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Study of the relationship between speed, heart rate and the accumulation of lactic acid in the blood

by Petar Bonov

During runs of increasing intensity there is a transition point between 'extensive' and 'intensive' phases of lactic acid accumulation. Determination of this point can aid the coach in defining optimal running speeds for effective middle- and long-distance preparation. The exponential relationship between heart rate and lactate accumulation can also be used to evaluate the degree of energy expenditure and an athlete's potential for adaptation to stress.

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Translated from the original French by Hilary Lissenden

1 Introduction

In the course of our research to determine the most effective preparation of elite middle- and long-distance runners we carried out tests monitoring the body's resistance and methods of adaptation to the stress of races of varying intensity. In this article I will present some of the results of these studies.

The specific objectives of our research were as follows:

- To establish the relationship between speed and the accumulation of lactic acid in the blood
- To establish the relationship between heart rate and the accumulation of lactic acid in the blood

2 Procedure – speed and the accumulation of lactic acid

The tests were carried out during a standard training session of 5 x 1000m repetitions with 3 min. recovery between each. The athletes were requested to increase their speed over the course of the session: in the case of the women, from an initial 3.57 m/sec. (or 4.40 min./km) to an eventual 4.65 m/sec. (3.35 min./km); in the case of the men, from 4.17 m/sec. (4.00 min./km) to 5.71 m/sec. (2.55 min./km). Heart rate was monitored continuously throughout the test using a Polard-Elektro Finlandais 3000. The concentration of lactic acid in the blood was recorded between the first and second minute of each rest interval.

When analysed, the results yield varied and informative data. Figure 1 is an empirical representation of the variations in blood lactate accumulation across the 3 event

'groups' (the 800 metres; the 1500 to the 5000 metres; and the 10,000 metres to the Marathon).

From this graph it is evident that in all events an increase in speed produces an increase in the concentration of lactic acid in the blood. At the start of the run, this process is extensive: in other words, a 'steady state' occurs in which running speed increases but blood lactate concentration remains constant. Then, at a given moment (corresponding to a certain running speed), the rate of accumulation of lactate rises sharply.

This transition point from extensive to intensive lactate accumulation largely determines the level of the anaerobic threshold. It is dependent on the influence of several factors, the main one being the fitness level of the particular athlete under consideration. Knowing the point at which transition occurs can help the coach to obtain a theoretical definition of optimal running speeds in order to effect a balance.

At the same time, regardless of the athlete's level of fitness, the shape of the lactate curve is influenced by the 3 following factors:

- Natural ability – aerobic or anaerobic (endurance or speed) type
- The discipline for which the athlete is preparing (the 800 metres, the 1500 metres, the 5000 metres, the 10,000 metres or the Marathon).

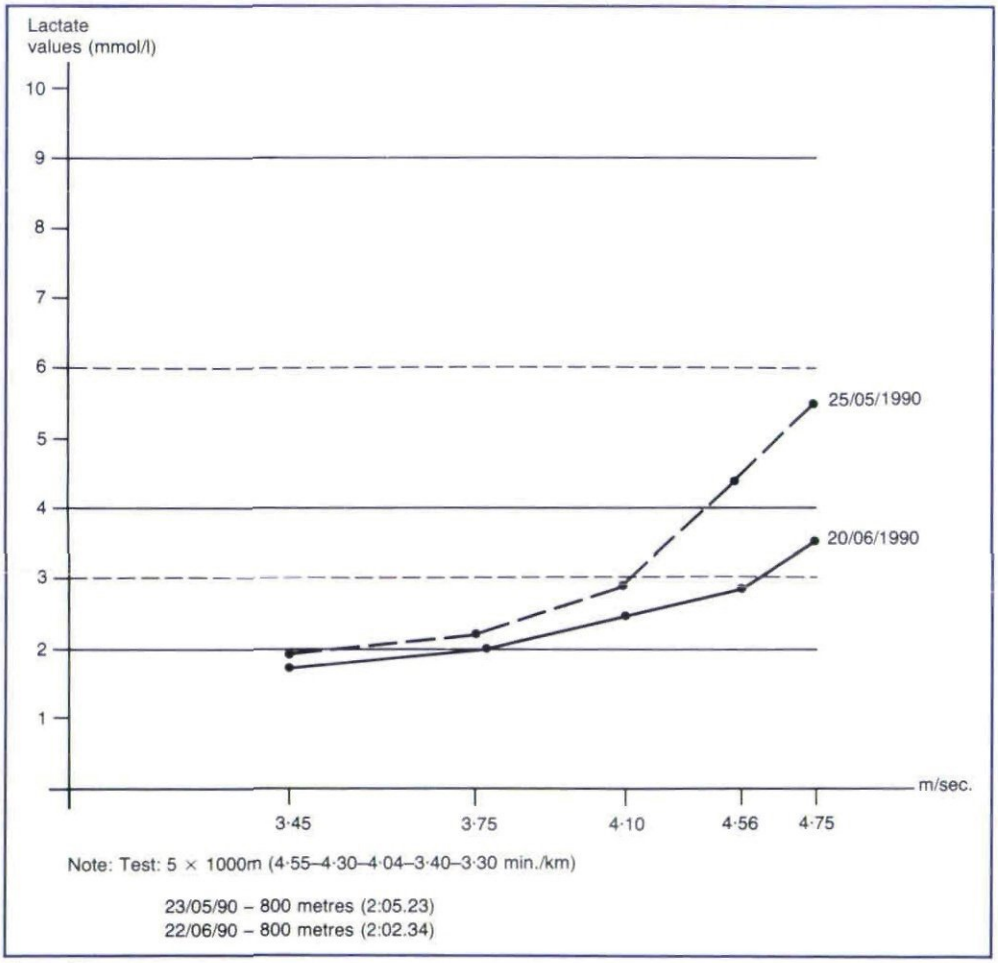

Figure 1

- The intensity and frequency of training sessions

3 Heart rate and lactic acid accumulation – the nomogram

A subsequent study of the pulse rate data led to the conclusion that the relationship between heart rate and the build-up of lactate is similar to that described above (lactate/speed). This relationship is presented in Figure 2.

Figure 2 shows a 'nomogram' which illustrates the pulse frequency dynamics during the initial phase of the recovery period. From this, an approximate concentration of lactic acid in the blood can be determined. The pulse measurements, recorded at intervals of 10 seconds three times – immediately after the running effort, between 20 and 30 sec. of recovery, and between 60 and 70 sec. of recovery – are given along the horizontal axis. Along the vertical axis are the theoretical blood lactate values.

Thus elaborated, the nomogram can reveal indirectly and approximately the degree of energy expenditure during runs of varying intensities.

4 Conclusion – some useful training indications

An analysis of the results of our studies invites the following conclusions, which

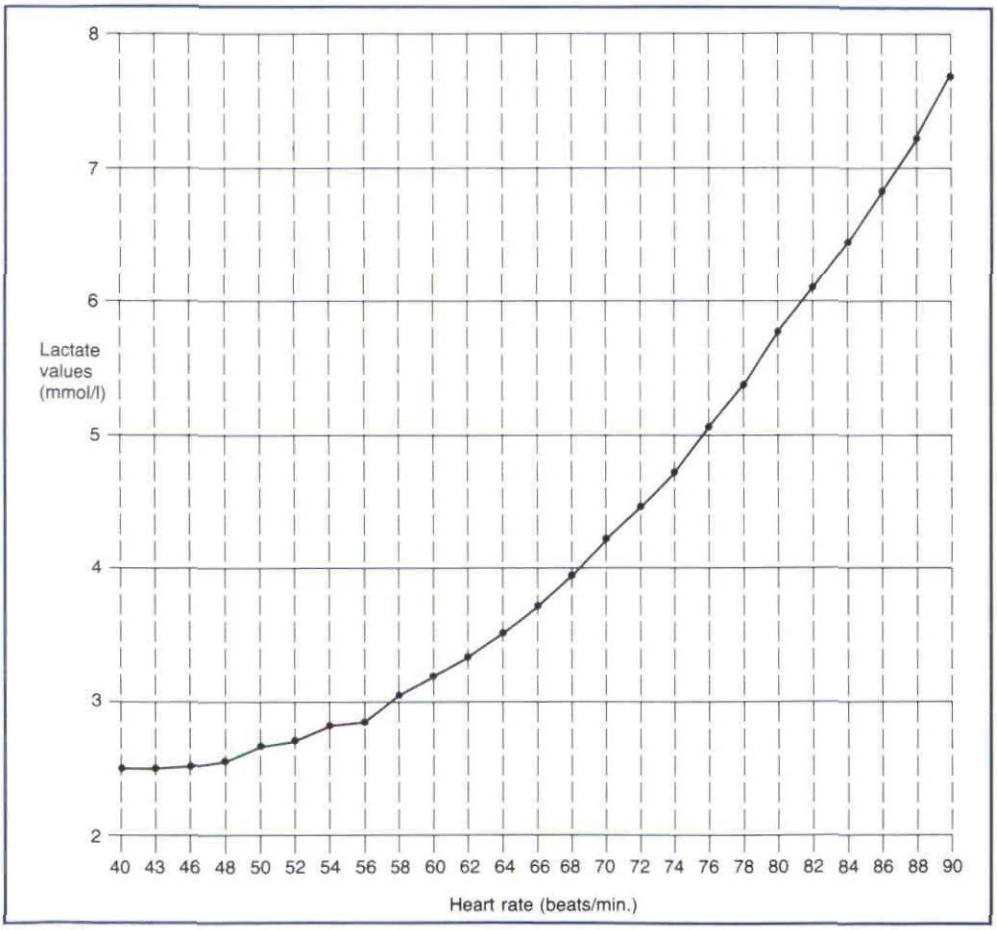

Figure 2

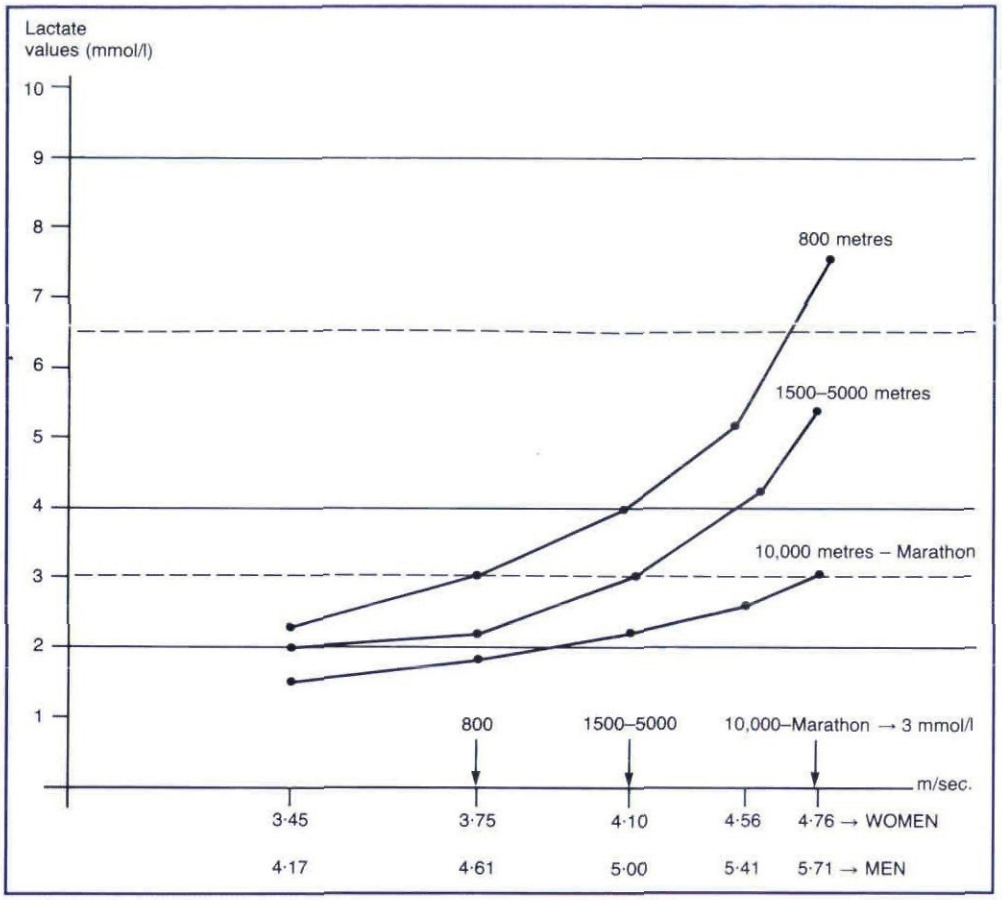

Figure 3

constitute potentially useful training indications:

- The process of accumulation of lactic acid in the blood during runs of increasing intensity can be divided into two separate stages as follows:
  - 'Extensive' phase;
  - 'intensive' phase.
- There is an exponential dependence between heart rate and the accumulation of lactate in the intensive activity phases and in the initial recovery.
- The extent of lactic acid accumulation during intensive activity, and the shape of the resultant lactate curve, is determined by the influence of four basic factors:
  - Innate potential (genotypical characteristics);
  - degree of fitness of athlete;
  - relevant discipline (from the 800 metres to the Marathon);
  - quality and quantity of the training carried out.
- The dynamics of the lactate build-up and pulse frequency during the initial recovery phase are an objective criterion for the evaluation of an individual's endurance and degree of adaptation to intensive activity.
- Figure 3 represents an example of an athlete who, having improved his aerobic resistance (in other words, raised his anaerobic threshold), has also improved his 800 metres performance from 2:05.23 to 2:02.34.