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Performance testing and improvement in human athletes

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Sports medicine poses perpetual challenges including the evaluation of fitness, prediction of performance, determination of training loads and the repairing and prevention of damages. Evaluation of fitness was initially carried out with measures at rest, but it was necessary to wait for the application of exercise physiology in order to find good parameters for evaluation of fitness and prediction of performance. Firstly, in competitive distance running *(Costill* 1967), performance has been correlated with maximal level of oxygen uptake (VO_2 max). Later, low to moderate correlations between VO_2 max and race times have been obtained *(Pollock* 1977). But, since the introduction of the anaerobic threshold *(Kinderman* et al 1979), it is well accepted that, the oxygen uptake corresponding to the lactate threshold, is the best determinant in human endurance sports *(Takeshima* and *Tanaka* 1995).
The blood lactate profile (HLa-P) has become a widely accepted method of athletic performance evaluation and it is also a training intensity indicator. HLa-P includes, however, different parameters such as anaerobic threshold (AnT), individual anaerobic threshold (iAnT), maximum lactate steady state (MLSS) and Critical Power (CP). So far, it appears necessary to have an overview of these different parameters.

The concept of Anaerobic Threshold (AnT) was first introduced by *Wasserman* in 1967. It has been suggested to be a key parameter defining the ability to maintain high intensity exercises. It also represents a critical intensity above which endurance performance is severely limited. *Heck* et al (1985) have stated that the value of 4 mM of blood lactate is the AnT for running human athletes. Another term for AnT is the Onset of Blood Lactate Accumulation (OBLA) proposed by *Sjodin* and *Jacobs* (1981). This was defined as the intensity at which blood lactate concentration begins to increase, which also corresponds to 4 mM. This 4 mM threshold has been well established as a statistical mean value for large groups of athletes, but it is in fact an oversimplification of the relationship between lactate accumulation and relative exercise intensity.

The AnT is usually determined during a stepwise increasing test procedure. However, the methodology used differs between studies. Thus, it makes comparisons of results difficult from one methodology to another. According to *Foxdal* et al (1994) the following points should be taken into account :

- the choice of blood sampling site (arterial, veinous or capillary)
- the choice of blood media analysed (plasma, whole blood)
- the design of the exercise test (duration of each step, size of the increment between each step).

For *Foxdal* et al (1994) the most accurate protocol in order to predict the maximal endurance running capacity based on the OBLA determination seems to be a test protocol of repeated 8 min running duration in combination with a mean increase in running velocity of 0.25 $m.s^{-1}$, used when the lactate measurements were performed with haemolyzed capillary blood.
In contrast to the AnT concept, *Stegmann* and *Kindermann* (1982) have suggested that each person has individual Anaerobic Threshold (iAnT). The iAnT represents the highest metabolic rate at which elimination of lactate from the blood continues to equal the rate of diffusion from exercise muscle to the blood. Some authors have shown that trained, as well as untrained subjects, exercising at their iAnT can do so for 30 min without any significant change in blood lactate concentration during the last 15 min of exercise (*Mc Lellan* and *Jacobs* 1989 ; *Mc Lellan* et al 1991). The iAnT is determined during an incremental load test from the changes in blood lactate, both during and after the test. *Stegmann* and *Kindermann* (1982) have found that lower exercise intensities were evident at iAnT when compared to those of the 4 mM AnT.
Another concept is the Maximal Lactate Steady State (MLSS) which represents the upper limit of blood lactate concentration resulting in a lactate steady state during constant workload. According to the procedure published by *Heck* et al (1985), it was defined as the highest blood lactate concentration increasing by no more than 1.0 mM within the last 20 minutes of constant workload. But, to achieve a real MLSS, it has been found necessary to have 4 or 5 exercise sessions up to 30 min duration, performed at exercise intensities between 50 % and 90 % of VO_2 max. A single constant workload is performed per day to ensure a sufficient period of recovery between constant load tests. It appeared *(Heck* et al 1995) that the mean blood lactate level at this MLSS is statistically close to 4 mM (3.9 ± 1.1 mM with a range from 2.2 to 6.7 mM). In addition, the MLSS determined by means of the AnT or the iAnT during an incremental test appears to be overestimated, especially in highly trained endurance athletes *(Beneke* 1995).

In order to bring a more easy evaluation of this MLSS, the critical power concept (CP) has been proposed. This was first described by *Monod* and *Scherrer* (1965) and has been defined by them as the highest tolerable work rate during prolonged exercise without fatigue. With this concept, *Billat* et al (1994) recently proposed an easy protocol in order to provide an immediate estimation of the exercise intensity corresponding to the MLSS using only 2 submaximal tests of 20 minutes each, performed at 65% and 80% of the VO_2 max and separated by 40 minutes of complete rest.

Using CP and AnT *Moritani* et al (1981) found a significant correlation between these 2 parameters. These authors have argued that physiologically AnT and CP may be similar, as CP appears to represent the maximal rate of work beyond which energy reserves will ultimately be depleted. In contrast, more recently, other authors such as *McLellan* and *Cheung* (1992) and *Clingeleffer* et al (1994) proposed that the terms CP, iAnT, and AnT cannot be interchanged because they do not indicate the same work level.

In conclusion, blood lactate profile is an important parameter (eventually associated with ventilatory threshold) for evaluation of an athlete's fitness and prediction of performance in endurance sports. Further studies are necessary in order to select the best blood lactate profile for each sport. This discussion has to take into account the balance of aerobic and anaerobic processes for energy expenditure related to each sport. Furthermore it can be assumed that the determination of several variables VO_2 max, H La-P, biomechanic parameters, muscle type, age and training habits will improve performance prediction for athletes competiting in different disciplines.

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24.–28. Juni 1996, Bonn	AESM-Pferdesportkongreß Kontaktadresse: Dr. Arno Lindner, Im Eichholz 10, D–53127 Bonn, Tel. (0228) 283286 Fax (0228) 284761
28.–30. Juni, 1996, Utrecht	Fifth Annual Scientific Meeting des European College of Veterinary Surgeons Spezial Seminare für Großtier- und Kleintierpraktiker (Laparaskopie, Laser, Chirurgie, „Walking casts“, Neues der AO-Vet) Kontaktadresse: ECVS, Frau Monika Gutscher, Winterthurerstr. 260, CH-8057 Zürich Tel. (0041 1) 365 14 56, Fax (0041 1) 313 03 84
29. Aug. – 1. Sept. 1996, Bern	Rückenerkrankungen beim Sportpferd Kontaktadresse: Klinik für Nutztiere und Pferde, Universität Bern, Länggassstraße 124, CH-3012 Bern, Tel. 031 631 22 43, Fax 031 631 26 20
27.–28. September, Beichlingen/Erfurt	3rd International Course in diagnostic and surgical Laparoscopy in the horse Kontaktadresse: Vet End Scope GmbH, Kiebitzpohl 35, D-48291 Telgte, Tel. 02504/3065, Fax. 02504/7929