Acid-base status during a graded field test related to marathon performance

J.A. Zoladz [1], A.J. Sargeant [2] and J. Emmerich [1]

[1] *Department of Physiology and Biochemistry, Academy of Physical Education, Al. Jana Pawla II 62a, 31-571 Cracow, Poland.*

[2] *Department of Muscle and Exercise Physiology, Faculty of Human Movement Sciences, Vrije University, Meibergdreef 15, 1105 AZ Amsterdam, The Netherlands.*

It is well documented that short term maximal exercise results in a decrease in muscle and blood pH. The resulting acidosis has been suggested to impair muscle function (Boyd et al. 1974, Sahlin 1986, Cooke et al. 1988).
However rather few data are available on the changes in acid-base status during high intensity exercise performed by top class, highly trained, athletes. In this paper data collected in a graded field test is presented for a group of runners with personal best marathon time in the range of 2:13:27 to 2:20:51.

Data is presented for a group of four top class male marathon runners who performed a graded field test within a few weeks of a marathon race. Additionally and for comparison, data for subject K.J. is included. This subject performed his last marathon 2 months prior to the test and significantly decreased his training programme during the intervening period. The graded field test was performed on an artificial running track. The test consisted of five separate bouts of running. Each bout lasted six minutes with an intervening 2 minutes rest period during which arterialized capillary blood samples were taken. Blood was analyzed for pH, pO_2, pCO_2 using the instrument Plastomed, Poland. The values of base excess (BE) and bicarbonate concentration (HCO_3^-) were calculated by this system. Lactate concentration was determined according to the method described by Barker and Summerson (1941) and modified by Strom (1949).
The exercise intensity during the test was regulated by the runners themselves by using the Sport Tester Polar Electro PE 3000 (Finland). The subjects were asked to perform the first bout of running at a constant heart rate (HR), which was 50 beats per minute below their individual maximal heart rate. Every subsequent bout, each of which lasted 6 minutes, was performed with an increment of 10 beats/min in the target HR.The mean velocity of each bout was then expressed for each individual in relation to their most recent marathon performance. Data is given as mean ± SD.

The average marathon velocity (vM) was 18.46 ± 0.32 km/h. On the basis of the formulas presented by Davies and Thompson (1979) we calculated that our runners at the speed corresponding to 100 % of vM had an oxygen uptake of 65 ± 1 ml/kg BW, which was approximately 84 % of VO_2max.
In the graded test there was a linear increase in heart rate with running velocity ($p<0.02$).
No systematic changes in the blood acid-base status was observed until mean running velocity of the bout exceeded vM. In the bouts performed at velocities above vM there was a marked increase in lactate concentration and significant decrease in pH, HCO_3^-, BE and pCO_2.
Thus in the last sub-vM bout in which mean velocity was 97 ± 0.8 % of marathon velocity blood pH was little changed compared with the rest value (mean value 7.36 ± 0.03 in both cases). In subsequent bouts at speeds above the mean marathon speed there was a marked and progressive fall in blood pH (fig.1).
The blood lactate concentration at a mean running velocity of 97.1 ± 0.8 % of vM was 2.33 ± 1.33 mmol/l which compares with a rest value of 1.50 ± 0.60 mmol/l was not significantly higher. However when running velocity exceeded the vM by only 3.6 ± 1.9 percent, the lactate concentration rose to 6.94 ± 2.48 mmo/l ($p<0.05$ vs.rest). The running velocity, associated with a fixed blood lactate concentration of 4 mmol/l in the group of four runners was estimated, by linear interpolation of the data, to be in the range between 97.8 to 102.1 % of the mean marathon velocity.

The results of the group of 4 top class marathon runners demonstrates that blood pH changes little in the bouts performed at running speed below 100% vM. However once vM was exceeded there was a marked change in acid base status. It is interesting to note the significant differences in the response of K.J. This runner had reduced his training in the period between the marathon and the graded test and blood pH during the test started to fall at some what lower relative velocities (%vM) compered with the group as a whole. (Figure 1.)

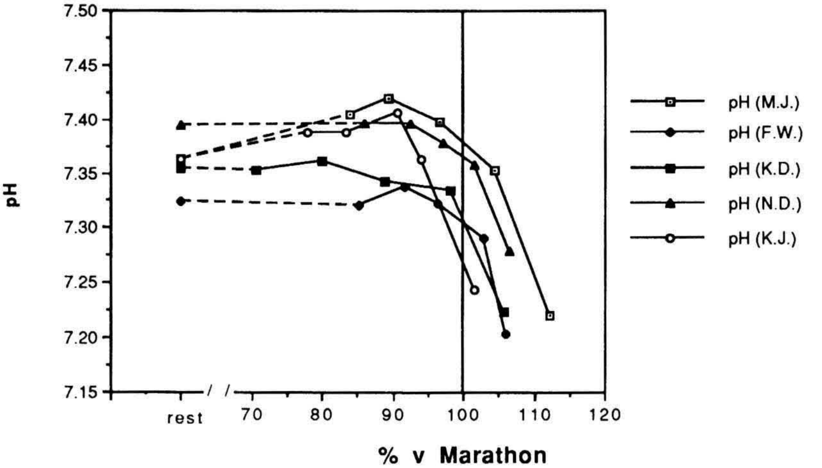

Figure 1. Blood pH levels in relation to running velocity during the graded test bouts, expressed as % of the mean marathon velocity.

Our data are in accordance with those published by Fohrenbach et.al. (1987), who found that at the end of a run of 45 min duration, at an intensity corresponding to the marathon velocity, no decrease in pH was observed when compared to the values at the 10^{th} minute of exercise. In conclusion, it seems probable that these top class marathon runners run the marathon at highest velocity which can be sustained without a significant decrease in blood pH, although blood lactate concentration is already somewhat elevated.
Furthermore it seems that this form of graded field test may be a sensitive indicator of the training status for these runners as indicated by the quantitative changes seen in the responses of runner K.J. during a period of reduced training. As such, it may prove to be a valuable tool for optimizing training programmes.

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