BLOOD LACTATE MONITORING IN A PERIODIZED DISTANCE TRAINING PROGRAM: A CASE STUDY

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INTRODUCTION: The degree of success of any sports team directly relates to the coach's ability to project a long term annual or quadrennial plan while effectively incorporating and prioritizing specific subcomponents (DeWeese, Hornsby et al. 2015). Competitive running is inherently quantified in measures of distance and duration, which impact physiological variables and therefore is of particular interest to sport scientists. Monitoring techniques aimed at assessing physiological variables can offer tremendous insight into the effectiveness of the current training paradigm and offer guidance. Recent research has used blood lactate concentrations to develop training intensities for track and field and cross-country (Belcher and Pemberton 2012, Belcher and Pemberton, 2012). The use of blood lactate measurement for prediction and validation of running intensity and subsequent pacing has been suggested as the best index for aerobic capacity and endurance running performance (Yoshida, Chida et al. 1987). Blood lactate monitoring can ensure that a training session is performed at specific intensities that follow an annual plan. Using blood lactate as a marker of training intensity alongside periodization theory, Belcher and Pemberton proposed a 22 week model to demonstrate the effectiveness of combining physiological monitoring and coaching (2012). This study focused on the application of this model throughout a competitive phase in the collegiate season, wherein the emphasis turned to aerobic power. The emphasis of increased aerobic power is reflected by blood lactate values > 6, RPE ranging from 16-17, and HR above 180 (Belcher and Pemberton, 2012). The purpose of this paper is twofold 1) to observe a collegiate national level athlete's training plan during a competitive period; and 2) to expand on how training paces and blood lactate can be used as a monitoring tool.

METHODS: The study involved retrospective analysis of archived monitoring data from one athlete of a nationally ranked collegiate cross country and track team (Table 1). Monitoring took place over the course of three seasons, including indoor track, outdoor track and cross country. The subject read and signed a written informed consent document as approved by the university's Institutional Review Board.

Testing sessions occurred on a weekly basis throughout the three seasons. Blood lactate concentrations were measured immediately after each testing session and within 1 minute of the completed session (Hart, Drevets et al. 2013). A blood sample (0.7uL) was taken from the distal index finger and immediately analyzed with a handheld blood lactate meter (Lactate Plus, Nova Biomedical Corporation, Waltham, MA). Testing sessions followed the device recommended specification and running intensity (min/mile) and blood lactate value were recorded for each testing session. (Tanner, Fuller et al. 2010). Research has demonstrated that this device is a valid and reliable instrument across a wide range of blood lactate concentrations (Hart, Drevets et al. 2013). Pearson correlation was performed to assess the relationship between blood lactate concentration and training intensity (minutes per mile).

Table 1: Descriptive Statistics

Age (yrs)	Height (cm)	Body mass (kg)	Sum of Skinfolds	Relative V̇O2max (ml/kg/min)	5000m PR	800m PR
21	170	52.1	78.5	62.1	17:14	2:04

RESULTS: The results of this study indicate the study participant experienced higher lactate values as the pace of each interval increased with regards to intensity. Raw blood lactate values were grouped according to interval pace, which directly related to this study participants' prescribed pacing level structure as set forth by the team's head coach. Mean blood lactate values were calculated for each specific training paces. A correlation analysis between mean blood lactate values and pace time revealed a significant negative correlation ($r = -0.93$, $p < 0.001$) when examining pace and mean blood lactate values from all three seasons (indoor track, outdoor track, cross country) and pace of interval. Table 2 displays pace level groupings and mean blood lactate values of this study participant.

Table 2: Correlation between interval pace and participant blood lactate.

Intensity Level	Time (minute/mile)	Mean Bla (mmol)
Fast (Maximal Pace)	4:08	17.1
Mile Race Pace	4:56	13.6
3k Race Race	5:06	14.6
Goal 5k Race pace	5:20	12.5
5k Race Pace	5:35	14.6
Marathon Race Pace	6:10	8.9
Easy Pace	7:00	7.4

Pearson's Correlation ($r = -0.93$), $p < 0.001$

DISCUSSION: One of the primary goals of the competition period in a periodized annual plan is to improve the athlete's ability to perform at race pace (Belcher and Pemberton, 2012). When programming during this time period, there is an increased emphasis on overall aerobic power, or V02 max training. From our results, the blood lactate values during the competitive period of training corresponded with the prescribed intensities during a competition period block. In addition, the blood lactate concentrations during testing intervals were similar to those taken on race day, thus accomplishing the primary goal of training at similar intensities. In addition, in both the track and cross country seasons, workouts indicate significant negative correlations between pace and BLA. As expected, the faster the athlete ran over the course of the workout, the higher the blood lactate measurement. The workouts and blood lactate measurements can be taken and applied to two training models, including Jack Daniels and Belcher and Pemberton (Belcher and Pemberton, 2012, Daniels, 2013). Our results expand on the Belcher model, and demonstrate how the competitive block can look in a collegiate season, which is longer because of racing schedule and importance of multiple peaks. Coaches and sport scientists can apply a combination of these models to prescribe training. The coach can use race performances to obtain workout intensities from the Daniel's VDOT chart, and blood lactate norms can be applied and then used to reflect the actual efforts of the athlete. The Daniels VDOT chart gives approximate training paces based on previous research and competition results (Daniels, 2013),. The goals of each block of training can be closely monitored to assure the athlete is training appropriately. This is especially important when paces fluctuate because of terrain or weather conditions.

Lactate monitoring in a practice and race setting is still a novel concept, as it is often difficult to successfully implement. It is only made possible when the sport scientist, coach and athlete are able to work together seamlessly. As coaches prescribe set intervals, the sport scientist must be able to monitor without influencing the athlete's workout. The measurement of blood lactate concentration is currently the most precise method of monitoring training intensity (Maglischo 2003). The following table is an applied example of how a collegiate coach, athlete and sport scientist can work together to effectively prescribe and monitor daily programming as part of an annual plan (Table 3). As seen above, it is similar to the prescribed and observed workout paces, however E pace and M pace are slightly slower. This is more in line with the VDOT chart and will allow for more recovery and specific focus (Daniels, 2013).

Table 3: Performances and Prescribed Workloads as Part of an Annual Plan

Performance	VDOT	E Pace	M Pace	T Pace	I Pace	R Pace
17:14 5k, 2:04 800m	61	7:16 min/mile	6:09 min/mile	5:50 min/mile	5:20 min/mile	4:56 min/mile
	Lactate (mmol)	6.0-8.0	8.0-10.0	10.0-12.0	>12.0	Max

Block	General Prep	Specific Prep	Competition	Peak	Transition
Increased Emphasis	E Pace	M and T Pace	I Pace	I Pace	E Pace

(Alban adapted from Daniels, 2013 and Belcher & Pemberton 2012)

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