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A Standardized System of Training-Intensity Guidelines for Track and Field and Cross Country Coaches

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ABSTRACT

A training program designed to optimize athletes' performance abilities cannot be practically planned or implemented without a valid and reliable indication of training intensity and its effect on the physiological mechanisms of the human body. The objectives of this paper are to (a) review training-intensity guidelines developed for coaches, inclusive of the associated physiologic metrics validated in a field study; (b) describe a seasonal application of the guidelines for coaches; and (c) share supporting commentary from coaches interviewed in the field study. A standardized system of training-intensity guidelines for the sports of track and field/cross country was field tested. The system was modeled after the standardized system of training-intensity guidelines used by USA Swimming. Track and field and cross country coaches were asked to comment on the perceived utility of the standardized training-intensity guidelines. Results of the field study show that coaches uniformly confirmed the utility and applicability of the training-intensity guidelines.

Key Words: blood lactate, training intensity, training prescription



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A wide variety of training-intensity guidelines and training-intensity scales have been developed to assist coaches with the prescription and monitoring of training intensity (Friel, 2004). Many of the methods described in the popular literature, however, are conjectural and/or imply a degree of biological specificity or adaptation that cannot be validated (Fry, Morton, & Keast, 1992; Seiler & Kjerland, 2006). In addition, much of the advice given within the popular literature pertaining to training intensity is non-specific, contradictory, and often simply unhelpful (Hills, Byrne, & Ramage, 1998). Because of this, one of the most daunting tasks sport coaches face is to sift through the literature and identify valid and reliable methods for monitoring training intensity (Gambetta, 2007). This can be a particularly difficult task for certain groups of sport coaches, such as American track and field or cross country coaches, who do not have the sport science preparation needed to determine and prescribe optimal workload intensities for their athletes (Smith, 2005; Vigil, 1997). It has been argued that training recommendations are being made by many American track and field and cross country coaches to beginning, intermediate, and elite athletes without precise knowledge of the effects on athletic performance (Hawley, Myburgh, Noakes, & Dennis, 1997). As a consequence, the resulting training adaptations may differ from those desired, thus diminishing the effectiveness of subsequent workloads and the training program as a whole, and inhibiting the ability of athletes to succeed (Bompa, 1999; Janssen, 2001; Olbrecht, 2001).

Measurement of blood lactate concentration is currently the most precise method of monitoring training intensity (Maglischo, 2003). The development of valid and reliable training-intensity guidelines, based on the blood lactate curve and energy metabolism, has the potential to provide track and field and cross country coaches with specific logical directions for the prescription of workload intensities. Therefore, dividing the blood-lactate intensity curve into intensity zones and attributing to each zone a major training effect can facilitate coaches' ability to more objectively plan training programs, and thereby help limit overtraining.

The objectives of this paper are to (a) review training-intensity guidelines developed for coaches, inclusive of the associated physiologic metrics validated in a field study; (b) describe a seasonal application of the guidelines for coaches; and (c) share supporting commentary from coaches interviewed in a field study. A standardized system of training-intensity guidelines for the sports of track and field and cross country was field tested. The system was modeled after the standardized system of training-intensity guidelines used by USA Swimming. Track and field and cross country coaches were asked to comment on the perceived utility of the standardized training-intensity guidelines. Results of the field study show that coaches uniformly confirmed the utility and applicability of the training-intensity guidelines.

The intensity guidelines developed can facilitate the ability of coaches to create training sets and programs, knowing which main training effect to expect. In addition, classifying training intensity according to the predominant training effects allows coaches to more easily



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communicate with sport scientists and other coaches. Furthermore, this type of classification system diminishes the amount of subjectivity found when training is classified according to only subjective terms, such as hard, easy, light, etc., and provides coaches with a common language and uniform classification of training based on scientific evidence.

Training-Intensity Guidelines

The standardized training-intensity guidelines model consists of nine intensity zones that can be condensed into four broad classifications. These are: (1) recovery training, (2) endurance training, (3) speed or sprint training, and (4) economy training. A summary of the standardized training-intensity guidelines model is provided in Table 1.



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Table 1.
Training-Intensity Guidelines Model

Category (Abbreviation)	Intensity / Speed	Lactate (mmol/L)	% of MLSS Heart Rate (HR)	RPE
Recovery (REC)	<80% of MLSS	<1	<90 to 95	<9
Extensive Endurance (E1)	80 to 90 % of MLSS	1 – 2.5	90 to 95	10 - 12
Intensive Endurance (E2)	90 – 95% of MLSS	2 – 3.5	95 - 100	12 - 14
MLSS (E3)	95 – 103% of MLSS	3 – 5	100 - 106	14 - 16
Vo ₂ max (E4)	109 – 111% of MLSS	> 6	Max HR	16 - 18
Lactate Tolerance & Buffering (S1)	90 – 100% of max run for 1 to 3 minutes	Max	N/A	19+
Lactate Production (S2)	90 – 100% of max run for 5 to 50 seconds	N/A	N/A	N/A
Sprint (S3)	Max speed for 0.1 to 5 seconds	N/A	N/A	N/A
Economy (Econ)	Race pace or speed at which technique can be maintained	N/A	N/A	N/A

Recovery Training.

Recovery training (REC) is characterized by low-intensity training, usually below the aerobic threshold or less than 80% of the Maximal Lactate Steady Testing (MLSS) velocity, which maintains a high rate of blood flow throughout the body without causing acidosis or the depletion of muscle glycogen stores (Maglischo, 2003). This allows the muscles to replenish their glucose stores, enhances the rate of recovery and rebuilding processes of the muscles, and permits athletes to increase the amount of more intense training they can perform each week.



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Measures of heart rate as well as those associated with a 20-point Borg Rating of Perceived Exertion (RPE) scale should be below the values associated with extensive endurance training.

Endurance Training

Improving aerobic endurance delays athletes' reliance on the anaerobic metabolism, allowing them to run faster in the middle of the race before the onset of acidosis and fatigue. The broad category of endurance training (the focus of the training-intensity guidelines model developed and field tested for the present paper), consists of four levels of intensity: (1) extensive endurance training (E1), (2) intensive endurance training (E2), (3) MLSS training (E3), and (4) aerobic power training (E4).

Extensive endurance training

Extensive endurance training (E1) enhances the rate of oxygen delivery and utilization of both slow twitch (ST) and low-threshold fast twitch (FT) muscle fibers, provided the duration of the run is sufficient to deplete the glycogen stores of the ST muscle fibers that were initially used. It also increases the number and size of mitochondria and improves capillarization, blood shunting abilities, and lactate removal rates, all of which contribute to improvements in both aerobic capacity and aerobic power. Extensive endurance training should be performed at an intensity of 80 to 90% of MLSS pace, a heart rate approximating 90 to 95% of MLSS heart rate, and an effort of 10 to 12 on a 20-point Borg RPE scale (Bompa, 1999; Janssen, 2001; Maglischo, 2003; Olbrecht, 2001).

Intensive endurance training

Intensive endurance training (E2), about 90 % to 95% of the MLSS or approximately 95 to 100% of MLSS heart rate and 12 to 14 on a 20-point Borg RPE scale, results in a slightly elevated blood lactate value when compared to E1 (Bompa, 1999; Janssen, 2001; Maglischo, 2003; Olbrecht, 2001). This rise in blood lactate probably indicates that a greater number of FTa muscle fibers are being recruited. For that reason, E2 probably provides a greater stimulus for increasing the aerobic capabilities of both ST and FTa muscle fibers than E1.

MLSS training

Significant reductions in blood lactate values occur following training that approximates the MLSS, about 100 to 106% of MLSS heart rate and a perceived exertion of 14 to 16 on a Borg 20-point scale (Acevedo & Goldfarb, 1989). This adaptation probably occurs because MLSS training overloads aerobic metabolism, without engaging anaerobic metabolism to any great extent. The adaptations associated with MLSS training enhance the rate at which athletes clear lactate from the working muscle, enabling them to exercise at a higher percentage of their Vo_2 max before reaching their MLSS.



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A study conducted by McGehee, Tanner, and Houmard (2005) examined the accuracy of the maximal 30-minute run for estimating the velocity at MLSS. The study concluded that because of the simplicity of a 30-minute maximal run, the ease in interpreting the results, and the minimal equipment needed, a 30-minute maximal run for distance can be used by coaches and athletes to estimate the MLSS and heart rate at MLSS in an attempt to optimize run training intensity and performance.

Aerobic power training

Aerobic power training (E4) maximally taxes the heart's ability to deliver oxygen-rich blood to the body, providing the greatest stimulus for the development of $\dot{V}O_2$ max. Aerobic power training should occur at a speed that is 107 to 110% faster than the MLSS velocity and should produce maximal heart rates as well as a sensation of effort that is greater than 16 on a 20-point Borg RPE scale. Training at this intensity will increase the oxygen use and lactate removal rates of FTa and FTb muscle fibers and will also improve an athlete's ability to withstand acidosis.

Speed or Sprint Training

Training activities that utilize primarily anaerobic metabolic processes are classified as speed or sprint training: Speed 1 (S1), Speed 2 (S2) and Speed 3 (S3). This type of training is used to enhance an athlete's sprinting speed so that races can be started at a faster pace, with improved ability to buffer lactic acid, so that speed can be maintained despite the debilitating effects of acidosis (Maglischo, 2003).

Speed 1 training is designed to enhance lactate buffering and pain tolerance, anaerobic capacity, and strength endurance. Exercises executed at maximal or near maximal speeds for approximately 50 seconds to 3 minutes will fully activate and exhaust the anaerobic glycolytic system's capacity to produce energy (Janssen, 2001). Training to increase anaerobic capacity, therefore, should consist of maximal or near maximal exercises lasting approximately 50 seconds to 3 minutes (Olbrecht, 2001; Wilkinson, 1999). The rest periods between repetitions should be long enough to maintain running form, but not allow full recovery. This means that the recovery periods should range from 30 seconds to several minutes (Janssen, 2001).

Training that is meant to increase the glycolytic enzymes that regulate the rate of anaerobic metabolism (i.e., anaerobic power) and enhance speed endurance has been classified as S2 training. Maximal sprinting for 5 to 30 seconds will completely activate the enzymes that regulate anaerobic glycolysis and provide an appropriate stimulus for adaptations to increase the rate of anaerobic glycolysis. Active rest periods long enough to allow full recovery, approximately 3 to 5 minutes, should be enough for most of the high-energy phosphate stores to be replenished (Wilkinson, 1999). The number of repetitions that a runner is capable of completing before sprinting form is lost, usually 3 to 10, determines the number of repetitions that should be completed during a training session (Wilkinson, 1999).



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The main scope of S3 training is to increase maximum speed, strength, and reaction time. The primary stimulus for S3 training is force of acceleration (Bompa, 1999). Acceleration is the rate of velocity change that allows an athlete to achieve maximum velocity in a minimal amount of time (Gambetta, 2007). Training to enhance acceleration should consist of 0.1 to 5-second bursts of high-intensity work periods, 90 to 100% of maximum, with long recoveries, usually 1 to 2 minutes or longer in duration (USA Track & Field, 2005). Training at this intensity will also activate the phosphate energy system, increasing the activity of the enzymes that release energy through the ATP-CP reaction.

Economy Training

Training used to develop the specialized combination of neuromuscular abilities and metabolic capabilities needed to be successful in a specific event is classified as economy training (ECON). Training at competition-specific velocities allows athletes to become more efficient at performing the movements associated with that exercise, which reduces the exercise energy requirements, allowing the athlete to perform the exercise with less effort. When completing ECON training, the athlete should be provided enough time between exercise bouts to run each successive bout at the determined competition-specific intensity (Bompa, 1999; Maglischo, 2003; Olbrecht, 2001; Wilkinson, 1999).

Seasonal Application of Training-Intensity Guidelines

Periodization of the training process is the systematic organization of a training year and/or season into distinct, smaller periods of a more manageable size, each of which are attributed specific performance and/or developmental targets. Contemporary periodization models are based on the following sequence of training and competition: (1) the general preparatory period, (2) the specific preparatory period, (3) the competition period, (4) the taper or peak period, and (5) the off-season or transition period (Bompa, 1999; Freeman, 2001; Maglischo, 2003; Olbrecht, 2001; Rowbottom, 2000). Figure 1 represents a sample model of a periodized training program for a long-distance runner (i.e., 5000, 8000, half marathon and marathon).



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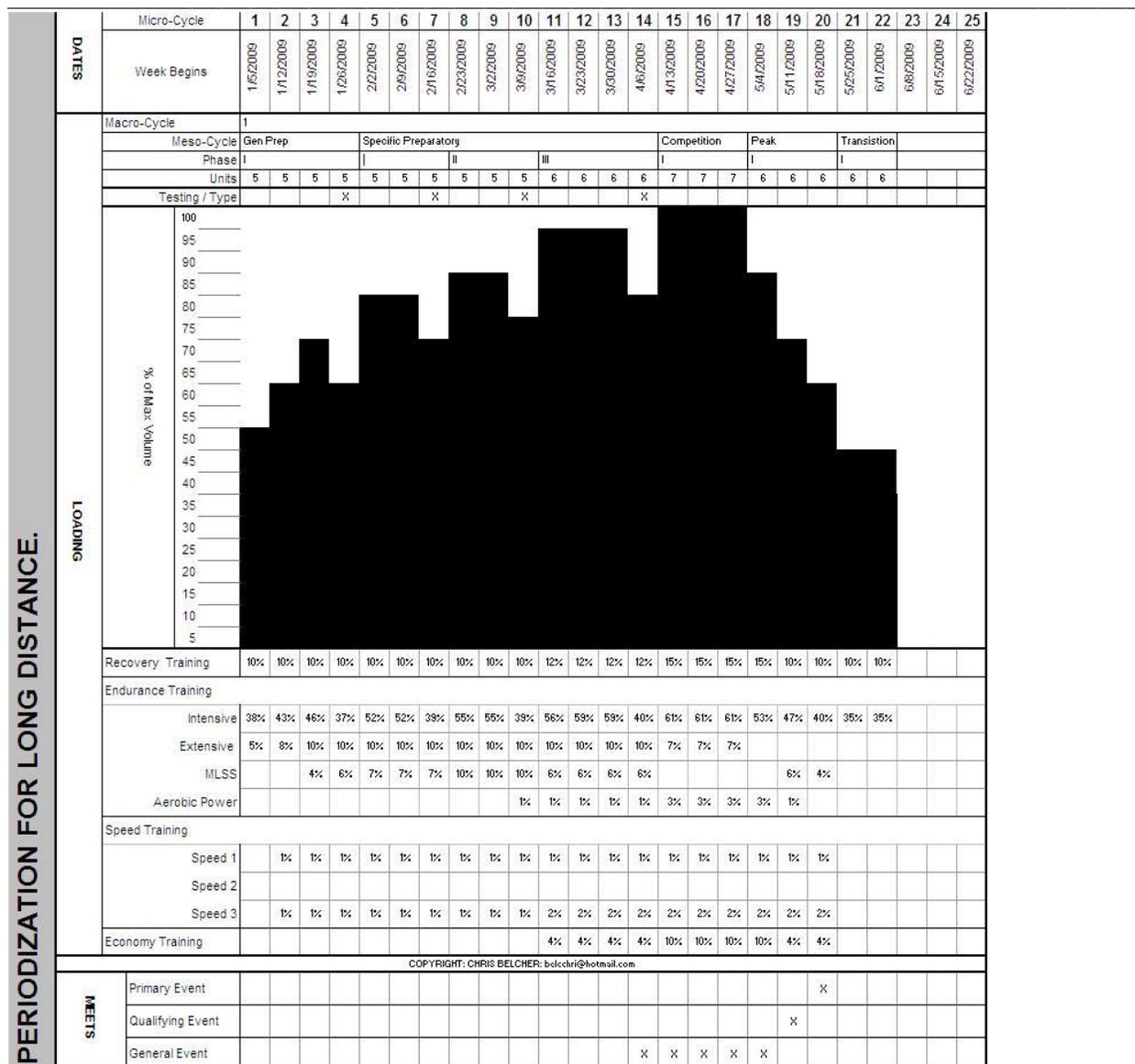


Figure 1. Training-Intensity Guidelines Derived From the Literature Review

General Preparatory Period

The aim of the general preparatory period is to re-introduce the athlete to training. A majority of the volume completed should be within the E1 and E2 endurance training zones (i.e., 80 to 95% of MLSS velocity, 90 to 100% of MLSS heart rate, or a sensation of effort between 10 to 14 on a 20-point Borg RPE scale). The primary goals of this period are to:

- Improve rates of oxygen consumption and lactate clearance from ST muscle fibers.
- Improve or maintain anaerobic power.
- Maintain aerobic and anaerobic muscular endurance.



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- Increase muscular strength.

Specific Preparatory Period

During the specific preparatory period the training emphasis is on increasing volume and improving endurance. The primary difference between the general preparatory period and the specific preparatory period is that a greater amount of volume will be completed at the MLSS and aerobic-power training-intensity levels. The primary goals of the specific preparatory period are to:

- Continue to improve rates of oxygen consumption and lactate clearance from ST muscle fibers.
- Continue to improve or maintain anaerobic power.
- Continue to maintain aerobic and anaerobic muscular endurance.
- Continue to increase muscular strength.
- Improve rates of oxygen consumption and lactate clearance from FT muscle fibers.

Competition Period

During the competition period, the coach must adjust the distribution of volume and intensity to compensate for various competitions and the event area the athlete specializes in (Bompa, 1999; Freeman, 2001; Maglischo, 2003; Olbrecht, 2001). The primary goals of the competition period are to:

- Maintain rates of oxygen consumption and lactate clearance from ST muscle fibers.
- Improve anaerobic power.
- Improve aerobic and anaerobic muscular endurance.
- Improve athlete's ability to perform at race pace.

Peak or Taper Period

The peak or taper period usually last one to two weeks and coincides with the most important competition of the year. The primary goals of the peak or taper period are to:

- Maintain rates of oxygen consumption and lactate clearance from ST muscle fibers.
- Maintain or improve anaerobic power.
- Maintain or improve aerobic and anaerobic muscular endurance.
- Maintain or improve athlete's ability to perform at race pace.

Off-Season or Transition Period

The primary goal of the off-season or transition period is to allow the athlete to recover from the physical and psychological stresses of the training year and/or season, and to complete the minimal amount of training necessary to maintain the underlying bio-motor and metabolic



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adaptations obtained during the training year (Bompa, 1999; Freeman, 2001; Maglischo, 2003; Olbrecht, 2001).

Coach Comments on the Utility of the Training-Intensity Guidelines

Following the development of the training-intensity guidelines model, four track and field and/or crosscountry coaches were contacted and recruited to participate in a brief training-intensity guidelines education session. During the education session each coach received educational information materials, with a table displaying the training-intensity guidelines. The materials provided the coaches with a basic reference consisting of general guidelines on how to construct training sets, monitor training intensity, and explain the physiological characteristics associated with the identified intensity zones. These education sessions lasted approximately 30 minutes and were conducted in one-on-one researcher-coach settings.

Approximately two weeks after each education session an hour long semi-structured follow-up interview was conducted to explore each coach's receptivity to, and perceived utility of, the standardized training-intensity guidelines developed. The general inductive approach was utilized, as articulated by Thomas (2006), for analyzing the qualitative data collected pertaining to each coach's receptivity to, and perceived utility of, the standardized training-intensity guidelines. From the information gathered, a basic demographic table of each of the coach's athletic and coaching history and education was constructed (Table 2).

The development of training-specific knowledge among sport coaches is a complex process, which requires the pursuit of individualized and usually impromptu learning pathways (Knowles, Gilbourne, Borrie, & Nevill, 2001). Generally, coaches develop their expertise from reflecting upon their own experiences as performers, as well as their experiences from previous coaching situations, and from observing and communicating with their coaching colleagues (Knowles, Gilbourne, Borrie, & Nevill, 2001). In addition, according to Quinlan (2002) coaches value experience and practical knowledge acquired from participation in sport and from other coaches above knowledge gained from sports science research. Therefore, it was not surprising that the high school and college coaches who provided commentary regarding the utility of the training-intensity guidelines indicated that their knowledge and training practices were derived largely from personal interpretations of previous competitive and coaching experiences.



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Table 2.
General Coaching Demographics

	College Coaches		High School Coaches		
	Coach 1	Coach 2	Coach 1	Coach 2	
Official Title	Asst. Track and Field Coach	Head Cross-Country/Assistant Track Coach	Head Cross-Country/Assistant Track Coach	Head Cross-Country and Head Track Coach	
Gender	Male	Male	Male	Male	
Total Years Coaching					
	High School	0	3	30	21
	College	5	29	0	0
Athletic History					
	High School	Yes	Yes	Yes	Yes
	College	4 years	0	2 years	3 years
Education					
	Formal		M.S. in Physiology	Minor in Health/Coaching	
	Professional seminar/Clinic	USATF Classes			USATF Classes
	From other coaches	Yes	Yes	Yes	Yes

Standardized Training-Intensity Guidelines as a Tool to Plan Objective Workloads

All of the college and high school coaches indicated that they believed that the standardized training-intensity guidelines could be used as a tool to enhance their ability to plan more objective workloads. For example, one college coach stated, “You can be more accurate with paces you run everything at.” Additionally, high school coaches expressed the idea that the training-intensity guidelines would enhance their ability to plan more objective workloads, and that they provided a more objective “measuring stick” than the methods they currently use to determine training intensity, allowing them to better “track” and “categorize” training. Coaches also expressed that the standardized training-intensity guidelines would allow them to better tailor workouts to specific athletes. According to one Coach, “What I really like, about this... I think it actually permits the coach to be able to be more individualized... it really opens them up to, to being their own person.”



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Standardized Training-Intensity Guidelines as a Tool to Understand Advances in Sport Science

College and high school coaches indicated that they believed that the standardized training-intensity guidelines would help them more easily understand modern trends, advances in sport science, and track and field training strategies. Most strikingly however, the main theme that emerged focused on the dissemination of knowledge among coaches.

A college coach indicated that the standardized training-intensity guidelines would help him not only in relating to other coaches, but also across a variety of different sports: “I think you will be able to relate more to elite coaches, their articles, their training methods. You can use it to relate across sports as well—bicycling, swimming, any endurance sport.” Similarly a high school coach believed that the standardized training-intensity guidelines would allow him to better understand what other sports, and in particular what other coaches, were doing: “By using those intensity levels you can look at the workout and then you can go, ‘Ok, now wait a minute, how does that fit in. Oh, I can see now why.’ It at least opens the door to understand why they are doing it.”

Standardized Training-Intensity Guidelines as a Tool to Enhance Communication between Coaches, Athletes, and Sport Scientists

Similar to the utility expressed relative to understanding modern trends and training, all of the coaches believed that the standardized training-intensity guidelines could be a useful tool to allow coaches to more easily communicate with other coaches, athletes, and sport scientists. When asked to identify the strengths of the standardized training-intensity guidelines, all coaches were quick to note the value of common terminology and associated terminology and definitions. College coach 1 (see Table 2) captured this sentiment commenting on the “broad range” of information associated with and used to develop the standardized training-intensity guidelines as a possible detriment, stating:

The strength is, in my mind...the broad range that you cover, you have gone over every aspect of training for an endurance athlete... What I need to do now is take what I have learned from what you have done, and try to, you know, quantify it in a way that will... make it useful to me. If I don't make it useful to me then it's my fault, because there is good information.

College coach 2 stated, “I think the research is a big strength...the terminology and the stuff you do is proven, you know, to work, and that's legit.” College coach 1 also believed that the amount of information and the way it had been used to devise the standardized training-intensity guidelines were strengths: “It's nice to have the specific stuff there. It's nice to have it all broken down. And I think the plus with this is that...it's all there...It's very specific and it gives a lot of detail...It gives examples... it gives possibilities.”



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Summary and Conclusion

Valid and reliable training-intensity guidelines, based on the blood lactate curve and the associated readily assessed psycho-physiologic metrics (i.e., heart rate and RPE), provide specific directions for the prescription of workload intensities, thereby enabling more objectively planned and monitored training programs—a benefit specifically noted by the coaches interviewed in this study. As beneficiaries of the training-intensity guidelines model, track and field and crosscountry athletes are likely to experience a decreased incidence of overtraining and increased performance potential. Finally, this paper is important because it (a) contributes to the empirical body of knowledge, in terms of the application and utility of training-intensity guidelines in the sports of track and field and cross country; (b) culminated in a user-friendly (coach-ready) training-intensity guidelines model, inclusive of track and field and crosscountry training-set construction guidelines and seasonal application and sport periodization examples; and (c) provides an inquiry model from which further study can be engaged.



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