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ORIGINAL ARTICLE

A program of circuit resistance training under hypobaric hypoxia conditions improves the anaerobic performance of athletes



Un programme d'entraînement en résistance sous conditions d'hypoxie hypobare améliore les performances anaérobies des athlètes

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Hypoxic training;
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Summary

Objective. — Training high—living low model has been studied as an intermittent hypoxic training (IHT) for anaerobic performance improvement. To test the hypothesis that a high-intensity circuit strength training (CST) performed in hypoxia increases the anaerobic running performance at sea level.

Equipment and methods. — Twelve sub-elite male 400-m runners were divided into two groups: hypoxia (HYP) ($n=6$) and control (NOR) ($n=6$). Twelve sessions were performed over a period of four weeks (three days/week) without any additional running training. Hypobaric training was performed at a simulated altitude of 3000 m (700 hPa; 10.15 PSI). The anaerobic running performance was tested with a repeated interval running training (RIR). Based on an “all-out”

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MOTS CLÉS

Entraînement en altitude ;
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300-m test performed before and after CST, the subjects performed as many sets as they could at 90% of the individual maximal speed reached with a three-minute rest period between sets. **Results.** – As compared to controls, the HYP group showed the following responses post CST: RIR +20.5% (number of sets) ($P < 0.03$); (HYP: 4.3 ± 1 to 6.6 ± 1.9 vs. NOR: 3.6 ± 1 to 4.6 ± 1.3), maximal lactate accumulation (in the last set) +8.1% ($P < 0.03$) (HYP: 11.8 ± 1 to 15.7 ± 1.3 vs. NOR: 12.5 ± 0.9 to 14.6 ± 1.6). Maximum and recovery heart rates finishing the test and hematology did not show statistically significant differences ($P > 0.05$). However, CST in HYP showed a higher HR_{avg} (152.6 ± 6.2) than sea level training (144.4 ± 5.1) ($P < 0.01$).

Conclusions. – These data indicate that a CST in hypoxia conditions increases the anaerobic performance in trained athletes.

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Résumé

Objectif. – Le modèle « travailler en altitude—vivre en bas » a été étudié comme moyen d'amélioration d'hypoxie sur la performance anaérobie, l'hypothèse de cette étude étant qu'on était en mesure de l'augmenter par rapport au niveau de la mer grâce à un exercice de forte intensité (CST).

Matériels et méthodes. – Douze coureurs mâles sub-élites étaient divisés en deux groupes, hypoxie (HYP) ($n=6$) et témoin (NOR) ($n=6$). Douze séances ont été réalisées sur une période de quatre semaines à raison de trois jours par semaine. L'entraînement en hypobarie était réalisé à une altitude simulée de 3000 m (700 hPa, 10,15 PSI). La performance de course en anaérobie a été testée par *interval training* (RIR). Basé sur un test « à fond » de 300 mètres, les sujets exécutaient autant de séquences qu'ils pouvaient à 90 % de leur vitesse maximale avec des pauses de trois minutes entre séquences.

Résultats. – Le groupe hypoxie a montré, par rapport aux témoins : RIR +20,5 % ($p < 0,03$), HYP : 4,3 à 1,9 vs NOR, lactatémie maximale +8,1 % ($p < 0,03$) (HYP 11,8 à 15,7 vs NOR : 12,5 à 14,6). Les fréquences maximales et de récupération en fin d'exercice et l'hématologie n'ont pas montré de différences significative. Cependant, CST était plus élevé en HYP qu'au niveau de la mer.

Conclusion. – Ces données montrent qu'un exercice de forte intensité pratiqué en hypoxie est en mesure d'augmenter la performance anaérobie.

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1. Introduction

Athletic disciplines involving anaerobic performance use both power strength and repeated interval running as specific methods of training. These exercises require a greater specificity of effort including also psychological stress. Under this premise, training in hypoxia athletes has an elevated perception of effort providing a greater specific stimulus for anaerobic metabolism than the same exercise in normoxia [1]. However, despite this fact, the use of different models of intermittent hypoxia training (IHT) to improve athletic performance is subject to extensive discussion at the moment among researchers, coaches and athletes [2]. Two models are classically used in this regard:

- the "living high—training low" (LH-TL) model has been employed with the principal goal of enhancing aerobic performance through the stimulation of EPO release and red blood cell concentration [3] and more recently;
- the "training high—living low" (TH-LL) model, which could improve anaerobic performance by providing an additional stimulus to training [1,4,5].

Whereas the aerobic performance has been shown to increase following LH-TL protocols [3], some authors have described improvements in anaerobic performance using the TH-LL approach [4,6–8]. In contrast, there are also studies that have found no significant benefits to applying either LH-TL [9] or TH-LL [10]. The inconclusive data from the studies have led to a continuing debate on the usefulness of intermittent hypoxia exposure/training for elite athletes both aerobic as anaerobic disciplines. These discrepancies could be due to the wide variability in some experimental factors, including the type and duration of hypoxia exposure, the volume and intensity of the exercise, the subject training status, the individual response to hypoxia and the time point for evaluating performance, in the revised literature [11]. Despite these discrepancies, there are well-documented psychological, metabolic and muscular effects of exposure and training in hypoxia conditions for anaerobic metabolism [6,8]. However, to our knowledge, there are no previous studies measuring the anaerobic performance specifically in runners after of the training protocol of circuit strength training (CST) performed in hypoxia. The CST is a well-established training method commonly used by endurance athletes to improve both the neuromuscular and cardiovascular fitness throughout resistance exercises [12]. Regarding to the running performance, the stride length and frequency

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