

Prediction of race pace in long distance running from blood lactate concentration around race pace

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ABSTRACT

Muñoz-Pérez I, Moreno-Pérez D, Cardona-González C, Esteve-Lanao J. Prediction of race pace in long distance running from blood lactate concentration around race pace. *J. Hum. Sport Exerc.* Vol. 7, No. 4, pp. 763-769, 2012. The aim of this study was to develop an equation for predicting the performance in 10 kilometers road race (10k), Half Marathon (21k) and Marathon (42k), using the blood lactate concentration (bLA) close to race pace. 64 runners of different levels completed the study (10k (n = 19): 32min-56min, 21k (n=24): 1h04min-1h57min; 42k (n=21): 2h38min-4h02min). A few days before their main competition, subjects conducted a test in track at constant pace over 2400m. They ran at two different speeds that were slightly lower (V1) or similar / faster than the competition expected pace (V2). bLa samples were taken during and after every pace. The results did not show any mathematical model to estimate the 10k mark. In the 21k, it was found a model that included V2 and bLA2: $V21k \text{ (km / h)} = (V2 * 1.085) + (-0.282 * bLA2) - 0.131$, $r^2 = 0.97$, ETE = 0.414 km / h. In the 42k, it was found a model that included V1 and BLA1: $V42k \text{ (km/h)} = (V1 * 1.085) + (-0.429 * BLA1) - 0.170$, $r^2 = 0.81$, ETE = 0.626 km/h. Two equations were capable of predicting performance, for 21k and 42k through bla concentration at a pace close to the expected for the competition. **Key words:** TRACK LACTATE; RACE PACE; PERFORMANCE PREDICTION.

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INTRODUCTION

Prediction of running performance in the endurance races gives the coach crucial information about how to plan the competitive strategies. In the last decades, plenty of mathematical models have been developed to achieve an accurate prediction of the performance for the middle, long and ultra-distance competitions (Davies & Thompson, 1979; Deason et al., 1991; Farrell et al., 1979; Fay et al., 1989; Petit et al., 1997).

Both anthropometric (Bale et al., 1985; Bale et al., 1986; Berg et al., 1998) and physiological variables (Davies et al., 1979; Farrell et al., 1979; Fay et al., 1989; Föhrenbach et al., 1987; Grant et al., 1997; Nicholson & Sleivert, 2001) are capable of predicting the performance. However, it seems that the best predictor is still the performance at other competitive distances (Coquart & Bosquet, 2010; Deason et al., 1991; Farrell et al., 1979; Noakes et al., 1990; Slovic, 1977).

Considering the large number of variables that are able to predict the performance, the blood lactate concentration (OPLA) at speeds close to competition is one of the most used references both in the scientific and the practice fields. Farrel et al. (1979) obtained a significant correlation between the speed developed on a treadmill at OPLA intensity (Onset Plasma Lactic Accumulation), and the performance during a marathon. Authors like Fay et al. (1989), Nicholson and Sleivert (2001), Noakes et al. (1990), Roecker, et al. (1998), also used the OPLA at a certain speed as variable to predict the performance in races, obtaining significant correlations. Moreover, the determination of bLA at the expected competition pace is a common practice used by coaches to determine runner's strategy in distances like the marathon.

The previously aforementioned studies are in most cases developed on treadmill. Nevertheless, a key point for runners when the main competition is coming will be to be closely familiarized with race pace on specific conditions. That is the reason why field testing, although carried out in less controlled conditions, would become more useful. The general purpose of this study was to design a test capable of predicting the performance from a simple protocol to be administrated on a regular basis in the environment of a training group. So far, the study of Förenbach et al. (1987) has been the one with more characteristics in common with the aim of the present study. They used the OPLA at fixed speeds in relation with the marathon competition and only to predict two times in particular (2h45min y 3h30min). To the best of our knowledge, there is no flexible protocol with field tests at freely chosen speeds according to the expected competition race pace. Because of that, the aim of the present study was to develop an equation that could predict the performance of endurance runners in races of 10 kilometers (10k), Half Marathon (21k) and Marathon (42k), from the OPLA at speeds around the competition pace.

MATERIAL AND METHODS

Participants

A total of 64 different level recreational runners completed this study. Their range of personal best times over the distances were: for 10k (n=19), 32min-56min; for 21k (n=24), 1h04min-1h57min; and for 42k (n=21), 2h38min-4h02min (Table 1). The inclusion criteria were 1) to declare to have trained specifically for the race distance with a minimum of 12 weeks, and 2) to finish the competition showing a maximum effort and reaching their personal best, or their season's best performance.

Athletes who were evaluated but did not complete a good performance in competition were excluded. The study was approved by the Ethics Committee of the Universidad Europea de Madrid. All the subjects who participated in this research signed an informed consent before the start of this study.

Table 1. Obtained data (mean \pm SD).

		V1(km/h)	HR1	LA1(mMol/L ⁻¹)	V2(km/h)	HR2	LA2(mMol/L ⁻¹)
10k	n=19	14.6 \pm 1.9	164 \pm 6	5.0 \pm 1.7	15.6 \pm 1.9	172 \pm 5	8.0 \pm 2.4
21k	n=24	13.6 \pm 2.5	154 \pm 12	3.3 \pm 1.6	14.6 \pm 2.5	164 \pm 11	4.9 \pm 1.9
42k	n=21	13.5 \pm 0.9	152 \pm 10	2.0 \pm 0.8	14.4 \pm 1.0	158 \pm 9	3.0 \pm 1.6

V1= Velocity corresponding to a lower than expected competition pace, V2= Velocity equal or greater than expected in competition. HR1= Heart Rate corresponding to V1. HR2= Heart Rate corresponding to V2. LA1= Blood Lactate Concentration associated to V1. LA2= Blood Lactate Concentration associated to V2.

Testing Procedures

All the subjects were evaluated between 5 to 10 days before their main competition. The warm-up consisted of 15 min of continuous jogging under the 70% of their maximal real Heart Rate (HR) real or maximal theoretical HR in case of those who did not know real maximal HR. This run was followed by dynamic stretches and a familiarization over a 200 meters distance with the initial pace. The tests were performed on a synthetic running track surface, on imperceptible wind days, and with temperatures below 23° C. Two paces were established around the target to the competition. In each of those selected paces, two repetitions were performed in steadily pace over 1200m. The pause between the two paces was minimal, and it was taken to obtain a sample of capillary blood lactate (bLA). The race pace was set by acoustic signals recorded in the heart rate monitor (Polar S810, Kempele, FIN). Cones were placed every 50 meters on the track as reference pace points. The time spent to cover 50, 100 or 200m at the desirable race pace was estimated to program the acoustics signals of the heart rate monitor. The short rest to obtain the sample of bLA between the two 1,200m bouts at a given velocity was standardized to the time between two beeps closer to a 30 seconds gap. Thus, as the runner had finished the bout, without leaving the place, his HR was recorded, the bLA sample was obtained, and when a new acoustic signal sounded, the athlete started the same race pace until accomplishing the total 2,400m at the same pace. One velocity was estimated to be slightly lower than expected in the competition (V1), and the other one was at the same race pace or a bit higher speed than the expected for competition (V2). If the subject expressed a certain facility when the protocol had been completed, a third repetition was carried out. For data analysis only two paces were selected, so that they resulted the nearests both above and below the average final velocity performed in competition.

Lactate

The bLA samples were taken in capillary blood (0.5 μ L). The sample was obtained from the earlobe, both after each 1,200m repetition and after 1 minute of the 2nd repetition at the same speed. After 3 minutes of rest, when the first pace was finished, the measurements were repeated with the equal or superior competition pace (V2). The bLA concentration was analyzed through the portable analyzer LactatePro™ (KDK Corporation, Kyoto, Japan) (V.C 3%).

Competition

The athletes took part in competition distances that had been standardized by the local athletics federation. In all the races, an electronic timing system was used with a chip in the shoe or ankle. Thus, the official net times were taken as the variable to predict. The average velocity during the race, in connection to time spent in it, was obtained and defined as V10k / V21k / V42k.

Statistical analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) 13.0 (SPSS Inc., Chicago, IL). V10k/V21k/V42k variables were set as the dependent variables and BLA1, bLA2, V1 and V2 as independent ones. Multiple regressions were used with the aim of predicting V10K / V21k / V42k. The estimation for standard error was calculated (ETE).

RESULTS

No significant correlations were found between the variables included in the mathematical model that would predict the mark of the participant athletes in 10k.

Regarding the performance prediction equation over 21k, a mathematical model was found which included a direct significant correlation between V2, bLA2 and time in competition: $V21k \text{ (km/h)} = (V2 * 1,085) + (bLA2 * -0.282) - 0.131$ ($r^2=0.97$; $p<0.01$) ; ETE=0.414 km/h.

In the 42k, it was achieved a direct significant model of correlation between V1, bLA1 and race time: $V42k \text{ (km/h)} = (V1 * 1.085) + (bLA1 * -0.429) - 0.170$ ($r^2=0.81$; $p<0.05$) ; ETE=0.626 km/h.

DISCUSSION

The results obtained in this study show two equations for predicting the performance in the distances of 21k and 42k.

The bLA1 concentrations of our subjects are very similar to those found by Föhrenbach, as predictors of the running speed of 42k, et al. (1987). Currently, we do not know information to compare our results found for the 21k race. The study did not discover any significant model to predict the performance in 10k.

The reason that the variables studied (bLA) have been unable to predict the performance in 10k in a reliable way could be the metabolic interaction in this distance. A previous study of Weyand et al. (1994) showed that the best variable to predict the performance in races from 100 to 400 meters was the Peak Oxygen Deficit (POD). Meanwhile, the peak VO_2 was the best predictor for the races from 800 to 5000 meters. A research of Stratton et al. (2009), highlighted how the velocity associated with the maximal VO_2 (vVO_{2max}), regardless of the level of the athletes, was the best predictor of the performance for a 5000m race. Maffulli et al. (1991) identified a higher correlation between running speed and the second physiological threshold in competitions equal or higher to 5000m, but they did not find any significant correlation with other variables that were studied.

Because of that, other studies found that up to the 10k races, one of the best predictive variables of the performance is VO_{2max} , or the vVO_{2max} (Morgan et al., 1989). In our study, the bLA associated with V1 and V2 for 10k ranged between 5 and 8 mMol/L. These lactic concentrations are common in metabolic intensities around or above the second physiological threshold (Beneke, 1995; Nicholson & Sleivert, 2001). Therefore, these concentrations exceed the intensity where the levels can remain steady for a long time (Billat et al., 2004; Beneke et al., 2000; Beneke, 2003).

This phenomenon may have influenced the fact that none significant equation was found for 10k, which would only be valid if the intensity of competition for the runners was less than the second physiological

threshold. However, we have not found any special connection using only the data of those runners. We also found that the sample size was small, which is one of the limitations of this work.

Another limitation of the present study could be the wrong choice of the initial pace during testing or a very intensive warming. Nevertheless, this seems unlikely due to the fact that, if so, it also could have occurred in the other distances, and runners were instructed to practice initial pace before starting. Another limitation is the amount of sample selected. These results are part of a longer term study which will increase the size of the sample. However, the equations shown did demonstrate certain strength and this implies a remarkable practical application.

Up to date, many studies have used a large number of variables: from anthropometric variables (Bale et al., 1986; Berg et al., 1998), to number of days per week and trained athlete's age (Bale et al., 1985), maximal oxygen uptake (VO_{2max}) (Davies et al., 1979), or multiple regressions that only include physiological variables (Maffulli et al., 1991; Morgan et al., 1989; Roecker et al., 1998; Slattery et al., 2006). Others used both physiological and anthropometric variables (Deason et al., 1991; Hagan et al., 1981). The practical value of this work relies on the use of a simple methodology, which is also conducted under conditions close to competition and familiar to the regular training practice.

The two models presented in this study provide more simplicity, compared to the previously published models, in predicting performance in competition. And even if it was possible to improve prediction with the inclusion of other variables (VO_2 , etc), the objective was to design a simple protocol applicable by coaches as a tool for selecting adequate competition strategies.

CONCLUSIONS

In conclusion, this paper presents two equations that predict performance in 21k and 42k from lactate at rates close to the expected in competition. There was no reliable model for 10k, probably due to the metabolic intensity of the test.

REFERENCES

1. BALE P, BRADBURY D, COLLEY E. Anthropometric and training variables related to 10km running performance. *Br J Sports Med.* 1986; 20(4):170-173. doi:10.1136/bjism.20.4.170 [Back to text]
2. BALE P, ROWELL S, COLLEY E. Anthropometric and training characteristics of female marathon runners as determinants of distance running performance. *J Sports Sci.* 1985; 3(2):115-126. doi:10.1080/02640418508729741 [Back to text]
3. BENEKE R, HÜTLER M, LEITHÄUSER RM. Maximal lactate-steady-state independent of performance. *Med Sci Sports Exerc.* 2000; 32(6):1135-1139. doi:10.1097/00005768-200006000-00016 [Back to text]
4. BENEKE R. Anaerobic threshold, individual anaerobic threshold, and maximal lactate steady state in rowing. *Med Sci Sports Exerc.* 1995; 27(6):863-867. doi:10.1249/00005768-199506000-00010 [Back to text]
5. BENEKE R. Methodological aspects of maximal lactate steady state-implications for performance testing. *Eur J Appl Physiol.* 2003; 89(1):95-99. doi:10.1007/s00421-002-0783-1 [Back to text]

6. BERG K, LATIN RW, COFFEY C. Relationship of somatotype and physical characteristics to distance running performance in middle age runners. *J Sports Med Phys Fitness*. 1998; 38(3):253-257. [[PubMed](#)] [[Back to text](#)]
7. BILLAT V, SIRVENT P, LEPRETRE P, KORALSZTEIN JP. Training effect on performance, substrate balance and blood lactate concentration at maximal lactate steady state in master endurance-runners. *Pflugers Arch*. 2004; 447(6):875-883. doi:[10.1007/s00424-003-1215-8](https://doi.org/10.1007/s00424-003-1215-8) [[Back to text](#)]
8. COQUART JBJ, BOSQUET L. Precision in the prediction of middle distance-running performances using either a nomogram or the modeling of the distance-time relationship. *J Strength Cond Res*. 2010; 24(11):2920-2926. doi:[10.1519/JSC.0b013e3181c69278](https://doi.org/10.1519/JSC.0b013e3181c69278) [[Back to text](#)]
9. DAVIES CT, THOMPSON MW. Aerobic performance of female marathon and male ultramarathon athletes. *Eur J Appl Physiol Occup Physiol*. 1979; 41(4):233-245. doi:[10.1007/BF00429740](https://doi.org/10.1007/BF00429740) [[Back to text](#)]
10. DEASON J, POWERS SK, LAWLER J, AYERS D, STUART MK. Physiological correlates to 800 meter running performance. *J Sports Med Phys Fitness*. 1991; 31(4):499-504. [[PubMed](#)] [[Back to text](#)]
11. FARRELL PA, WILMORE JH, COYLE EF, BILLING JE, COSTILL DL. Plasma lactate accumulation and distance running performance. *Med Sci Sports Exerc*. 1993; 25(10):1091-1097. [[PubMed](#)] [[Back to text](#)]
12. FAY L, LONDEREE BR, LAFONTAINE TP, VOLEK MR. Physiological parameters related to distance running performance in female athletes. *Med Sci Sports Exerc*. 1989; 21(3):319-324. doi:[10.1249/00005768-198906000-00016](https://doi.org/10.1249/00005768-198906000-00016) [[Back to text](#)]
13. FÖHRENBACH R, MADER A, HOLLMANN W. Determination of endurance capacity and prediction of exercise intensities for training and competition in marathon runners. *Int J Sports Med*. 1987; 8(1):11-18. doi:[10.1055/s-2008-1025633](https://doi.org/10.1055/s-2008-1025633) [[Back to text](#)]
14. GRANT S, CRAIG I, WILSON J, AITCHISON T. The relationship between 3 km running performance and selected physiological variables. *J Sports Sci*. 1997; 15(4):403-410. doi:[10.1080/026404197367191](https://doi.org/10.1080/026404197367191) [[Back to text](#)]
15. HAGAN RD, SMITH MG, GETTMAN LR. Marathon performance in relation to maximal aerobic power and training indices. *Med Sci Sports Exerc*. 1981; 13(3):185-189. [[PubMed](#)] [[Back to text](#)]
16. MAFFULLI N, CAPASSO G, LANCIA A. Anaerobic threshold and performance in middle and long distance running. *J Sports Med Phys Fitness*. 1991; 31(3):332-338. [[PubMed](#)] [[Back to text](#)]
17. MORGAN DW, BALDINI FD, MARTIN PE, KOHRT WM. Ten kilometer performance and predicted velocity at VO₂max among well-trained male runners. *Med Sci Sports Exerc*. 1989; 21(1):78-83. doi:[10.1249/00005768-198902000-00014](https://doi.org/10.1249/00005768-198902000-00014) [[Back to text](#)]
18. NICHOLSON RM, SLEIVERT GG. Indices of lactate threshold and their relationship with 10-km running velocity. *Med Sci Sports Exerc*. 2001; 33(2):339-342. [[PubMed](#)] [[Back to text](#)]
19. NOAKES TD, MYBURGH KH, SCHALL R. Peak treadmill running velocity during the VO₂ max test predicts running performance. *J Sports Sci*. 1990; 8(1):35-45. doi:[10.1080/02640419008732129](https://doi.org/10.1080/02640419008732129) [[Back to text](#)]
20. PETIT MA, NELSON CM, RHODES EC. Comparison of a mathematical model to predict 10-km performance from the conconi test and ventilatory threshold measurements. *Can J Appl Physiol*. 1997; 22(6):562-572. doi:[10.1139/h97-036](https://doi.org/10.1139/h97-036) [[Back to text](#)]
21. ROECKER K, SCHOTTE O, NIESS AM, HORSTMANN T, DICKHUTH HH. Predicting competition performance in long-distance running by means of a treadmill test. *Med Sci Sports Exerc*. 1998; 30(10):1552-1557. doi:[10.1097/00005768-199810000-00014](https://doi.org/10.1097/00005768-199810000-00014) [[Back to text](#)]

22. SLATTERY KM, WALLACE LK, MURPHY AJ, COUTTS AJ. Physiological determinants of three-kilometer running performance in experienced triathletes. *J Strength Cond Res.* 2006; 20(1):47-52. [[PubMed](#)] [[Back to text](#)]
23. SLOVIC P. Empirical study of training and performance in the marathon. *Res Q.* 1977; 48(4):769-777. [[PubMed](#)] [[Back to text](#)]
24. SPARLING PB, WILSON GE, PATE RR. Project overview and description of performance, training, and physical characteristics in elite women distance runners. *Int J Sports Med.* 1987; 8(2):73-76. doi:10.1055/s-2008-1025708 [[Back to text](#)]
25. STRATTON E, O'BRIEN BJ, HARVEY J, BLITVICH J, MCNICOL AJ, JANISSEN D ET AL. Treadmill velocity best predicts 5000-m run performance. *Int J Sports Med.* 2009; 30(1):40-45. doi:10.1055/s-2008-1038761 [[Back to text](#)]
26. WEYAND PG, CURETON KJ, CONLEY DS, SLONIGER MA, LIU YL. Peak oxygen deficit predicts sprint and middle-distance track performance. *Med Sci Sports Exerc.* 1994; 26(9):1174-1180. [[PubMed](#)] [[Back to text](#)]