-FULL PAPER GUIDELINE-

EFFECTS OF REPEATED SPRINT TRAINING IN NORMOBARIC HYPOXIA ON AEROBIC CAPACITY AND TOLERANCE TO FATIGUE IN RUGBY SEVENS PLAYERS

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Abstract

This study aimed to evaluate the effects of 6 weeks of repeated sprint training in normobaric hypoxia condition on aerobic capacity and tolerance to fatigue performance in rugby sevens players. Fourteen rugby sevens players, aged between 18-22 years, from Chulalongkorn university were recruited for this study. The participants, matched by their peak oxygen uptake (VO_2peak), were randomly assigned into either hypoxic (RSH, n=7) or normoxic (RSN, n=7) group. Both RSH and RSN completed a repeat sprint training (RS), consisting of 3 sets of 6-s × 10 sprints at 140% vVo_2max with 6% incline, on a motorized treadmill in hypoxic room (F_IO_2 = 14.5%) and at sea level (F_IO_2 = 20.9%), respectively, 3 times a week for 6 consecutive weeks in addition to their normal training. Before and after training, VO_2peak and ventilation threshold (VT) were measured during an incremental running test, while fatigue index was determined during repeated sprint ability test. Independent t-*test* and *dependent sample* t-*test were used for statistical analysis*. The results showed that RSH induced a significant increase in VO_2peak compared with their baseline (+8.69%, $p<0.05$) and a decrease in fatigue index compared with their baseline (-13.80%, $p<0.05$), but no change in VT, after 6-week training. No significant differences in such parameters were observed in RSN. Therefore, it was concluded that a 6-week of repeated sprint training in hypoxic condition was effective for improving aerobic capacity and tolerance to fatigue during running-base anaerobic sprint test in rugby sevens players.

Keywords: Repeated sprint training / Hypoxia / Rugby sevens / VO_2max

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INTRODUCTION

Rugby sevens is increasingly becoming a popular sport because of its safer and more exciting and it has recently been accepted into the 2016 Olympic Games. Rugby sevens is a variant of traditional rugby union which is consisting of 15 players. Although, playing techniques and rules are similar to rugby union, rugby sevens have seven players playing 14 minutes each match. Despite this, rugby sevens requires a higher number of intermittent high-intensity load with shorter rest period, it need physical fitness and training that are different from rugby union (Ross, Gill & Cronin, 2014). In deed, the motion analysis revealed that rugby sevens use an approximately 60 % of aerobic energy and 40% of anaerobic energy systems (Bompa and Claro, 2009). It is because this heavily anaerobic energy demand,, players are susceptible to fatigue, which is eventually resulted in reduced mobility and ability of rugby seven players (Higham et al., 2012).

At present, several methods of training have been used for the development of athletic performance in a team sport. Of these, a repeated sprint (RS) training is considered an effective and efficient form of an interval training in RS training is typically consisted of a multiple sprints in the range of 6-10 seconds with rest duration not more than 1 minute per round. Thus, the load characteristic of RS training is quite similar to what rugby players encounter during a competition. To date, despite extensive studies in other team sports, little is known about the effect of RST on aerobic performance and the ability to repeat maximal and short sprints which is essential to rugby sevens.

Simulated altitude training has been shown to improve physical performance of endurance athletes compared to identical training in normoxia (Brocherie et al., 2015). Thus far, there are only few studies examining the effects of RST in simulated altitude on sea-level performance of team-sport athletes. In one study, Galvin et al. (2013) found that 12 sessions of RS training (10x6 s, 30 s recovery) in hypoxia (13% FiO_2) over 4 weeks resulted in significant improvements in capacity to perform repeated aerobic high intensity workout when compared to an equivalent normoxic training. In another study, however, Goods et al., (2015) reported that cycling RS training in hypoxia provided no additional benefit to sea-level repeated cycling performance as compared to normoxia. This discrepancy could be related to differences in training protocol (cycling vs. running) and level of subject's physical fitness (well-trained vs trained), and so on, between studies.

Given that RS training in hypoxia is a promising training strategy for improving a repeated sprint performance of athletes in many team sports but its effect on rugby sevens is still lacking, therefore this study aimed to examining the effects of RS training in hypoxia on aerobic capacity and the repeated sprint ability in rugby sevens players.

MATERIALS AND METHODS

Subjects

Fourteen rugby sevens players, aged between 18-22 years, from Chulalongkorn University were recruited for this study. The participants, matched by their peak oxygen uptake (VO_2peak), were allocated into either hypoxic (RSH, n=7) or normoxic (RSN, n=7) group. All procedures was approved by the ethical committee of the Chulalongkorn University (protocol no.080.1/61). The physical characteristics of subjects in each group was shown in Table 1.

Table 1 Physical characteristic of subjects

	RSH (n=7)	**RSN (n=7)**
Age (yrs)	20.86 ± 1.68	20.14 ± 1.86
Body Weight (Kg.)	80.37 ± 5.65	78.05 ± 15.35
Body Fat (%)	18.84 ± 4.86	19.14 ± 5.01

Incremental running test

All subjects visited the laboratory for familiarization one week before the experiment. Before and after training, each subject was asked to complete an incremental running test on a motorized treadmill in order to determine peak oxygen uptake (VO_2peak). The test began with running at an initial speed of 10 km/h with a constant 1% incline for 1 minute. The speed was then increased by 0.5 km/h every minute until voluntary exhaustion. All subjects were verbally encouraged throughout the test. Respiratory gas exchange variables were measured breath-by-breath using a portable Cortex Metamax3B (CORTEX Biophysik GmbH, Germany) during the test. Before each test, gas volume was calibrated using a 3-L syringe and a gas analyzer was calibrated using a standard gas mixture of 15% O_2 and 5% CO_2.

Training protocol

One week after completion of VO2peak test, the subjects in both RSH and RSN group performed a repeat sprint (RS) training, 3 times a week for 6 consecutive weeks in addition to their normal training. A training protocol consisted of 3 sets of 6-sec × 10 sprints at a velocity corresponding to 140% vVO_2peak on a motorized treadmill with 6% incline. RS training was conducted in either a hypoxic room (F_IO_2 = 14.5%) or at sea level (F_IO_2 = 20.9%). A detail of training protocol was depicted in Fig 1.

Repeated sprint ability test

Running-based Anaerobic Sprint Test (RAST) was used to determine the repeated sprint ability as previously described (Zagatto et al., 2009). In brief, after 10 minutes of warm-up the subjects were required to complete a 6 x 35 meters run at a maximal effort with 10 seconds allowed between each sprint for a turnaround to commence the next sprint. The running time for each sprint was recorded using timing light gates (Kinematic measurement system, Australia) and total time calculated. Fatigue index was calculated from a following formula;

Fatigue index (FI) = (maximum power value - lowest power value) / total running time for 6 rounds.

Statistical analysis

Dependent sample *t*-test was used to determine the mean difference in dependent variables within group (before vs after training). The mean differences between groups (RSH vs. RHN) were analyzed using independent t-*test*. The level of significance was set at $P < 0.05$. All statistical analyses were completed using SPSS 23.0 (SPSS Inc., Chicago, IL., USA). Data were expressed as means ±SD.

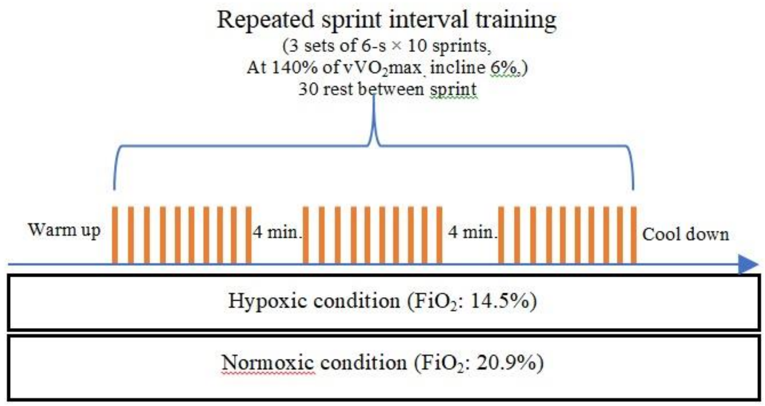

Fig. 1 A protocol for each training session.

RESULTS

Table 2 VO_2peak, ventilatory threshold, velocity at VO_2peak, and fatigue index in RSH and RSN before training

Variable	**RSH (n=7)**	**RSN (n=7)**	**p-value**
VO_2 peak) ml/ kg/ min(	46.96 ± 2.49	49.69 ± 4.08	.162
VT) ml/ kg/ min(	31.30 ± 6.77	31.73 ± 9.20	.923
VT (%VO_2peak)	66.24 ± 11.67	63.74 ± 16.68	.751
vVO_2peak	14.21 ± 1.25	13.50 ± 1.15	.289
Fatigue Index) Watt/sec(	10.20 ± 3.55	10.05 ± 1.84	.921

As shown in Table 2, there were no significant differences in VO_2peak, ventilator threshold (VT) either expressed as absolute or relative to VO_2peak, velocity at VO_2peak (vVO_2peak), and fatigue index between groups at the beginning of the experiment. After 6 weeks of training, VO_2peak was increased significantly in RSH (+8.69% from baseline, $p<0.05$) compared with RSN (-1.21% from baseline, $p>0.05$) (Table 3). However, no difference was detected in VT either expressed as absolute or relative to VO_2peak between groups. Interestingly, fatigue index was significantly improved after 6 weeks of training in RSH (-13.80%) compared with RSN group (-0.20%) as shown in Table 3.

Table 3 Changes in VO_2peak, VT, and fatigue index after training in both groups

Variables	RSH			RSN		
	Before	After	% change	Before	After	% change
VO_2peak)ml/ kg/ min(	46.62 ± 2.54	50.67 ± 1.51	+ 8.69 *	49.90 ± 4.43	49.83 ± 3.76	0.14
VT) ml/ kg/ min(	30.68 ± 7.20	32.91 ± 7.71	+ 7.27	31.38 ± 10.02	31.00 ± 4.48	-1.21
VT (%VO_2peak)	65.39 ± 12.54	64.86 ± 14.58	-0.81	62.74 ± 18.04	62.38±9.32	-0.57
vVO_2peak (km/h)	14.58 ± .86	14.75 ± .76	+1.17	13.42 ± 1.24	13.67 ± 1.29	+ 1.19
Fatigue Index)Watt/sec(	10.87 ± 3.38	9.37 ± 2.62	-13.80 *	10.05 ± 1.84	10.03 ± 1.57	-0.20

*$p<.05$ compared with before training

DISCUSSION

The major findings of this study were that RSH resulted in increased VO_2peak and reduced fatigue index after 6-week of training as compared with RSN. These results suggested that the addition of hypoxia to RS training for 6 weeks can improve aerobic capacity and tolerance to fatigue in rugby seven players. The details of discussion were described below.

In this study after 6 weeks of training, RSH group showed a greater improvement of VO_2peak and fatigue index than in RSN group. This finding was agreed with a previous report of Czuba et al. (2011) who evaluated the efficacy of intermittent hypoxic training (IHT) at workload of 95% of lactate threshold on aerobic capacity and endurance performance in well-trained cyclists. They found a significant increase in VO_2max and LT after only 3 weeks of IHT. Similarly, Brechbuhl et al., (2018) also demonstrated that repeated sprint training (10 sessions) for 10 days in RSH (FiO_2=14.5%) resulted in a significant increase in VO_2max and workload at blood lactate accumulation in RSH group compared to the RSN group in well-trained tennis players. In contrast, Goods et al., (2015) found no additional benefit of repeated sprint training in hypoxia on sea-level cycling performance. The explanation for this difference in results is currently not known but it could be due to the specificity of training (cycling vs. running). In fact, the cardiovascular and muscular systems differently respond and adapt to different types of exercise.

In this study, RSH group also showed a greater improvement of tolerance to fatigue as mesured by fatigue index, than in RSN group (Table 3). This finding was in line with the finding of Galvin et al. (2013) who reported that 4 weeks of RS training in hypoxia (FiO_2=13.0%) enhanced a total distance covered during the intermittent running test as compared to equivalent training in normoxia. However, the mechanism by which this is unclear. Puype et al. (2013) recently investigated the effect of sprint interval training (SIT) performing 6 weeks of SIT on a cycling ergometer (30-s sprints vs 4.5-min rest intervals; 3 day/wk.) in normoxia (FiO_2=20.9%) versus hypoxia (FiO_2=14.4%) on muscle glycolytic and oxidative capacity in healthy male. They found that SIT in hypoxia resulted in a better increase in muscle phosphofructokinase activity and anaerobic threshold than that in normoxia. Another mechanism may involve increased recruitment of fast motor units during RS training in hypoxia (Scott et al., 2016). However, a further study is needed to warrant this mechanism.

CONCLUSION

Our results indicated that the addition of hypoxia to repeated sprint training is more effective than normoxic training to improve aerobic capacity and repeated sprint ability in rugby sevens players. A further study is required to clarify the cellular mechanism involved.

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