Acute effects of physical responses after high-intensity exercise under hypoxia, normoxia, and hyperxia

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Abstract

Introduction: Evidences have suggested that exercise intensity has great effect on physical responses, like lactate, glucose, heart rate (HR) and oxygen saturation (SpO_2), especially in high-intensity exercise. In addition, different oxygen-supplied conditions might also influence physical responses during post-exercise recovery. Hence, the purpose of this study was to examine the acute effects on three oxygen-supplied conditions (hypoxia, normoxia, hyperxia) for post-exercise recovery after high-intensity exercise.

Methods: Six participants (16.0±0.9 years old, 176.5±5.0 cm, 64.5±5.5 kg) were instructed to repeat five consecutive sprints (20 seconds) at 90% of their maximal speed on the treadmill, and then were gave three oxygen-supplied conditions (hypoxia: FiO_2 13%, normoxia: FiO_2 21%, hyperxia: FiO_2 97%) for 30 minutes at post-exercise recovery. Lactate and glucose were analyzed after exercise, and we also recorded HR and SpO_2. One-way ANOVA with repeated measures were used to compare the effects of different oxygen-supplied conditions on physical responses.

Results: Greater SpO_2 was found on hyperxia (97.6±0.2%) as compared to hypoxia (86.7±2.3%) and normoxia (95.4±0.9%) after high-intensity exercise (p< .05). Unfortunately, there were no significant differences on lactate (hypoxia: 14.5±3.4, normoxia: 14.0±1.1, hyperxia: 13.6±1.5 mmol/L), glucose (hypoxia: 6.3±1.4, normoxia: 6.6±1.2, hyperxia: 6.0±0.5 mmol/L) and HR (hypoxia: 115.6±4.1, normoxia: 112.2±7.0, hyperxia: 113.9±9.6 bpm). **Discussion:** To our results, it might promote the level of peripheral muscle oxygen saturation under hyperoxia condition, which resulted in greater SpO_2. In addition, there still had decreasing tendencies under hyperoxia condition, although there were no significant differences on lactate, glucose, and HR.

Conclusion: Under hyperoxia condition, it would facilitate post-exercise recovery after high-intensity exercise, particular in muscular oxygenation.

Keywords: submaximal exercise, oxygen content, oxygen supplement

Introduction

Recently, the scientists found that low volume, high intensity interval training improve exercise performance and other benefices rapidly (Burgomaster et al., 2005; McKay at al., 2009; Gibala et al., 2006; Talanian et al., 2006). When the intensive training load was complete increased without enough recovery, fatigue may accumulate resulting in a reduced performance capacity (Coutts et al., 2007; Kellmann, and Kellmann, 2010). High-intensity exercise may result in less oxygen available to the muscle (Peeling and Andersson, 2011). In addition, different oxygen-supplied conditions might also influence physical responses during post-exercise recovery (Rousseau et al., 2005; Eiken et al., 1987). Evidences have suggested that hyperoxia can prevent the fall in SaO_2 and enhance the glycolytic activity during exercise (Linossier et al., 2000; Peeling and Andersson, 2011). On the other hand, acute hypoxia could aggravate oxygen transport, sympathetic activity, peripheral vasoconstriction, and metabolic regulation, which may facilitate improvements in oxygen delivery (Richardson et al., 2009; Mackenzie et al., 2008). Heart rate, lactatic acid and glucose are useful in detection of exercise intensity and recovery (Jeukendrup and Van-Diemen, 1998; Blomstrand and Saltin, 2004). Hence, the purpose of this study was to examine the acute effects on three oxygen-supplied conditions (hypoxia, normoxia, hyperxia) for post-exercise recovery after high-intensity exercise.

Methodology

Six high school male sprinters were participated in this study. All of them had experienced regular training and competition at least 3 years. Written consent was obtained from each subject before data collection. Each subject’s age, height, weight and specific speed test (150 meters sprint) were also recorded and listed in Table 1.

No.	Age (years)	Height (cm)	Weight (kg)	$Speed_{max}$ (m/s)
1	17	171.2	60	9.0
2	16	180.4	64	8.6
3	15	178.9	65	8.9
4	15	180.9	75	8.7
5	17	178.2	60	9.0
6	16	169.1	63	8.8
Mean ± SD.	**16.0±0.9**	**176.5±5.0**	**64.5±5.5**	**8.8±0.2**

Table 1. Subjects

Each participant was instructed to repeat five consecutive sprints (20 seconds) at 90% of their maximal speed on the treadmill (H/P Cosmos Pulsar, 3P 4.0, Nussdorf-Traunstein, Germany), and then were gave three oxygen-supplied conditions (hypoxia: FiO_2 13%, normoxia: FiO_2 21%, hyperxia: FiO_2 97%) for 30 minutes at post-exercise recovery (Figure 1). Lactate and glucose were taken from ear-lobe and analyzed (Biosen C line, EKF Diagnostic, Germany) after exercise, and we also recorded HR (Polar 610i^{TM}; Kempele, Finland) and SpO_2 (Pulse oximeter OxiHeart OX-700). Data were extracted and averaged at the time of 5, 10, 15, 20, 25 and 30 min during recovery. One-way ANOVA with repeated measures were used to compare the effects of different oxygen-supplied conditions on physical responses.

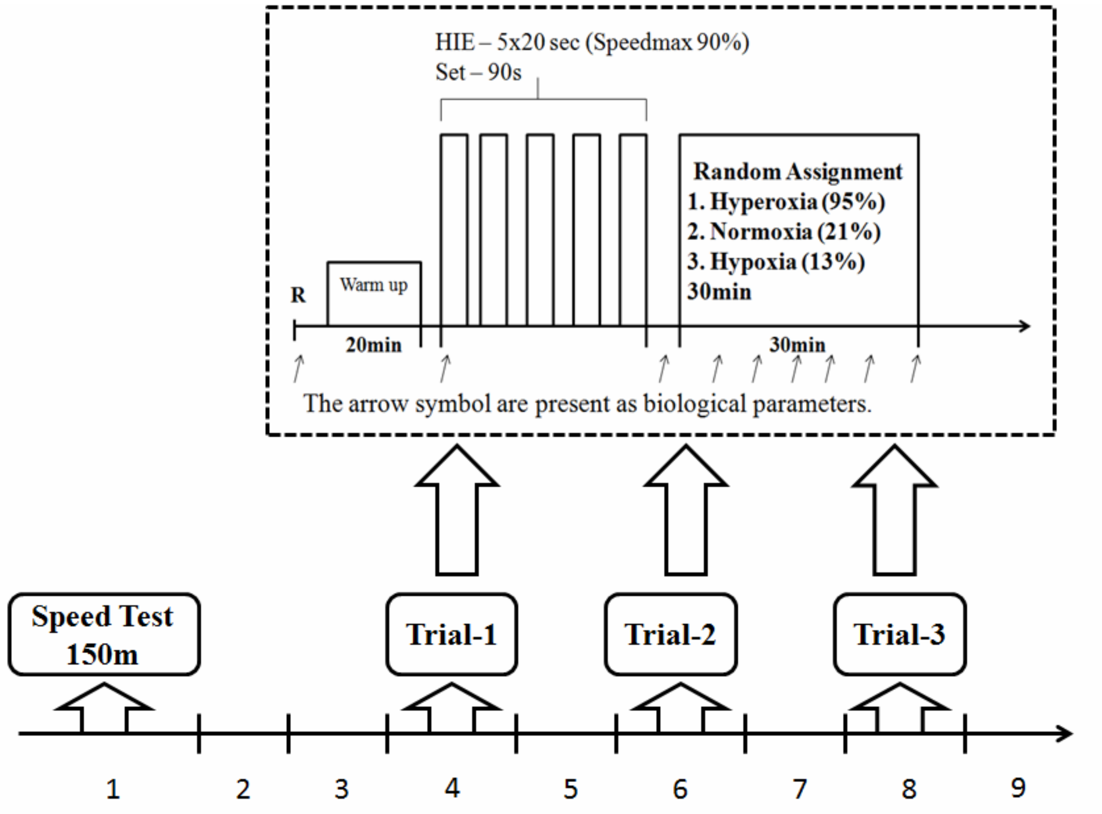

Figure 1. Experimental design and flow chart

Results

Greater SpO_2 was found on hyperxia (97.6±0.2%) as compared to hypoxia (86.7±2.3%) and normoxia (95.4±0.9%) after high-intensity exercise (p< .05) (Figure 2). Unfortunately, there were no significant differences on lactate (hypoxia: 14.5±3.4, normoxia: 14.0±1.1, hyperxia: 13.6±1.5 mmol/L), glucose (hypoxia: 6.3±1.4, normoxia: 6.6±1.2, hyperxia: 6.0±0.5 mmol/L) and HR (hypoxia: 115.6±4.1, normoxia: 112.2±7.0, hyperxia: 113.9±9.6 bpm).

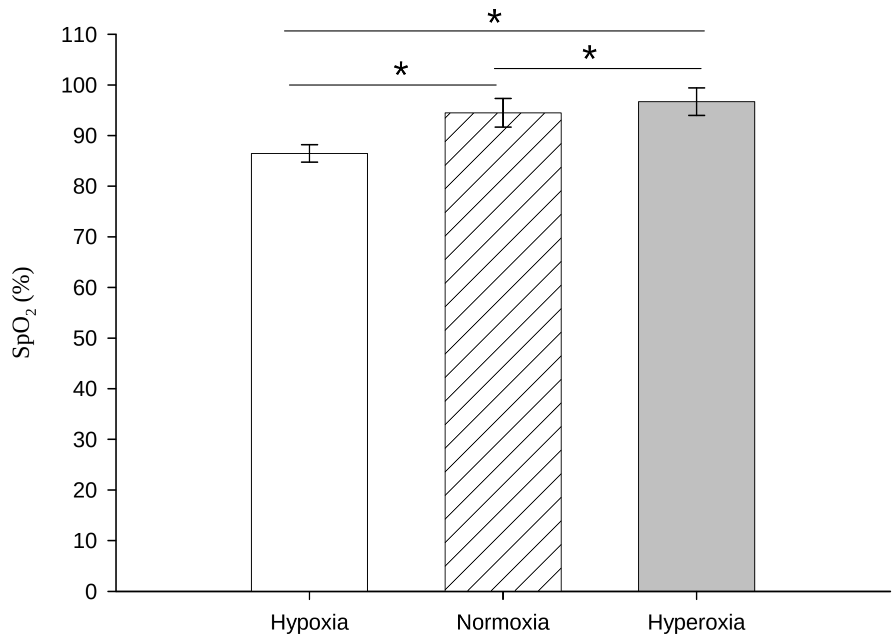

Figure 2. SpO_2. *: Sinificant correiation with P< 0.05

Discussion

This study was to examine the acute effects on three oxygen-supplied conditions for post-exercise recovery after high-intensity exercise. During post-exercise recovery, we found 1) no difference in heart rate, 2) no difference in lactate, 3) no difference in glucose, 4) significant difference in SpO_2. Evidence has suggested that it may improve the recovery time of SpO_2 during post-exercise period under hyperoxic condition as compared to normoxia (Peeling and Andersson, 2011), furthermore, other result was also found that greater SpO_2 occurred under normoxia when compared to hypoxia (Haddad et al., 2012). The possible reason is that hyperoxia might decrease in hemoglobin de-saturation (Nummela, et al., 2002). Hence, to our results, it might promote the level of peripheral muscle oxygen saturation under hyperoxia and normoxia, which resulted in greater SpO_2. Although there were no significant differences on lactate, glucose, and heart rate, there still have decreasing tendencies under hyperoxic condition. However, Hughes et al. (2003) indicated that oxygen supplement after exercise would increase the insulin, and this might result in decreasing the glucose. Stellingwerff et al. (2005) claimed that the closer match between pyruvate production and oxidation during hyperoxia resulted in decreased muscle and blood lactate accumulation.

Conclusion

As a result, we concluded that oxygen supplement (hyperoxia) would facilitate post-exercise recovery after high-intensity exercise, particular in muscular oxygenation.

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