Effects of 3 days training with hyperoxia on muscle energy metabolism and systemic circulation

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Abstract

Objective: An experimental 3 day training application using the treadmill and hyperoxia, as a rapid improvement in muscle energy metabolism and systemic circulation were used in this study.

Methods: Six 400 m male track specialist, mean age 17 ± 1.17 years of age were requited. The research test consisted of 400 m performance (pre and post test) and training test. The training test were separated into day 1 (Tr-1) and day 3 (Tr-3) representing the intermittent mode, and day 2 (Tr-2) representing the continuous running. Intermittent workload Tr-1 and Tr-3 was set at 90% of the subject's best time for (3x3x90 %); continuous running was sustained at 50 % and performed on Tr-2.

Results: Results indicated five of the six subjects significantly increased their 400 m speed 0.05-0.15 m/s. Only one subject showed no improvement (-0.19 m/s). Two interval training sessions (Tr-1, Tr-3) blood lactate concentration indicated a downward trend post test and in the 9^{th} interval training session a significant difference occurred (p<0.05). NH_3 in 6^{th} interval training and after the end of the 3^{rd} min. (E3) decreased significantly (p <0.05), and H_2O_2 on the 3 day of training indicated no significance (p>0.05). While looking at the heart rate during interval training, Tr-1 and Tr-3 indicated a downward trend.

Conclusions: From these findings of this study the best time to incorporate this type of training model can be used one month before a race, while the athletes are in their best physical condition and metabolism is able to adapt to the three days of intense hypoxia training on the treadmill. As a result of this the increased muscle co-ordination between the ability and muscle activity of the neurological system the athletes will be able to improve 400m time but as from a metabolic stand point changes will take longer to show adaptation.

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Introduction

Mankind's dream of running faster on the track have led sports scientists and coaches to work together to refine the athletes peaking cycle. In this study we looked at the 400 m run which is a combination of speed and endurance. One month before a race, athletes need to be in their best physical condition, at this point fine tuning the athlete is necessary to ensure the athletes performance peaks on the day of competition. And the training with hyperoxia was used to relative lower production of blood lactate (Hollmann et al., 2002; Jang, 2003; Huang, 2008). Therefore, the aim of this study was to design a training protocol for the 400 m run. The training protocol consisted of 3 days training with hyperoxia on the treadmill. The goal was to enhance the athlete's performance by altering the metabolism and systemic circulation.

Method

Subject

Six 400 m male track specialist participated in this study. Three days prior to the test, athletes discontinued any type of high-intensity training, in order to limit training effect on the test outcome. Subjects were 17±1.17 years old, 174±5.74 cm tall, 62± 5.04 kg weight and 5.67±0.83 years training experience. All athletes were required to fill out a consent form in order to participate in this study.

Experimental Design

Training sessions were performed 3 days a week (Figure. 1). Training design and intensity of the 1st (Tr-1) and the 3rdday (Tr-3) were similar. It consisted of an intermittent training intensity of 90% of the individual's best performance in the 400 m run. Training consisted of 3 sets at a pace of (1.7 m/s) 3 minutes rest was allowed between each set. Each set was composed of three 20 second intervals at a pace of (2.5 m/s) followed by a resting period of 30 seconds between the intervals ($3 \times 3 \times$ 20s). On the 2nd day (Tr-2) subjects were required to perform a continuous training session at an intensity of 50 %, of their best performance in the 400m run, for 15min. Subjects wore an oxygen mask during the whole training session in addition to 10 minutes after the training set. Oxygen concentration was set at 90 %. Two training tests were conducted. The first was after the first 400 m test (T-1). Two days of rest were allowed before conducting the training period Tr-1. The second test (T-2) was conducted on the second day after Tr-3. The biological parameters (Figure. 2) were measured during training (after Tr-1, Tr-3 and at the end of the set): La, HR, NH_3. 10μl blood was drawn to analyze lactate with a German lactic acid analyzer (EKF) and 20μl blood was also drawn to analyze Ammonia (NH3) with a Japanese ammonia analyzer. A Polar 610i was used to record heart rate. After the 400 m test T2, lactate was taken after the 1^{st},3^{rd},5^{th},7^{th},10^{th} and 15^{th} minute of the recovery period.

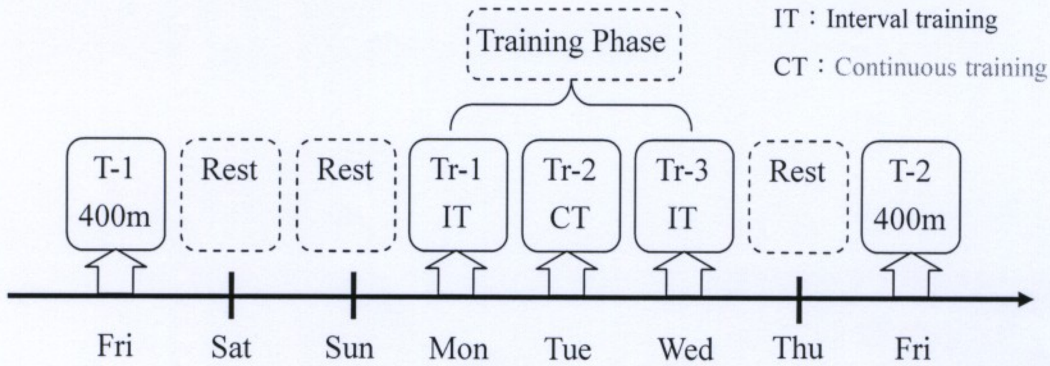

Figure 1 Experimental flow chart

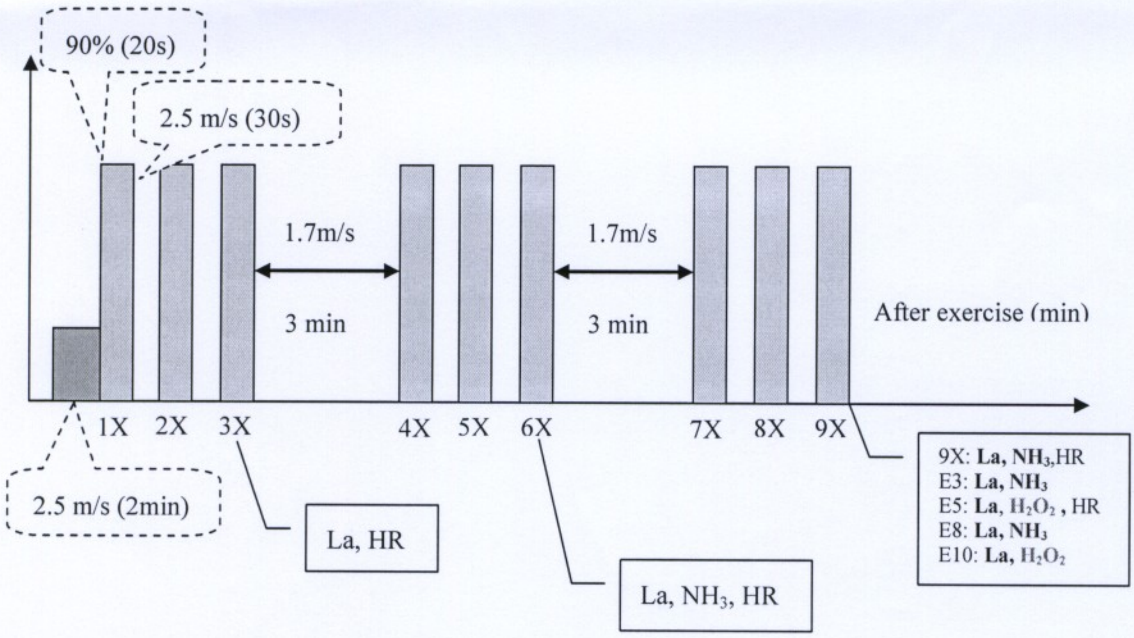

Figure 2 Training test Tr-1 and Tr-3's training methods, content and biological parameters

Statistics

All data are presented as mean±SE. A paired *t*-test was used to determine the 400m performance and lactic acid. The differences of lactic acid, ammonia, free radicals, and heart rate between the two training sets (Tr-1 and Tr-2) were analyzed using the paired *t*-test. Statistical significance was accepted at $p < 0.05$.

Results

After each subject's best T-1 (400m) performance, the training speed for the study was determined and set at 90% and 50% (m/s) of their maximal speed in the 400m (Table 1). Figure 3 and 4 represent lactate and NH_3 at the 1st (Tr-1) and 3rd day (Tr-3) of training. R represents lactate and NH_3 before the intermittent training with hyperoxia on treadmill. Furthermore, lactate and NH_3 parameters are shown at the end of each set (3X, 6X, 9X) and during the recovery period (E_3 -E_{10}). In contrast to Tr-1 lactate and NH_3 parameters in Tr-3 decreased during the training and recovery period. In addition, the highest lactate levels were measured and recorded at the end of the third set (9X) in Tr-1 (13.68±3.25 mmol/l) as well as in Tr-3 (10.40±2.87 mmol/l). In contrast to T1 (11.71±3.07 mmol/l) the blood lactate concentration in T2 (8.41±1.52 mmol/l) decreased significantly ($p<0.05$) at the end of the second set (6X). Continuing on, NH_{3max} (124.00±41.12 μmol/l) of Tr-1 occurred in the 8th min of rest (E8), but the NH_{3max} of Tr-3 (122.00±39.64 μmol/l) occurred at the end of the second set (6X). Results indicated that NH_3 at the end of the second set (6X) and in the 3rd min of rest (E3) were significantly ($p < 0.05$) lower in Tr-3 (6X=70.00±19.14, E3= 6.17±21.72 μmol/l) when compared to Tr-1 (6X=97.67±20.26, E3=118.67±25.09 μmol/l).

Table 2 pre-test max speed on 400 m, 90% max speed and 50% max speed means±SD

	400m speed (T-1)	90% speed	50% speed
Speed(m/s)	7.47±0.10	6.72±0.10	3.74±0.05

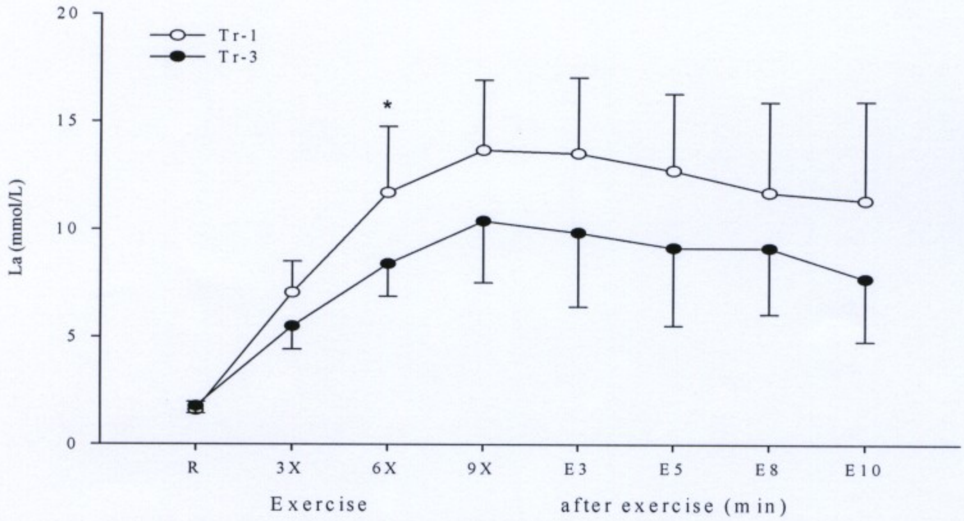

Figure 3 Lactate during the 1st (Tr-1) and 3rd day (Tr-3) of training including recovery time (E)

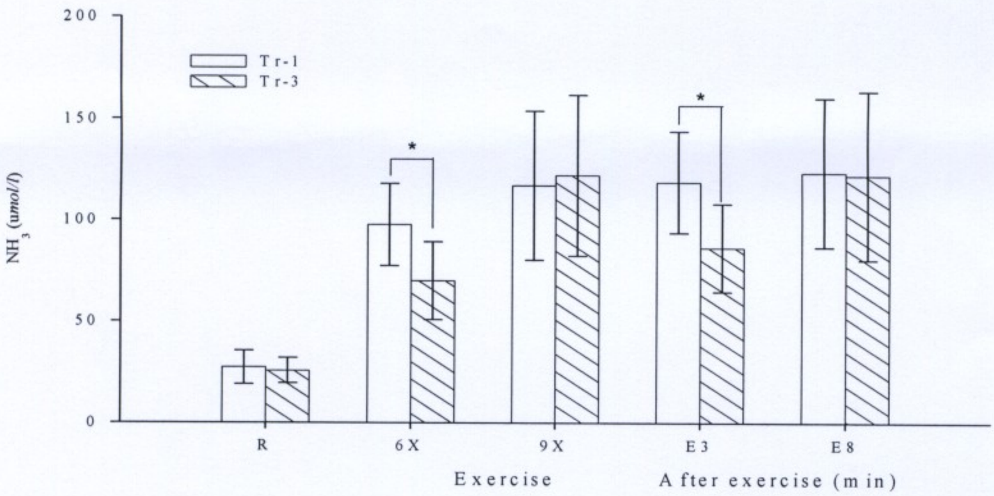

Figure 4 NH_3 during the 1st (Tr-1) and 3rd day (Tr-3) of training including recovery time (E)

Table 3 shows the results of the H_2O_2 and heart rate and their differences. The differences between Tr-1 and Tr-3 indicated no significance (p>0.05). Maximum heart rate was measured at the end of the third set (9X) in Tr-1 (193.83±10.25 min^{-1}) as well as in Tr-3 (187.33±12.93 $min^{-1)}$. Heart rate during Tr-3 (training period 3X, 6X, 9X) was slightly lower than in Tr-1. The decrease in heart rate was not significant (p >0 .05).

Table 3 H_2O_2 and Heart Rate during the 1st (Tr-1) and 3rd day (Tr-3) of training including recovery time (E)

		R	E5	E8	
H_2O_2	Tr-1	1.71±0.35	1.88±0.47	1.85±0.45	
(mmol/l)	Tr-3	1.59±0.41	1.81±0.36	1.86±0.39	
		3X	6X	9X	E5
HR	Tr-1	187.33±9.54	191.5±10.48	193.83±10.25	111.33±14.02
(min^{-1})	Tr-3	177±12.68	183.83±11.51	187.33±12.93	101.33±17.63

Figure 5 shows the results of the 400m tests T1 and T2 (m/s) and their differences. Results indicate that five of the six subjects increased their 400 m speed significantly (0.04-0.15 m/s). Only one subject showed no improvement (-0.19 m/s). The improvement between T1 and T2 was not significant (p >0 .05).

Continuing on, lactate before and after the post-test T2 indicated a slight increase over T1 with the exception of R, E1 and E3, which showed no differences (Fig. 6). Also, there was an increase in lactate (E5、E8、E10、E15) but not significantly (p >0 .05). In conclusion, maximum lactate increased from 17.83±1.02 mmol/l (E10) in T1 to 19.12±1.6 mmol/l (E8) in T2 (Fig. 6).

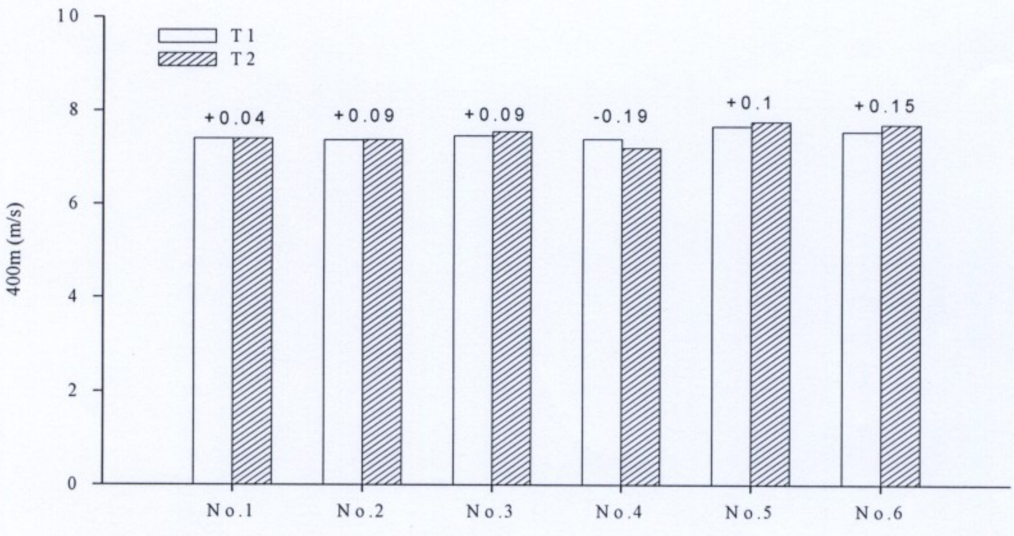

Figure 5 Individual results of 400 m pre-test (T-1) and post-test (T-2)

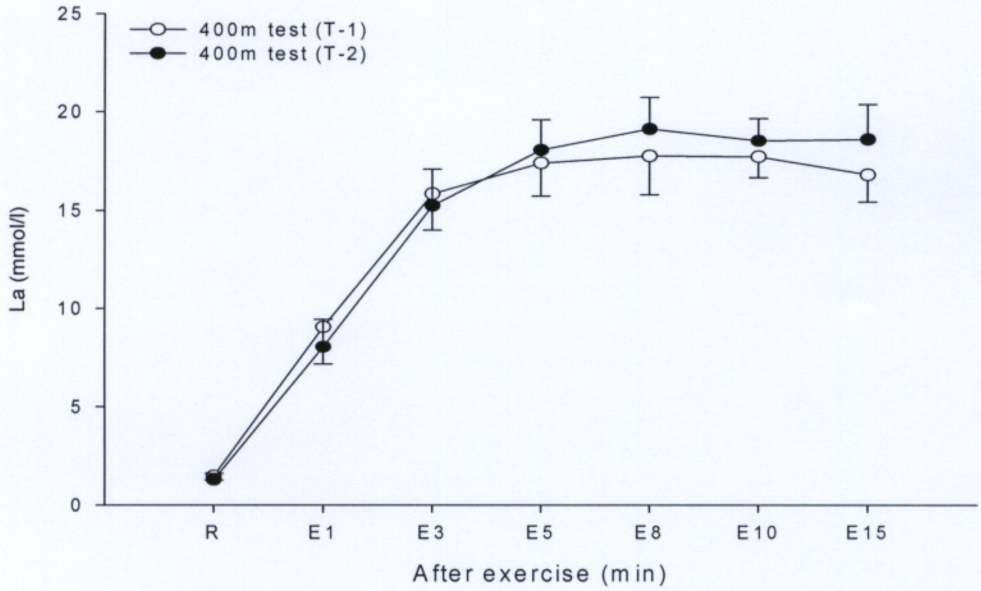

Figure 6 Comparison of lactate (mmol/l) during 400 m pre-test and post-test

Discussion

In this study, lactic acid and NH_3 showed a downward trend (Tr-1 vs Tr-3), under high-intensity exercise with hyperoxia, that PCr have better efficiency (stellingwerff et al., 2006), and relative lower production of blood lactate (Hollmann et al., 2002; Jang, 2003; Huang, 2008). In this study H_2O_2 indicated no significant change which was different from Cooper et al (2002) findings. This could possibly be caused by antioxidants (Muna et al., 2001) and HSP70 (Kinnunen et al., 2005) but in order to better understand this further research would need to be conducted. Heart rate and 400 m speed performance were not significantly improved. This indicated that further time to adapt is required.

Conclusion

From these findings of this study the best time to incorporate this type of training model can be used one month before a race, while the athletes are in their best physical condition and metabolism is able to adapt to the three days of intense hypoxia training on the treadmill. As a result of this the increased muscle co-ordination between the ability and muscle activity of the neurological system the athletes will be able to improve 400m time but as from a metabolic stand point changes will take longer to show adaptation.

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