MODULE 6

6.3. HIGH LEVEL SPORT IN THE SIERRA NEVADA

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1. High level sport in Sierra Nevada

When people think of high-level sport and the Sierra Nevada, they tend to think of snow and mountain sports. This makes sense, as some of the best Spanish performances in the history of these disciplines come from local Sierra Nevada athletes, such as Regino Hernández in snowboarding, Mª José Rienda and Carolina Ruiz in alpine skiing, Ana Alonso in ski mountaineering, Reyes Santa Olalla and Rocío Delgado in freestyle skiing, Nico Molina in mountain running and Victoria Padial in biathlon. But since 1992 with the creation of the High Performance Center of Sierra Nevada by the Consejo Superior de Deportes, there are numerous athletes, of different modalities, who come to the Sierra Nevada from all corners of the world, to benefit from the available geographical characteristics, facilities and sports support services offered. In this module we are going to talk about the importance of altitude in sports performance and the advantages offered by Sierra Nevada to high performance athletes who choose to travel there for their training.

2. What is altitude and hypoxia?

In geography, altitude is the elevation of a point on Earth with respect to sea level. The Sierra Nevada is the highest mountain massif in Western Europe, second to the Alps. Its maximum altitude is the Mulhacén peak, some 3,479 meters above sea level. And within the Sierra Nevada, Pradollano, with its 2,078-2,400 meter height, is the population center located at the highest altitude in Spain.

At altitude, the composition of the air does not vary, regardless of being at different points of the planet. Whether on the summit of Everest (8848 m), in the CAR of Sierra Nevada (2320 m), or on the beach of Motril (0 m), the air will be composed of approximately 78% nitrogen, 21% of oxygen and a remaining 1% of different gases. However, not everything remains the same as we increase in altitude. The temperature decreases by about one degree for every 154 meters while atmospheric pressure decreases by about 10 mmHg for every 100 meters. Given that atmospheric

pressure is the pressure that air exerts on a surface, with higher altitude there will be less air to exert said pressure and therefore the air will be thinner. It isn't that there is less air, rather the air has changed and is more "separated". It is precisely these changes in atmospheric pressure that are most relevant in sport.

The decrease in atmospheric pressure will make it more difficult for oxygen to enter our bodies. This difficulty in oxygen diffusion explained by a decrease in its partial pressure causes a lower availability of oxygen in our blood, cells and tissues. This oxygen deficit which hinders bodily functions is known as hypoxia, while the condition of normal oxygen levels in the body, characteristic of low altitudes, is called normoxia.

Hypoxia causes stress in organisms that can lead to beneficial or detrimental adaptive responses depending on the hypoxic dose to which we are exposed. In the same way as with medication, low doses applied with little time of exposure to altitude, or low altitudes, will be harmless or ineffective; conversely, high doses caused by very high altitudes, very rapid ascents or very long exposure times, may have adverse effects on our health and athletic performance.

3. Why is altitude relevant in sport?

Interest in sports performance and altitude, or hypoxia, arose during the 1968 Olympic Games in Mexico. The venue for these Games was Mexico City, at an altitude of 2240 meters. If consider the example of track and field during the Mexico Games, we can observe how the higher speeds of athletes were obtained by the effects of altitude and the reduction of aerodynamic resistance due to lower atmospheric pressure and less dense air. As a result, world and/or Olympic records were broken in 13 of 14 of these sprint, jumping and throwing events.

In contrast, no records were set in the long-distance or middle-distance events, with the exception of the 800 m event. The gold medalists in the 1,500 m, 3,000 m steeplechase, 5,000 m, 10,000 m and marathon (42,195 m) events ran 1%, 5%, 6%, 7% and 8% slower, respectively, than the world records in that same year of 1968. A competitive advantage could also be observed in athletes native to high altitude zones and in athletes who had spent preparation periods at altitudes similar to those of Mexico City. Interestingly, athletes from the central highlands of Kenya were able to win 39% of the medals in the 800m and marathon events.

The 1968 Olympic Games were the perfect experiment to demonstrate how the influence of a less dense air at altitude allows for obtaining higher maximum speeds in short duration events. Also of note was how the decrease in the partial pressure of oxygen worsens average running speeds in medium and long duration events by making it more difficult to obtain the metabolic energy necessary for these efforts, due to the oxidation of sugars and fats.

Therefore, if we measure how far we are able to kick a ball on a soccer field in Granada and replicate the measurement on the soccer field of the CAR of Sierra Nevada at 2,320m, we will observe how the ball travels further in Sierra Nevada due to the lower air resistance and its higher flight speed. And if we were to count the number of laps someone could run for an hour around the Motril athletics track and then replicate the test on the athletics track of the CAR in the Sierra Nevada, we would see the number reduce.

4. **How can the altitude of the Sierra Nevada help athletes improve their performance?**

In elite sport, there are two reasons to train at altitude:

- Competition at altitude: Altitude, as we have already seen, affects performance in different ways depending on the characteristics of the sporting event. The purpose of this training is to adapt to the effects of altitude in order to minimize the negative aspects. It is estimated that a minimum previous adaptation of 2 weeks is necessary, which will be increased depending on the altitude of the competition, travel, jet-lag, and other factors.

- Competition at other lower altitudes (sea level): Training at altitude is used as a means of training, seeking through a planned strategy to take advantage of the benefits it offers for subsequent performance. This second aspect is the most common and the one we are going to discuss.

There are different approaches to altitude training depending on the type of sport we practice, the time of the season in which we find ourselves, our previous experience, the proximity in time of our next competitions, the altitude at which they will take place, etc.
The most traditional strategy used by athletes who come to the CAR of Sierra Nevada is called: “Live high, train high”. This altitude training strategy seeks the improvement of oxygen transport in blood by red blood cells and hemoglobin (hematological factors). These improvements in the red cells explain the improvement of the maximum oxygen consumption by athletes (the maximum capacity to absorb, transport and use oxygen during physical exertion). Other adaptations observed at the muscular level (peripheral adaptations) are gaining more and more interest from the scientific community, as they are also responsible for significant improvements in sports performance and even health. Some of these positive adaptations are increased capillarization, increased myoglobin, increased enzymatic activity and oxidative capacity and improved buffering capacity against the acidity generated by lactic anaerobic stress.

We can describe the three main phases related to a high altitude training camp:

1. Initial acclimatization phase. This phase is critical for the success of the training camp since any overly-intense training in these first days, or poor recovery or hydration, will be difficult to compensate later. Normally this acclimatization phase has a duration of 7

todays for athletes with no experience in altitude training, but it can be shortened in athletes with previous experience.

2. Central training phase. It is characterized by a progressive increase in training volume to levels similar to those performed in normoxia. After the increase in volume, the intensity can be progressively increased. This phase usually lasts 2-3 weeks.

3. Phase of preparation for the return to normoxia. The last days of the concentration at altitude are intended for physiological and mental recovery from the fatigue induced by the concentration. This phase will be modified in duration and intensity due to the proximity of the competitions.

Other frequent strategies carried out by coaches and athletes during their concentrations at altitude are those of “Live high-Train low”; “Live high-Train high and low”; “Live high-Train high and higher”, etc. But these strategies that combine different conditions of hypoxia and normoxia, of work and rest in the same day, can be carried out in only a few locations in the world, as is the case of the CAR of Sierra Nevada. The natural environment, infrastructure and easy access between the CAR of Sierra Nevada and nearby towns and areas make it a unique place to combine training in environments and facilities of high quality and different heights, with only roughly 30 minutes of traveling.

Athletes of many kinds are well-versed in these practices, such as our national teams in different sports like rowing and canoeing with their training in the Cubillas and Canales reservoir, cyclists who can cycle in altitude ranges from 0 to 3,000 meters in the same day, and triathletes and swimmers who can alternate between training facilities in the mountains of Sierra Nevada and back down in Granada in less than 40 minutes. There is a long list of relevant sports and possibilities.

The configuration of these training strategies combining different altitudes aims to optimize adaptations according to their main objectives. Exposure to moderate hypoxia in the CAR of Sierra Nevada is used for passive periods of life, rest and nights, and light and moderate intensity training, technical, tactical, strength training, speed, explosiveness and other complementary training. Training in normoxia would be used to maintain training stimuli at a high intensity favored by higher oxygenation at lower altitudes. And trainings at higher altitudes, above 3,000m, are used to perform repeated efforts of very high intensity and low duration (<30 seconds) that improve fatigue resistance to high intensity efforts.

5. What other factors should athletes take into account to make their experience successful?

Altitude in experienced athletes is an additional stressor that, if well planned, will have a positive impact on sporting performance and health. Conversely, if not managed correctly, it can be an additional risk factor.

6. Should prior health status be considered before starting an altitude training camp?

Yes, as we know that altitude increases the risk of respiratory tract infections. Illnesses will decrease our hematological adaptations in the same way that low iron availability will. Therefore, a strong immune system and correct iron stores will be important objectives prior to the start of the training period.

7. At what altitude should athletes train?

Different scientific studies have focused on this question concluding that an altitude between 2200 and 2500 meters would be an optimal altitude to improve oxygen transport. Staying at altitudes above 3000 meters carry significant risks of sleep and recovery problems.

8. How long should an altitude training stay last?

A minimum of 3 weeks is recommended to benefit from hematological adaptations, 4 weeks being ideal. The total hemoglobin mass, related to the transport of oxygen in the blood, improves by approximately 1% every 100 hours of exposure between 2,200 and 2,500m.

9. When should athletes descend from altitude before competition?

After a period of staying at altitude, two windows of favorable performance are generally used before competitions: at 2-3 days or at 17-22 days, although there are important individual differences. It is advisable to inform yourself regarding the readaptation of athletes to normoxia in order to optimize results.

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