Performance factors in Trail-running

Factores de rendimiento en carreras por montaña

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Trail running (TR) has become extremely popular over the last few years. As a result, the interest of the participants themselves and that of the professionals responsible for their health and performance has progressively increased. The field of research has not remained indifferent; an increasing number of studies have principally aimed to answer the main questions raised from a physiological and biomechanical point of view. According to the Federación Española de Deportes de Montaña y Escalada (Spanish Federation of Mountain Sports and Climbing) (FEDME), the main entity responsible for regulating this discipline, trail running is a sport that can take place in High, Medium and Low Mountains, with a minimum distance of 21 kilometres, except in the case of the Vertical Kilometre, and with a minimum elevation gain of 1,000 metres. The course shall always be along non-asphalted tracks and pathways, with no more than 50% on tracks that can be used by vehicles. The main difference between these races and the most traditional asphalt races are the accumulation of uphill and downhill sections, which gradually create a specific profile for each unique competition. Of still greater importance, from a physiological point of view, is the exponential increase in the number of participants who, over the last five years, have taken an interest in the ultra- long trail races (>80 km). It is therefore extremely likely that these maximum efforts induce situations of extreme fatigue. The runner must overcome considerable elevation gains and this has a direct impact on continuous effort, intense concentric and eccentric muscle action of the lower limbs, generated by the ascents and descents respectively. In contrast, level asphalt races are characterised by repeated stretch-shortening cycles of the lower limb extensor muscles. This subtle difference results in biomechanical movements in the athletes' running pattern that are different from those observed in asphalt runners. The investigations, which have focussed on an analysis of fatigue, suggest a reduction close to 40% of muscle strength and a fatigue amplitude similar in the knee extensors and the plantar flexors, although the central or peripheral source of fatigue in these muscle groups has yet to be determined. Surprisingly, there is no linear relationship between the loss of strength in the knee extensors and plantar flexors (main muscles involved when running) and the duration of the ultra races. Scientific literature has revealed a reduction in the loss of strength in races of more than 166 km. Millet *et al*. suggests that this fact may be due to the runner's conservative pacing strategy in races of such a long duration, although this characteristic has been described for trail runs and for level asphalt running races alike. Running alterations occurring after an ultra race, regardless of whether it is TR or asphalt, are similar. This suggests that, rather than the biomechanical characteristics inherent in both disciplines, the duration of the race is the triggering factor in the modification of the running kinematics, possibly in order to reduce the eccentric load component characteristic of the running action and this could explain the non-linear performance of the loss of strength.

Despite the kinematic difference between both disciplines, it is true that the short races of TR <42 km are completed by the faster runners in times of less than 4 hours, establishing a certain similarity with the half-marathon and marathon asphalt races. Based on this distance-time factor for completing a race, it was suggested that the key determinants for performance in these endurance races could be explained by following the traditional model proposed by di Prampero *et al*. which is primarily based on physiological factors, including maximal oxygen uptake(VO_2max), the percentage of VO_2max (% VO_2max), and running economy (RE).

Numerous investigations have found that the greatest velocity that can be sustained during a race is directly related to increased % VO_2max and is inversely proportional to RE. Performance factors in trail running. In fact, the differences observed in RE can largely explain the differences observed in the performance of runners with a similar VO_2max. Moreover, an improvement in RE has been related to a reduction in the marathon times of elite runners. Although it is true that

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elite TR runners have high oxygen uptakes, similar to those observed for long-distance runners, particular attention should be paid to the detail that, when a group of well-trained trail runners perform incremental tests on treadmills with a slope of 0, 12.5 and 25%, no correlations were observed between the RE values on slope running with those for level running. Therefore, an initial approach to the study of these athletes must consider the use of evaluation methods that include protocols for inclined tests. On the other hand, the energy cost of running varied, depending on the slope gradient of the test. Therefore, runners with a low RE, when the test was conducted on the level, obtained high RE values when the test was conducted on greater gradients and vice versus. The fact that some runners increased their RE to a lesser extent than others when increasing the treadmill slope cannot be explained on this occasion, by one of the principal parameters that explains a lower RE between runners with similar anthropometric and physiological values, such as the elastic energy storage capacity, given the fact that with a 25% slope, the mechanical muscular work is principally positive. Recently, through a regression analysis, Ehrstrom *et al.* identified that the classic performance model used for resistance tests did not explain the success in races of <30 km for a group of TR runners. The authors found that the classic physiological factors explained around 50% of the performance variability, whereby the lower limb strength (50%), VO_2max (20%) and the RE evaluated in a test on a 10% slope (4.5%) were the main performance indicators. These variables explained 98% of the times obtained in a 27 km race with 1,400 positive metres.

We can conclude that, although it is true that classic physiological (cardiovascular) factors are crucial for differentiating the different levels of runners in the pack, the incorporation of investigations that provide an in-depth evaluation of the strength variable, that is maximal strength and also the variation in strength throughout the trail , could help explain the characteristics inherent in this discipline. Furthermore, it would be interesting to see how this could affect races with harder conditions, either due to the gain level or the distance of the race, or the different levels ranging from elite runners to runners with finisher ambitions. Unquestionably, the field of study that this novel discipline offers performance and sports care professionals is a factor that is in demand by the present and future society.

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