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Review article

Endurance Training of Long-Distance Runners under High Altitude Conditions

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Abstract:

Introduction: The optimization of endurance training of long-distance runners at high altitudes permits the analysis of altitude as a factor that produces variations in the climate, temperature, atmospheric pressure, and the number of air particles, as well as the specificities of the geography to be considered when planning sports training.

Aim: To characterize the factors that influence training thoroughly, in order to enhance aerobic endurance of long-distance runners in the conditions of high altitudes.

Method: This study relied on the analysis of documents, with a systematic bibliographic review based on the analytical-synthetic and inductive-deductive methods, which permitted the identification and analysis of the main theoretical and methodological referents found in several papers indexed in *Google Scholar, Scopus, Pubmed, Scielo, Web of Science, Dialnet and Redalyc.*

Results: The factors that have a comprehensive influence on planning aerobic endurance of long-distance runners, such as the biotype, genetics and athlete's health; the socioeconomic and family aspects; teaching and didactic actions in planning this component of the preparation; the process of adaptation and

assimilation of training loads in aerobic endurance; the geographical characteristics, the biomechanical and psychological elements.

Keywords: training, endurance, altitude, long-distance runners.

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Introduction

The purpose of this documentary review is to analyze the situation of the scientific study of physical activities to enhance the physical endurance capacity of long-distance runners.

Bermúdez. C, Sáenz. P (2019) refer to the study of the existing bibliography, since it offers valuable information about state of the art of research related to a particular field, which permits the establishment of research lines for further specific investigation about the influence of height on endurance training of long-distance runners.

However, sports training has evolved in time due to the need to improve results. Hence, every sport discipline looks for different alternatives to enhance athlete performance. In this particular case, hypobaric or natural hypoxia is suggested, which produces a reduction in the atmospheric pressure with no variation of the oxygen levels. In other words, it has to do with training at heights above 2000 m. Consequently, a question arises from this idea: What factors influence endurance training of long-distance runners under the conditions of height? In this particular case, are “(...) training, the environment, physiology, biomechanics, anthropometrics”. (Ogueta-Alday, A. & García-López, J., 2016). This study relies on theoretical methods like the analytical-synthetic and inductive-deductive, as

well as statistical methods, which permit the assessment of opinions, characteristics, and particularities of this problematic, an important premise for practical implementation and diffusion of the results through experimentation.

Development

Endurance in long-distance runners

Jiménez-Simón, C. (2021) said that endurance is one of the most important and necessary physical capacities of humans, whose training demands an aerobic-anaerobic base in the athlete's body (Collazo, 2002).

Working on long-distance runners demands a prior process of detection and selection of talents before associating athletes with a particular sport, through "(...) athlete performance procedures, including a series of physical, psychological, and anthropometric tests". Reyna, M. C. G., Hernández, T. J. A., & Saborit, L. G., 2017); in this particular case, it is ultimately oriented to the identification of the biotype of long-distance runners. Dols, A. R. & Gómez, R. S. (2015) pointed out that during the competition "the aerobic consumption shown in long distances and shorter toes may be adjustments for the long-distance race (…)". (p. 51). In sight of that reality, López, J. O. A., & Rodríguez, M. V. (2019), argued that there must be an in-depth study "(...) of the size, shape, proportion, composition, and maturation of the human body, to provide better knowledge of behavior in relation to growth, physical activity, and the nutritional state". (p. 192). Likewise, the athlete's somatotype is a variable that "(...) influences the performance of the sport in particular, as well as its specialties, thus showing a

relative influence on the outcome". (Navarro, V. T. 2020, p. 41). In that sense, the following types were identified "(...) the endomorphic indicates the relative presence of soft rounded shapes in different parts of the body; the mesomorphic is related to a relative trend muscle-bone mass; and the ectomorphic has to do with the relative predisposition of linear forms over transversal forms". (Gris, G. M. 2020, p. 5).

Accordingly, it is important to safeguard the integrity of an athlete, which requires a previous medical diagnostic to know the health condition, and prevent body damage, according to a study done by Peralta González, M. A., Zanguña Fonseca, L. F., & Cruz Rubio, S. G. (2017), about altitudes and the physiological responses that "(...) may cause harm like the so-called *high altitude illness*, or *acute mountain sickness* (AMS), that generate complex clinical manifestations associated with breathing difficulty, dizziness, headaches, sleep disorders, nausea or vomit, physical and cognitive fatigue, lack of appetite, and other conditions". (p. 536). However, when this process is done properly "(...) the systemic blood pressure and minute volume tend to normalize as the days in the high locations pass (...)". (Peidro, R. M., 2015, p. 258).

Attention of the socioeconomic and household side of the athlete during the sport activity requires special attention to complete satisfactory preparedness. Consequently, it is important to set up management and self-management strategies that ensure success during training. In that sense, Collado-Martínez, J. A., & Sánchez-Sánchez, M. (2017), pointed out that

> "Regarding the social dimension, the role of family (parents, siblings, friends) is fundamental to contribute to sport and personal education; they sacrifice for their children so they can play sports, family members become role models, respect their children's decisions without creating pressure, transmit the value of effort, and demand an equal life as students". (p. 237)

In general, these athletes come from low-income families and have huge needs, so it becomes a scenario for coaches to establish ways of attention to keep motivation and interest throughout their practices.

In that sense, the socioeconomic and household needs are known to threaten the aspirations and dreams of athletes today, such as the lack of resources to afford transportation to and from the sports facilities where they train and compete, the purchase of sports material and gear, medication, food, and others.

Moreover, long-distance running, according to Sánchez Rodríguez, D. A., & Rodríguez Buitrago, A. (2018) is "(...) a series of tests where endurance plays a critical role in grading the outcome (...)" (p. 7), including the 3000 m, 10000 m, and the marathon for women, whereas men are in the 5000 m, 10000 m, and the Marathon.

Gutierrez; *et.al* (2017) did a study demonstrating that physical work in high conditions favors the effectiveness of using techniques to create and address issues during the last minutes of games, a better condition of the external manifestations of the physical loads, and the capacity for aerobic endurance.

Looking into the geographic characteristics, a number of variations can be found in high altitude, which are classified as follows, altitudes of up to 1000 meters above sea level; mid-altitude, up to 2000 meters above sea level; high altitude, up to 5500 meters; and very high altitude, over 5500 meters above sea level. However, for sports activities, moderate heights are recommended, between 1500 and 3000 meters above sea level, where most sports scenarios are located in the world. (Zapata, J. N. B., Herrera, L. D. R. L., Zambonino, J. M. B., Silva, G. C., & Gallardo, P. A. B. 2018, p. 49). For that reason, "(...) renowned selections like Cuba, Brazil, and the Dominican Republic in swimming, triathlon, the race walk, boxing, judo, and cycling have conducted training sessions in higher cities (...)" (Tarqui-Silva, L. 2015, p. 202).

Training under conditions of high altitude, according to Borrego, J. O. A., & Cordón, G. V. Z. (2020), requires "(...) the inclusion of science, technology, and state-of-the-art planning systems (...)". (p. 1087). It must comprise the athlete's level of training, the duration of the stay, age, previous experiences in high altitudes, type of nutrition, and interpersonal relations.

Hence, the particularities of sport training planning as a complex process based on laws, principles, a ruling didactic structure, the stages and periods that ensure a comprehensive formation in sports performance, along with the specifications of the context, in order to strengthen the physical capacities, and the direct consequences of the adjustment of different organs and systems, such as "(...) hematological adjustments, increased hemoglobin (Hb) and hematocrit to

withstand the appropriate dose of hypoxia". (Cañas, M. R. A., Pérez, J. L., Melgarejo, V. M., & Losada-Celis, E., 2017).

The environment has particular characteristics, including air resistance that effects on athlete's performance, according to a study done by Ogueta-Alday, A., & García-López, J. (2016), who said that "aerodynamic resistance accounts for 4--8% of the total resistance in 800-5000 m races, and approximately 2% in the 5000 m race and the marathon". (p. 280). In this context, Cuberos, R. C., Valero, G. G., Garcés, T. E., Molero, P. P., Arrebola, R. M., & Zagalaz, J. C. (2017), noted that appropriate training requires the phases of high altitude adjustment process: adaptation, acclimatization, and deterioration. Additionally, to get favorable results, it is necessary to "(...) run intervallic trainings, 1-2 hours a day, for 4-5 days a week, over several weeks, at a moderate altitude (...)". (Ruibal, B. 2015, p. 4).

In that sense, it becomes a complex and multidimensional process, in which air composition, advisable temperature "(...) between 5 and 15 °C in long-distance races (...)" (Ogueta-Alday, A., & García-López, J. 2016, p. 280), humidity, and the irregularities of the surface where the competition takes place are important. These external agents produce physiological changes and adjustments inside the body, which are determined by the VO2 max, the economy of running, age, gender, muscle fibers, biomechanics, and the physiological condition of the athlete.

Moreover, during a long-distance race, proper arm-leg, and even breathing coordination is required, from a "(...) biomechanical, motor, and energetic

perspective. A good technical race not only can mark the difference between running with pain or without pain, but also helps improve records, (Mauricio, C. L. D., Andrés, C. P. E., Alexander, P. P. F., & del Carmen, B. C. J., 2020). Accordingly, there must be an evaluation to detect errors, and design a feedback plan, especially in the striding phase (cushioning, back up, thrust, and fly) through laboratory and field tests

Likewise, the alteration of biomechanical and space-time parameters is dependent on the frequency and width of the stride. Dols, A. R. & Gómez, R. S. (2015), pointed that during a competition, “aerobic consumption is observed in long distances, and shorter toes seem to be adjustments for endurance races (...)” (p. 51).

As to the psychological qualities, first, the assessment of the motivation and interest of the athlete toward the sport, as well as the actions that coaches must perform to “(...) channel stress positively throughout the career of an athlete, and create a positive psychological force”. (Campos, G. G., Valdivia-Moral, P., Zagalaz, J. C., Ortega, F. Z., & Romero, O., 2017). This process must be done to fight various moods described by Tarqui-Silva, L. (2015), who noticed that during “the first days of permanence in high altitudes athletes may suffer from bad mood, anger, sadness, gloominess, susceptibility, and emotional vulnerability in sight of adverse situations” (p. 204).

Therefore, motivation is intended to strengthen mood, self-esteem, and aspirations. In that sense, Palmi, J., & Riera, J. (2017), the goal is that the coach or psychologist “(...) must have a very clear model that shows the athlete’s

abilities that help them feel positive sensations and avoid negative sensations during the intervention process". (p. 15). In short, the psychological aspects associated with sports, coaches, athletes, and even referees must be dealt with.

Furthermore, to cope with endurance, it is necessary to control heart rate, as the most frequently variable studied in the physiology of endurance practice.

It can be modified by the effects of training, though, it can be increased linearly with the intensity of exercise (Ortigosa *et al*., 2019).

According to Carrasco (2014), the functions of endurance lie in keeping an optimum intensity of loads as long as possible, and avoid the loss of intensity when dealing with prolonged loads; increase the capacity of withstanding voluminous loads during training and competition, including an accelerated recovery following the loads.

Aerobic endurance of long-distance runners

Depending on the most commonly used energy form, endurance can be classified as:

- Aerobic.
- Anaerobic.

Aerobic endurance is the capacity of the body to take prolonged physical exercise, without reducing efficiency (Zatsiorski, 1989), whereas anaerobic endurance is the capacity of the human body to maintain the demanded effort for a long period of time (Aragón and Fernández, 1995). It is the capacity of the body to withstand a high debt of oxygen by keeping an internal effort for the longest

possible time, in spite of the progressive decrease of organic reserves, which generally does not manifest purely, in practice.

It is characterized by an intense effort whose duration must overtake the “critical limit” (to cause an oxygen debt), without which it cannot be considered an anaerobic work. The pulse goes above 150-160 per min, while the oxygen debt is addressed.

It is important to consider different factors to conduct activities aimed to develop endurance, including:

- The athlete’s biotype.
- The athlete’s genetics and health.
- The athlete’s socioeconomic and household issues.
- Pedagogical and didactic actions to plan training.
- The process of adjustment and assimilation of loads when training aerobic endurance.
- The characteristics of the geographic context.
- The biomechanical and psychological elements.

Further research should include an intensity chart for planning and controlling endurance and the rhythms of the race during training, then compare it to the data from the best long-distance runners.

This regularity in laying out the performance curve of the best long-distance runners in the world was a goal in the formation process of future runners.

This study assumed the proposal made by Pérez-Iribar, G., Cartaya-Olivares, M. Ángel, & García-Pena, M. (2018), to plan sports training of this type of athlete. It can be contextualized and customized to any particular athlete, to design a plan of endurance training of long-distance runners, and make the logical adjustments depending on the conditions of altitude.

Conclusions

The results of this research contributed with the main factors to be considered in planning endurance training of long-distance runners in the conditions of height.

It shows that the factors studied for the development of endurance in long-distance runners in the conditions of high altitudes, such as the athlete's biotype, genetic, and health; the socioeconomic and household issues; the adjustment process and assimilation of training loads to achieve aerobic endurance; the characteristics of the geographic context (height, climate, relieve, atmospheric pressure); the biomechanical elements, and the psychological component are significant in this regard.

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Conflict of interests:
The author declares there is no conflict of interests in relation to this manuscript.