Increasing Running Economy and VO^2 max (Aerobic Capacity) in marathon performance

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Abstract

The purpose of this study is to identify the similarities and differences between oxygen uptake (VO2max) and running economy within marathon performance. Maximal oxygen uptake and running economy are factors that contribute to performance capacity within marathon runners (Sjodin and Svendenhag, 1985). Oxygen uptake (VO2max) is defined as the highest rate at which oxygen can be extracted, transported and consumed in the process of aerobic ATP synthesis (Shave and Franco 2006), to compare definitions, the definition of running economy is the use of energy demand for a given velocity of submaximal running, to determine running performance, also by measuring the steady-state respiratory exchange ratio and the consumption of oxygen (Saunders et al, 2004). Training influences onVO2 max and, with the presence of running economy, is to be limited by genetic factors (Davies and Thompson 1979). By using a treadmill testing, race time at 10 or 21.1 km was the best predictor of performance at 42.2 km in elite marathon runners and at 42.2 (Noakes et al, 1990).

Overview

In this topic, it will draw out the comparison between oxygen uptake and running economy to marathons best performance. Running was an act of survival for prehistoric men who were being hunted. Running became an honoured event in the ancient Olympics as marathoners were considered heroes (Laurence, et al 2004). Elite marathon runners continue to improve their world record pace for both women and men. Marathon runners encompass three major physiological determinants to performance, maximal oxygen uptake (VO2max) lactate threshold and running economy. Maximal oxygen uptake is reaching the maximum capacity for oxygen consumption by the body during marathon performance; also it is restricted by the supply of the cardio respiratory system to deliver oxygen to the working muscles. (Bassett et al, 2000). Running economy is the efficiency of muscle using oxygen without the build up of lactic acid in the skeletal muscle (Morgan et al, 1992).

Physical Demands

The variations in maximal oxygen uptake (VO2max) and the running economy are additional factors which are known to affect performance capacity within marathon runners. Running economy as well as the fractional utilisation of VO2 max at marathon race pace are additional factors which are known to affect the performance capacity (Sjodin and Svendenhag, 1985). According to Roy et al, (2000) states that an elite marathon runner with a high maximum oxygen intake per kilogram of body mass and a good running economy, he or she can run a distance without the accumulation of portions and lactate. Elite runners using 100% of their maximum oxygen uptake is limited due to high levels of fatigue, thus if the intensity exceeds above 75% of their overall oxygen transporting capacity, the supply of capillary to some parts of the working muscles is no longer sufficient (Costill, 1972).

The physiological demand on the marathon runners is explored through many terms which are used as the same to running economy for example ‘ oxygen cost’, metabolic cost’, and oxygen consumption. According to Hausswirth et al, (2001) suggested that these expressions

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may be defined by the rate of oxygen uptake at a steady state for example (between 60 to 90% of maximal VO2max) at a sub-maximal running speed. Running economy gives a better prediction on maximal oxygen uptake in elite runners who have a similar VO2max (Saunders et al, 2004). Elite marathon runners who have a sufficient running economy, can generate more speed per given oxygen uptake. The Olympic world champion Frank Shorter had an exceptional running economy and this was a major contribute to his marathon performance and success (Peronnet and Thibault, 1989). Marathon runners with good running economy use less energy and therefore less oxygen than runners with poor running economy at the same velocity (Saunders et al, 2004).

Different studies indicate a range of investigation on the physiological aspects of marathon runners. The studies emphasises on the importance of high aerobic capacity to a marathon performance, also establishing the ability of elite marathon runners to sustain a high rate of oxygen uptake for prolonged period of time (Moran et al, 1976). Research from Moran et al, (1976) states that during competition, elite marathon runners range from 68% to 100% of maximum oxygen uptake (VO2 max). Other research have shown a comparison in the estimated oxygen uptake, according to Costill et al (1969) studies found that elite marathon runners were able to sustain a pace which required 86% of their VO2 max. Further research found that elite marathon runners utilised 80-90% VO2max, and also they showed that the faster their running, the higher the VO2max and were more able to use a higher percentage of their VO2 max (Davies and Thompson, 1979).

On one hand, maximal oxygen uptake (VO2max) uses measures for marathon running, such as the fractional utilisation, which relates to a VO2max that is sustained for prolonged periods of time, however measures of VO2max does not provide an accurate prediction of an marathon runners performance potential in aerobic power events (Roger and Thomas 2001). On the other hand, running economy is a better predictor of performance than maximal oxygen uptake in elite runners who have a similar VO2max. (Saunders et al, 2004).

Physiology of Running Economy and Oxygen Uptake in Marathon Runners

The comparison between VO2max and running economy has been rather casually dealt with until very recently, and there still remains considerable disagreement as to the importance of this variable (Daniels and Jack, 1985). The physiology of Oxygen uptake (VO2max) is defined as the highest rate at which oxygen can be extracted, transported and consumed in the process of aerobic ATP synthesis. In specific terms, VO2max is expressed in millimetres of oxygen per kilogram of body weight per unit of time (i.e,ml.kg-1,min-1). The relationship between VO2max and marathon performance is evident, furthermore it is clear that well developed aerobic capacity (VO2max) is a prerequisite for marathon runners (Shave and Franco 2006).

The selection of fat for oxidation by the muscles is important since the stores of the most efficient fuel, the carbohydrates, are limited. The large amount of endurance training done by marathon runners is probably responsible for similar metabolic adaptations, which contribute to a delayed onset of fatigue and raise the VO2max. There is probably an upper limit in training kilometrage above which there are no improvements in the fractional utilisation of VO2 max at the marathon race pace. The influence of training on VO2 max and, to some extent, on the running economy appears, however, to be limited by genetic factors (Davies and Thompson 1979).

The metabolic pathway that the body produces during marathon running is known as the aerobic lipolyisis which uses the production of fat and oxygen (Slodin and

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Svedenhag 2001). Fat is stored in the body and breaks down slowly, so it delivers ATP at a slow rate. This slow rate (Running Economy) is good for marathon runners competing at 42.2km (total marathon time). This measurement is the maximum volume of oxygen that the body's muscles can use per minute to continue to make ATP aerobically. If running intensity increases past this point, oxygen consumption cannot, so the extra energy to run faster or up a steeper grade must come from the anaerobic pathway. VO2max is hard to measure, but since the heart rate increases with increasing training intensity, then heart rate can be used to indicate at what percentage of VO2max when one is training (Bassett et al, 2000).

Performance, Analysis And Testing

The study of running economy has important performance implications for the long-distance runner and may provide insight into mechanisms underlying economical human locomotion. A physiological aspect of running economy includes the oxygen uptake though out the marathon run (Morgan et al, 1992). The study of oxygen uptake and running speeds of two marathon runners were measured every three miles at a competitive marathon run. The runner's energy expenditures requiring from 68 to 100% of their VO2 max, confirming previous estimates. As the race progressed, both runners exhibited decreases whilst running at similar rates and slopes. At 23.4 miles, one runner was found to be utilizing 4.54 l/min, a value equivalent to his VO2 max (Maron, et al, 1976). Svedenhag and Sjodin (1985), shows that Oxygen uptake during running for example the running economy, is an important factor in determining running performance in endurance events. The relation to performance is particularly strong when the aerobic running capacity is calculated, for example when running economy is related to the maximal oxygen uptake. There is considerable inter-individual variation in running economy, and the reason for this is only partly understood (Helgerud et al, 1990).

A study was developed to identify performance matched male and female who had the same VO2max , females results indicated lower oxygen uptake during running at a standard sub-maximal was higher ($P<0.05$). For both sexes the oxygen uptake at average speed was 93%–94% of the oxygen uptake corresponding to the anaerobic threshold. It was found that the difference between performance-matched male and female marathon runners seemed primarily to be found in oxygen uptake and amount of training (Helgerud, et al 1990). Race time at 10 or 21.1 km was the best predictor of performance at 42.2 km in elite marathon runners and at 42.2 (Noakes et al, 1990).

Using a treadmill to measure submaximal and maximal running is a good indicator of identifying metabolic responses. Research from Costill et al, (1971) indicated that a world champion runner used a treadmill to find out whether or not running economy or oxygen uptake is more beneficial for a marathon performance. The findings of the research suggested that marathon running success is dependent upon running economy and the ability to utilise a large fraction of a well developed aerobic capacity. Other testing's showed a different view by arguing that using a treadmill to identify VO2 max and running economy provided a insufficient correlation of marathon performance (Grant et al, 1997).

The relationship between maximal oxygen uptake (VO2max) and running economy in elite marathon runners is analysed through the current model of running economy interacting with VO2max which controls the speed of the marathon times. A variety of combinations of these variables from elite runner's results in estimated running times that are significantly faster than the current world record (2:06:50). The fastest time for the marathon predicted by this model is 1:57:58 in a

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hypothetical subject with an exceptional running economy, VO2max of 84 ml.kg-1.min-1, and a lactate threshold of 85% of VO2max. This analysis suggests that the physiological possibilities of substantial improvements in marathon performance contains limited factors in endurance running and need additional refinement and empirical testing (Joyner 1991).

Conclusion

The close interaction between VO2max and running economy are both important for marathon performance, however to compare them both, research showed that running economy gives a better prediction on maximal oxygen uptake in elite runners who have a similar VO2max (Saunders et al, 2004). This emphasises that running economy is a better predictor of performance than maximal oxygen uptake in elite runners (Saunders et al, 2004). This research is supported by Peronnet and Thibault, (1989) as the Olympic champion Frank Shorter had outstanding running economy and this likely contributed to his success. On the other hand, research found that elite marathon runners utilising 80-90% VO2max, showed that the faster their running, the higher the VO2max and were more able to use a higher percentage of their VO2 max therefore their marathon performance time is more effective (Davies and Thompson, 1979). This indicates that VO2max and marathon performance is evident; furthermore it is clear that well developed aerobic capacity (VO2max) is a prerequisite for a marathons running performance (Shave and Franco 2006). To conclude the argument, it is evident that VO2max is a major factor of marathon performance however running economy is more utilised during performance, therefore running economy is more effective during training and performance.