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STANDARDISATION OF PHYSIOLOGY NOMENCLATURE

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Introduction:

In June 2004, the National Sport Science Quality Assurance Program (formerly the Laboratory Standards Assistance Scheme) hosted a workshop for physiology staff from Australian institutes/academies of sport and other institutions aligned with the LSAS exercise physiology laboratory accreditation program. A major theme of the workshop was related to the clarification and standardisation of nomenclature and terms of reference for a range of physiological parameters. An issue that has received much attention for a number of years.

This issue was also addressed at the 2004 NESC Applied Physiology Conference in October. Following this conference a working group was formed to review and discuss various aspects for standardisation of specific physiological nomenclature and terms of reference. It is the recommendations of this working group that form the basis of this paper.

Background:

A myriad of terms exist and are used, sometimes erroneously, across sports as well as institutes/academies for a number of 'common' sport science and training concepts. This potentially causes confusion amongst scientists, coaches and athletes. Not only for those who are required to work with a number of sports, but also for those new to the institute/academy network.

Potential benefits for the standardisation of nomenclature and terms of reference on a national basis include:

- promote consistency across sports and institutes/academies;
- assist with communication between scientists, coaches and athletes;
- provide a clear glossary of terms and definitions;
- offer strength to Australian sport science system;
- assist with the education process of scientists and coaches.

The following sections summarise recommendations for the standardisation of Physiology nomenclature and terms of reference on a National basis.

Lactate Thresholds:

Although the concept of blood lactate thresholds has been developing for over 60 years, there is still much controversy over both the explanation for and the methods that should be employed to identify them. In fact, there are probably more points of contention than agreement. In the context of this paper, we are aiming to standardise terminology and detection methods for lactate thresholds on a national level for Australian sport science. However, we must be conscious of international perception and ensure that whatever we decide is acceptable to the International community of physiologists and coaches with whom we are all in contact and who will read of work from Australia.

The majority of exercise physiology laboratories in Australia measure blood lactate thresholds on a routine basis as an integral part of the physiological assessment of endurance athletes. There are three main reasons for the measurement of the blood lactate response to exercise:

- indicator of training adaptation – blood lactate thresholds have been shown to be more sensitive indicators on training adaptations than $\dot{V}O_{2max}$, especially in highly trained athletes where there may be little or no change in $\dot{V}O_{2max}$ yet significant changes in endurance performance; numerous studies have also demonstrated that blood lactate thresholds can increase with training beyond the point where $\dot{V}O_{2max}$ fails to increase.
- correlation with endurance exercise – blood lactate thresholds are highly related to performance in various types of endurance activities and have been suggested as better indicators than the 'gold standard' $\dot{V}O_{2max}$.
- optimal training stimulus – multitude of data suggesting that blood lactate thresholds may provide best indices of exercise intensity by which to prescribe training and therefore a means by which to optimise training intensity.

The above three points give strong support to the evaluative and predictive power of the blood lactate response to exercise.

One problem in understanding and interpreting blood lactate thresholds is the overabundance of terms used to describe similar phenomena, and furthermore the use of the same terms to describe different phenomena. This is further complicated by the array of terms used internationally.

Table 1: Sample terminology for classification of changes in blood lactate response to progressive exercise.

1st Point / Threshold	
Lactate Threshold (LT)	First workload at which there is a sustained increase in blood lactate concentration above resting levels
Aerobic Threshold	Fixed 2.0 mmol.L^{-1} value (Kindermann et.al. 1979)
Lactate Threshold	Workload preceding a 0.4 mmol.L^{-1} rise in blood lactate above the baseline (ADAPT 1995)
Lactate Threshold	Point of deflection in the log [blood lactate] versus log $\dot{V}O_2$ transformation (Beaver et.al. 1985)
Lactate Threshold	Workload preceding non-linear rise in blood lactate during progressive work (Ivy et.al. 1980)
Maximal Steady State	Fixed 2.2 mmol.L^{-1} value (LaFontaine et.al. 1981)
Onset of Plasma Lactate Accumulation	Exercise intensity that elicited a blood lactate concentration 1.0 mmol.L^{-1} greater than baseline (Farrell et.al. 1979)

2nd Point / Threshold	
Anaerobic Threshold (AT)	The workload causing a rapid rise in blood lactate indicating the upper limit of equilibrium between lactate production and clearance
Aerobic-Anaerobic Threshold	Fixed 4 mmol.L^{-1} value (Mader et.al. 1976)
Onset of Blood Lactate Accumulation OBLA	Fixed 4 mmol.L^{-1} value (Sjodin and Jacobs 1981)
4 mmol/l Threshold	Fixed 4 mmol.L^{-1} value (Heck and Mader 1985)
Anaerobic Threshold	Modified Dmax utilising LT instead of first workload as start point (ADAPT 1995)
Anaerobic Threshold	Steep part of exponential increase in lactate concentration, approximately 4 mmol.L^{-1} (Kindermann et.al. 1979)
Dmax	Point on curve at maximal distance from line connecting starting and finishing workloads (Cheng et.al. 1992)
Individual Anaerobic Threshold	A fixed slope point on lactate power curve whose tangent is equal to 51^o (Keul et.al. 1979)
Individual Anaerobic Threshold	Based on a model to define workload at maximal lactate steady state – rate of diffusion in equilibrium with rate of elimination (Stegmann et.al. 1981)
Lactate Threshold	Non linear increase of at least 1 mmol.L^{-1} (Coyle et.al. 1984)
Maximal Steady-State Workload (MSSW)	Fixed 3 mmol.L^{-1} value (Borch et.al. 1993)

Although many terms and definitions exist most can be categorised into:

- fixed blood lactate concentrations – fixed blood lactate concentrations of 2.0 mmol.L^{-1}, 2.2 mmol.L^{-1}, 2.5 mmol.L^{-1}, 3.0 mmol.L^{-1} and 4.0 mmol.L^{-1} have all been used however they are strongly influenced by an athlete's nutritional and training/recovery status.
- individualised lactate and anaerobic thresholds – numerous methodologies for individualisation of blood lactate thresholds including log transformations, rates of metabolite accumulation, tangential methods and even subjective assessments to determine individualised LT and/or AT intensities.

The appropriateness of the methodology for evaluating and/or prescribing training or performance must be considered. Additionally, it is recognised that protocol related factors such as workload duration, continuous versus discontinuous workloads, ergometer type and blood sampling site can all affect the measurement of blood lactate response to incremental exercise. Therefore, consideration needs to be given to these factors.

Standardised methodology for identification of lactate thresholds is seen as important in allowing consistent and reliable identification of characteristic points on the blood lactate curve, both within sports but also across sports. Additionally, lactate thresholds are seen as central indicators of training adaptation and for exercise prescription.

Accordingly, the following terminology and definitions for blood lactate thresholds is supported and recommended for implementation of a National level.

Table 2: Blood Lactate Thresholds

Blood Lactate Threshold	***Abbreviation***	***Definition***
Lactate Threshold 1	LT1	The first intensity at which there is a sustained increase in blood lactate concentration above resting levels.
Lactate Threshold 2	LT2	The intensity indicating the upper limit of equilibrium between lactate production and lactate clearance.

Endurance Training Zones:

A myriad of terms for endurance training zones exist and are used across sports as well as across institutes/academies. This is highlighted by fact that various chapters in 'Physiological Tests for Elite Athletes' text use different terminology.

Table 3: Sample endurance training zone classifications (from:"Physiological Tests for Elite Athletes")

Sport	***Endurance Training Zones***
Cycling	Endurance, E1, E2, E3, E4
Kayaking	Aerobic, A1, A2, A3, A4, A5, A6
Rowing	Utilisation, U3, U2, U1, AT, Transport
Triathlon	T1, T2, T3, T4, T5, T6 * * Note different definition for zone determination applied

So whilst different terminology, descriptions and definitions are used, there is evidence of some commonality between them. It is on these grounds that a recommendation for standardised endurance training zone terminology and definitions is based.

The following five training zones (T1 – T5) and associated descriptions and definitions are supported and recommended for implementation on a National level. However, please note that the following table serves as a guide for prescription of training in relation to various physiological parameters. Values and ranges presented are "descriptive" and individual variations will occur. Values and ranges for individual athletes can be refined by working with an exercise physiologist.

Table 4: Endurance Training Zones.

Training Zone	***Description***	***Blood Lactate Threshold Relationship***	***Blood Lactate (mmol/L)***	***Percent HRmax (%)***	***Percent $\dot{V}O_{2max}$ (%)***	***Borg's RPE Scale***	***Critical Duration (h:min:s)***
T1	Light Aerobic	Below LT1	< 2.0	60 – 75	< 60	Very Light	> 3 hours
T2	Moderate Aerobic	Lower half between LT1 and LT2	1.0 – 3.0	75 – 84	60 - 72	Light	1-3 hours
T3	Heavy Aerobic	Upper half between LT1 and LT2	2.0 – 4.0	82 – 89	70 – 82	Somewhat Hard	20 min – 1 hour
T4	Threshold	LT2	3.0 – 6.0	88 – 93	80 – 85	Hard	12 – 30 min
T5	Maximal Aerobic	Above LT2	> 5.0	92 – 100	85 – 100	Very Hard	5 - 8 min

Description – general classification of five training zones according to aerobic intensity;
Blood Lactate Threshold Relationship – describes relationship between five training zones and two blood lactate threshold points; also describes position of training zones on 'standard' blood lactate curve;
Blood Lactate – guide to blood lactate concentrations typically associated with intensity of exercise in each training zone; overlap in values highlight individuality of responses.
Percent HR_{max} – guide to percentage of maximum heart rate typically associated with intensity of exercise in each training zone; overlap in values highlight individuality of responses.
Percent $\dot{V}O_{2max}$ – guide to percentage of maximum oxygen uptake typically associated with intensity of exercise in each training zone; overlap in values highlight individuality of responses.
Borg's RPE Scale - ratings of perceived exertion according to Borg's 6-20 rating (15 point) of perceived exertion table; Borg, G.A.V. (1962b). A simple rating scale for use in physical work tests. Kungliga Pysiografiska Sallskapets i Lund Porhandlingar, 2, 7-15.
Critical Duration – guide to time to exhaustion typically associated with intensity of exercise in each training zone; overlap in values highlight individuality of responses.

References:

Physiological tests for elite athletes. Australian Sports Commission, ed. Christopher J. Gore editor, Human Kinetics, Champaign Illinois USA, 2000.

Chapter 4: Blood Lactate Transition Thresholds: Concepts and Controversies, *Physiological tests for elite athletes*. Bourdon, 2000.