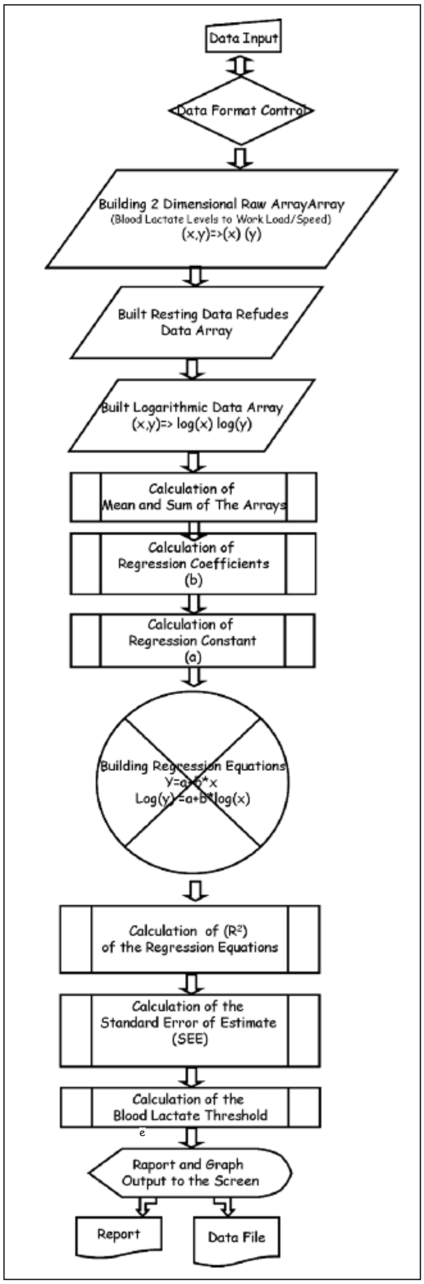

FIGURE 3: Algorithm of the software.

can be useful to determine the deviation of each point from the model.

This application should be useful for both laboratory and field studies to obtain objective test results. This study can be accepted as the first step for software on statistically and mathematically determined LTH. Other statistical and mathematical models of blood lactate threshold should be studied in future studies. Also graphical interface should be developed to clearly represent the breaking point. Also language support in different languages should be supported.

CONCLUSION

As it has been mentioned in the previous sections, there are different approaches to test the reliability of any LTH estimation method. Inter and intra evaluator methods are the most common methods used for evaluating the reliability of LTH methods. None of the current studies report 100% agreements on intra and inter evaluator agreements for visually detected LT methods.[16,26] Statistical and mathematical methods are not affected by personal factors and result of them can be accepted as more objective.[30] For the same statistical & mathematical method, the result is always same for the same data set. But they involve complex statistical and mathematical procedures and can only be applied by using computer and statistical software and they also need expertise on both statistics and mathematics.[16] So, It can be concluded that the current study proposes a user-friendly software that overcomes the subjectivity and complexity problems related with LTH methods.

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