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INTEGRATION OF BIOCHEMICAL TECHNOLOGY IN TRAINING GUIDANCE USING ENERGETIC PARAMETERS

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Abstract

Aim. The present study aims to demonstrate the validity and effectiveness of integrating biochemical and energetic technologies into the sports training process. Energetic parameters are employed as fundamental operational variables for the monitoring, modeling, and fine regulation of training load. The participants were subjected to a strictly individualized training protocol, systematically guided by continuous energetic assessments conducted throughout the entire duration of the experiment. The central objective of the study is to optimize performance by increasing exercise capacity in a quantifiable and biomechanically efficient manner.

Methods. The observational and interventional process was carried out over a period of two months. The initial evaluation phase included testing four subjects through standardized endurance assessment protocols, aimed at identifying functional characteristics and potential individual deficiencies. Within the experimental framework, training guidance methods based on energetic parameters were implemented, specifically through heart rate monitoring and the determination of blood lactate concentration. These procedures enabled the analysis of the correspondence between cardiovascular and muscular responses throughout physical exertion.

Results. The final assessments confirmed the study hypothesis, demonstrating that training guidance based on modern monitoring and control methods leads to a significant improvement in endurance capacity. These performance gains were achieved over a relatively short time frame and were associated with a reduced risk of injury, thereby highlighting the effectiveness and safety of the applied protocol.

Conclusions. The final assessments confirmed the study hypothesis, demonstrating that training guidance based on modern monitoring and control methods leads to a significant improvement in endurance capacity. These performance gains were achieved over a relatively short time frame and were associated with a reduced risk of injury, thereby highlighting the effectiveness and safety of the applied protocol.

Keywords: Training optimization, Energetic parameters, Biochemical monitoring, Blood lactate, Heart rate.

Introduction

Effort monitoring in sports activity represents a fundamental component of the training process, its importance increasing significantly as the deeply individualized nature of athletic preparation has become increasingly evident. At present, the monitoring of the biological effects generated by training stimuli on the human body is conducted across three principal levels (Bidiugan, 2022). The energetic level focuses on the supervision of energy production mechanisms, the associated metabolic costs, and potential metabolic imbalances induced by physical exertion. Two essential parameters are employed for this assessment: heart rate and blood lactate concentration. The determination of heart rate constituted the earliest method for quantifying physiological imbalances induced by physical load. Initially, pulse measurement was performed manually; however, technological advancements led to the development of automated monitoring devices (heart rate monitors), followed by the continuous expansion of cardiovascular assessment technologies (Tocitu, 2000). Currently, there are compact devices, comparable in size to a matchbox, capable of automatically recording exercise electrocardiograms, including in aquatic environments—an aspect of particular relevance for high-performance athletes in disciplines such as swimming. The second major parameter, blood lactate concentration, has provided critical information regarding exercise intensity, allowing the delineation of metabolic effort zones based on the biochemical pathways of energy production. Its practical relevance has been further enhanced by the miniaturization of lactate analysis equipment, now available in the form of portable devices similar in size to a stopwatch and at an accessible cost (Tocitu & Cătănoiu, 2001). These instruments have become indispensable, particularly in sports characterized by substantial environmental variability (e.g., cross-country skiing, kayaking–canoeing, cycling, rowing, marathon running, biathlon). One such device is the Lactate Pro 2, which was also employed in the present experiment (Mackenzie, 2005). The integration of data obtained from heart rate monitoring and blood lactate assessment, and the investigation of the relationship between cardiovascular and metabolic responsiveness, represent the culmination of the development of energetic training-monitoring methodologies. Within the sports training process, the most relevant information is often derived from the discrepancies identified between heart rate values and lactate levels, as these reflect the differential manner in which the organism responds to the physiological stress imposed by exercise.

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Objectives

The objective of this research was to optimize training methods through the integration of modern technologies, with the aim of achieving positive performance outcomes within a relatively short time frame while maintaining a low incidence of injuries.

The target group consisted of four performance athletes from an urban environment, aged between 18 and 25 years.

Table 1. Subjects group

NAME	AGE	SEX	WEIGHT (KG)	HEIGHT
A.L.	24	M	85	178
A.S	20	M	75	179
I.L.	18	M	77	185
T.M	25	M	81	178
C.T	18	M	71	183

Methods

Intervention protocol

For the purposes of this study, a variety of training methods were employed, incorporating modern technological tools. Each participant was closely monitored throughout the training sessions, and an individualized training program was assigned to every subject based on their specific needs, with the primary objective of developing aerobic endurance. From a training-guidance perspective, all sessions were directed according to energetic criteria. Real-time heart rate monitoring was performed using wearable heart rate sensors, and blood lactate concentration was periodically assessed to quantify the metabolic response to exercise. The training sessions emphasized aerobic effort, with subjects predominantly exercising within the stable aerobic zone (O_2 steady state), characterized by a heart rate of 150 ± 10 beats per minute and a blood lactate concentration ranging between 2.0 and 3.5 mmol/L. Each subject's weekly training program included four running sessions performed in the stable aerobic zone (O_2S), each with a duration of 60 minutes, aiming to establish a solid aerobic capacity foundation.

Testing Procedures

The Cooper Test consists of covering the greatest possible distance within 12 minutes of continuous running. Performance is expressed as the total distance covered, measured in meters or kilometers.

Objectives

The primary objectives of this test were to assess aerobic exercise capacity, particularly the estimated VO_2max, defined as the body's ability to utilize oxygen during sustained effort, as well as to collect blood lactate samples immediately after exercise.

Application Protocol

The test is conducted on a standard 400-meter athletics track or on a precisely measured flat surface. The duration is strictly timed at 12 minutes. The athlete is required to run continuously, maintaining either a constant or variable pace, without stopping. At the end of the test, both the total distance covered and post-exercise blood lactate concentration are recorded. The 30–15 Intermittent Fitness Test consists of a sequence of 30-second running intervals alternated with 15 seconds of active recovery (walking or standing), with running speed progressively increasing at each stage. The athlete runs back and forth over a standardized distance (typically 40 meters) between two marked lines, following an audio signal (beep test).

Table 2. Results for initial COOPER TEST

NAME	DISTANCE	BPM	LACTATE	VO2
A.L.	2425	196	17.7	42
A.S.	2800	192	14.8	51
T.M.	2900	195	15.6	53.6
C.T.	2300	198	18.3	40.12

Table 3. Results for the final Cooper Test

NAME	DISTANCE	BPM	LACTATE	VO2
A.L.	2750	194	14.4	50.2
A.S.	2900	192	13.1	53.6
T.M.	3100	193	14.3	58
C.T.	2520	195	16.8	45

Table 4. Results for the initial 30-15 TEST

NAME	LEVEL	LACTATE
A.L.	16	15.3
A.S.	17	14.8
T.M.	18.5	15
C.T.	14.5	16.4

Table 5. Results for the final 30-15 TEST

NAME	LEVEL	LACTATE
A.L.	18	14.6
A.S.	18.5	13.2
T.M.	19	14.5
C.T.	16	15.9

Key observations

Following the implementation of optimized and individualized training programs elaborated to the specific needs of the participants, measurable performance improvements were observed across all four subjects. Subject A.L. demonstrated the most pronounced progression, while Subject A.S., although exhibiting a comparatively smaller magnitude of improvement, also showed clear positive adaptations. Overall, the experimental intervention can be considered successful, as all monitored performance indicators improved substantially within a relatively short time frame.

Conclusions

The integration of biochemical monitoring technologies into training guidance, through the systematic use of energetic parameters, resulted in significant enhancements in endurance capacity. Additionally, reductions in both heart rate responses and blood lactate concentrations were recorded, indicating improved physiological efficiency. This approach also contributed to a marked decrease in the risk of injury and overtraining.

The outcomes obtained through the application of both the Cooper Test and the 30–15 Intermittent Fitness Test underscore the critical role of modern technological integration in the effective management and optimization of the training process.

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