International Journal of Sports Science & Coaching

Shock microcycle of repeated-sprint training in hypoxia and tennis performance: case study in a rookie professional player

Journal:	*International Journal of Sports Science & Coaching*
Manuscript ID	SPO-17-0350.R2
Manuscript Type:	Original Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Brechbuhl, Cyril; French Tennis Federation, National Technical Direction Schmitt, Laurent; National Centre of Nordic-Ski, Department of Research and Performance Millet, Gregoire; Universite de Lausanne, ISSUL, Institute of Sport Sciences Brocherie, Franck; French Institute of Sport (INSEP), Laboratory Sport, Expertise and Performance (EA 7370), Research Unit
Keywords:	Tennis, Altitude, physical fitness, repeated-sprint ability, competition period, block periodisation
Abstract:	The aim of this case study was to investigate the effects of a shock microcycle of repeated-sprint training in hypoxia (RSH) on physical fitness and tennis performance. One rookie professional tennis player performed repeated-sprint ability (RSA) and Yo-Yo Intermittent Recovery level 2 (YYIR2) tests before and after (+3 days and +21 days) 6 sessions of RSH (4 sets of 5 × ~6s repeated-shuttle sprint interspersed by ~24 s of passive recovery) practiced during a 14-day "in-season" period. Tennis performance was subjectively measured from match results and Association of Tennis Professionals (ATP) points obtained during four professional tournaments played before and after intervention. While no changes were found at +3 days post-RSH, improvements in physical fitness [single sprint time (-4.5%), RSA total time (-3.1%) and sprint decrement (-16.7%), as well as YYIR2 total distance covered (+ 21.4%)] were observable at +21 days post-RSH. Tennis performance obtained during the tournaments was better after intervention. From pre to post-RSH, the decreases in opponents' ATP ranking during matches won (1109 ± 334 points vs. 818 ± 212 points) and lost (499 ± 68 points vs. 256 ± 58 points) revealed a stronger opposition. Consequently, a three-fold increase (from 4 to 12 ATP points gained from pre to post-RSH) in participant's ATP ranking was recorded. In summary, a 14-day "in-season" shock microcycle including 6 sessions of repeated-sprint training in hypoxia revealed interesting effects in specific fitness and tennis performance in a rookie professional tennis player.

Article type: Case study

Corresponding author:
Dr Franck Brocherie
Laboratory Sport, Expertise and Performance (EA 7370), Research Unit, French Institute of Sport (INSEP), 11 Avenue du Tremblay, Paris, France
Email: franck.brocherie@insep.fr
Phone: +33 (0)1 41 74 43 54

Article Title: Shock microcycle of repeated-sprint training in hypoxia and tennis performance: case study in a rookie professional player

Authors: Cyril Brechbuhl[1, 2], Laurent Schmitt[2, 3], Grégoire P. Millet[2], Franck Brocherie[4]

[1] *National Technical Direction, French Tennis Federation, Paris, France.*
[2] *ISSUL, Institute of Sport Sciences, Faculty of Biology and Medicine, University of Lausanne, Lausanne, Switzerland.*
[3] *Department of Research and Performance, National Centre of Nordic-Ski, Premanon, France.*
[4] *Laboratory Sport, Expertise and Performance (EA 7370), Research Unit, French Institute of Sport (INSEP), Paris, France.*

Running title: RSH and tennis-specific performance

Number words: 240 for abstract, 2006 words from introduction to conclusion

Number of figures: 2

Number of tables: 1

Abstract

The aim of this case study was to investigate the effects of a shock microcycle of repeated-sprint training in hypoxia (RSH) on physical fitness and tennis performance. One rookie professional tennis player performed repeated-sprint ability (RSA) and Yo-Yo Intermittent Recovery level 2 (YYIR2) tests before and after (+3 days and +21 days) 6 sessions of RSH (4 sets of 5 × ~6s repeated-shuttle sprint interspersed by ~24 s of passive recovery) practiced during a 14-day "in-season" period. Tennis performance was subjectively measured from match results and Association of Tennis Professionals (ATP) points obtained during four professional tournaments played before and after intervention. While no changes were found at +3 days post-RSH, improvements in physical fitness [single sprint time (-4.5%), RSA total time (-3.1%) and sprint decrement (-16.7%), as well as YYIR2 total distance covered (+ 21.4%)] were observable at +21 days post-RSH. Tennis performance obtained during the tournaments was better after intervention. From pre to post-RSH, the decreases in opponents' ATP ranking during matches won (1109 ± 334 points *vs*. 818 ± 212 points) and lost (499 ± 68 points *vs*. 256 ± 58 points) revealed a stronger opposition. Consequently, a three-fold increase (from 4 to 12 ATP points gained from pre to post-RSH) in participant's ATP ranking was recorded. In summary, a 14-day "in-season" shock microcycle including 6 sessions of repeated-sprint training in hypoxia revealed interesting effects in specific fitness and tennis performance in a rookie professional tennis player.

Keywords: Tennis, altitude, physical fitness, repeated-sprint ability, competition period, block periodization.

Introduction

Tennis professional tour is characterized by a massive part of season dedicated to the competitions, *i.e.*, tournaments' participations. With this calendar, optimizing the training time appears particularly determinant with a permanent search for the most specific and effective training methods [1]. In order to overcome the limited time schedule, recent publications on intermittent sports such as football [2] or tennis [3] have shown that the use of shock microcycles leads to sport-specific performance improvements.

In this view, repeated-sprint training in hypoxia (RSH) has been proposed as a promising strategy in intermittent sports to improve sport-specific performance [4, 5]. For instance, Gatterer et al. [6] reported that repeated shuttle-run sprint training is feasible in a normobaric hypoxic chamber of limited size (5 m width) and highlighted that a 12-days shock microcycle performed in hypoxia (~3300 m) provided a putative benefit on selected repeated-sprint outcomes (*i.e.*, mean time) compared with similar training in normoxia. This was further accompanied by similar gains in specific aerobic fitness [*i.e.*, Yo-Yo intermittent recovery test level 2 (YYIR2)] after both training modalities, suggesting that RSH did not blunted aerobic adaptations [6]. Although one cannot rule out a placebo effect leading to a higher motivation and/or higher training intensity than usually, suggested RSH-related mechanisms were increased muscular perfusion, changed pH regulation and enhanced glycolytic activity for repeated-sprint outcomes [4], increased tissue oxygen extraction [7], citrate synthase activity and myoglobin content for YYIR2 [4]. Moreover, RSH has been consistently shown as beneficial in different team sports [*e.g.*, rugby [8], field-hockey [9]] and leads to an increase in best and mean repeated-sprint performance [for details, see [10]]. However, to date, no study has yet investigated the effect of RSH on tennis performance.

Regarding the fitness determinants of professional tennis [11], one may assume that RSH might rapidly induce beneficial adaptations and performance improvement. Therefore, the aim of this case study was to investigate the effects of RSH intervention (6 sessions) over a 14-day "in-season" period on specific fitness and tennis performance in a rookie professional tennis player.

Case report

Participant

An 18-year-old rookie professional tennis player (classified in the top-10 of the combined Junior ranking of the International Tennis Federation during the season preceding the present study; body weight 67.0 kg; stature 179 cm; BMI 20.9 kg.m^{-2}) voluntarily agreed to participate. At the time of the investigation, he had been training competitively for the past 8 years, and regularly participated in 8-12 training sessions per week (total training hours per week of 12-25 h) in a program that varies with the schedule of upcoming competition. The participant was informed of the experimental risks and gave his written voluntary informed consent for the tests and for the public reporting of his results. The study conformed to the Declaration of Helsinki, and was approved by the institutional review board.

Time line

All tests (see below) were performed prior to onset of RSH training (pre), after 14 days of intervention (+3 days) and following 2 weeks of tournaments participation (+21 days). Experimental intervention is described in Figure 1. Compared to pre- and post-RSH intervention (18.5 ± 4.0 h and 17.0 ± 1.0 h, respectively), the participant was submitted to on overall training volume of 24 ± 2.0 h during the shock microcycle. Tennis-specific fitness level was assessed using testing battery which was used routinely during participant follow-up. Further, in order to compare the impact on tennis performance, match results from four professional (*i.e.*, ITF Futures) tournaments played before and after intervention were collected.

Tennis-specific fitness tests

Single straight-line 20 m sprint, repeated-sprint ability (RSA) (8 × 20 m – 20 s recovery) and YYIR2 performances were tested as described elsewhere [9]. RSA was assessed using three scores: the best sprint time (RSA_{best}), the total sprint time (*i.e.*, sum of the eight sprints; RSA_{TT}) and the sprint decrement score [12]: S_{dec} (%) = [(RSA_{TT} / (RSA_{best} × 8) – 1] × 100. During the YYIR2 test, the test ended when the participant had failed to reach the finishing line in time for the second time and the total distance was then recorded.

Tennis performance

To evaluate the tennis performance during professional (*i.e.*, ITF Futures) tournaments, we considered the opponent's level [*i.e.*, Association of Tennis Professionals (ATP) ranking] and the number of ATP points gained by the participant before and after RSH intervention. These two criteria are based on the ATP world tour ranking which is the conventional method of assessing the performance of professional tennis players. Briefly, points score is given to a player regarding the round reached during tournaments.

Repeated-sprint training in hypoxia

During the 14-day "in-season" intervention period, the participant included 6 RSH sessions in his usual training routine (Figure 1). Briefly, each RSH session lasted ~1 h, including a 20-min warm-up, repeated-sprint training routine, and a 10-min cooling-down period. Specifically, RSH sessions consisted of 4 sets of 5 × ~6s repeated-shuttle sprint interspersed by ~24 s of passive recovery and were completed on an indoor synthetic tennis surface inside a 120 m² normobaric hypoxic training room (b-Cat, Netherlands) where ambient air was mixed with nitrogen (from pressurized tanks) to reduce FiO_2 to ~14.5% in order to simulate an altitude of 3000 m. Temperature and humidity were maintained at ~21°C and ~55% relative humidity. Participant was constantly reminded to exert "all-out" effort in trying to reach peak acceleration and to maintain the highest possible running speed for every sprint bout. Heart rate (HR; Polar Electro Oy, Kempele, Finland), arterial oxyhemoglobin

(SpO_2; GO2TM Achieve 9570-A, Nonin, Plymouth, MN, USA) and blood lactate concentration ([la]; Lactate Pro Analyser, Arkray Inc, Kyoto, Japan) were measured after each set (data not presented) and at the end of each RSH session. Ratings of perceived exertion (RPE; 6-20 and 0-10 Borg scales), overall perceived discomfort, perceived lower-limb discomfort, and perceived difficulty breathing (modified Borg CR10 scales) were collected at the end of each RSH sessions [13]. RSH training loads were calculated as total session duration × session RPE [14].

Data analysis

Absolute and relative (percentage differences between pre, +3 days and +21 days post-RSH) values are presented by descriptive statistics. Probabilities were also calculated to establish whether the true difference was lower than, similar to, or higher than the smallest worthwhile difference or change (SWC, 0.2 × overall pooled SD per dependent variable). A qualitative effect descriptor was assigned according to the likelihood of the change exceeding the SWC: 50-74% "*possible*", 75-94% "*likely*", 95-99% "*very likely*", >99% "*almost certainly*" [15]. Effects where the 90% confidence interval overlapped simultaneously the substantially positive and negative thresholds were deemed "*unclear*".

Results

Physiological responses at the end of RSH sessions corresponded to an averaged HR, SpO_2 and [La] of 168 ± 6 bpm; 87.8 ± 1.0 %; 9.9 ± 1.9 $mmol.L^{-1}$, respectively. Session RPEs were 15.6 ± 1.1/7.0 ± 0.8 au, corresponding to training load of 935 ± 68/418 ± 50 au. Overall perceived discomfort (6.8 ± 0.8 au), perceived lower-limb discomfort (7.3 ± 0.8 au) and difficulty breathing (7.0 ± 0.9 au) indicated "very severe" scores.

All specific fitness and tennis performance results are summarized in Table 1 and Figure 2.

While no positive changes were found at +3 days post-RSH, improvements in physical fitness [single sprint time (-4.5%, *very likely* greater than the SWC), RSA total time (-3.1%, *almost* *certainly* greater) and sprint decrement (-16.7%, *very likely* greater), as well as total distance covered during YYIR2 (+ 21.4%, *almost certainly* greater)] were observable at +21 days post-RSH. Tennis performance achieved during the tournaments was improved after intervention. From pre to post-RSH, the decreases in opponents' ATP ranking during matches won (1109 ± 334 points *vs*. 818 ± 212 points; 100/0/0, *almost certainly* greater) and lost (499 ± 68 points *vs*. 256 ± 58 points; 100/0/0, *almost certainly* greater) revealed a stronger opposition. Consequently, a three-fold increase (from 4 to 12 ATP points gained from pre to post-RSH) in participant's ATP ranking was recorded.

Discussion

The main finding of this case study is that a 14-day "in-season" shock microcycle including 6 sessions of RSH revealed interesting effects in specific fitness and tennis performance in a rookie professional tennis player. Notably, gains in sport-specific fitness were observed 21 days after cessation of additional RSH, whereas no change was noted 3 days after intervention. This may have accompanied the greater tennis performance recorded during the professional tournaments played after intervention (*i.e.*, between +3 days and +21 days post-RSH).

Although training overreaching/overtraining's risk may exist, periodization of intensive sessions is required to generate physiological adaptations and sport-specific performance enhancement [16, 17]. Here, the underperformance observed at +3 days suggests a temporary state of fatigue which was compensated after sufficient recovery period (*i.e.*, performance improvement at +21 days). These delayed benefits are in line with the specific timing recommendations for the "classical" hypoxic training methods (*e.g.*, living high-training high or living high-training low) with a positive window after 2–3 weeks of sea level training, after return from altitude training before a prime competition [18]. Therefore, this recently developed [7] RSH method seems suitable and effective to improve tennis-specific performance as previously demonstrated in various team-sports [rugby [8], football [6], field-hockey [9]].

While it appears in line with the findings of Gatterer et al. [6] using similar shock microcycle and exercise mode (*i.e.*, 12-day repeated shuttle-sprint training in hypoxia), as well as with a recent meta-analysis on the effects of RSH (*vs*. similar normoxic training) on normoxic sport-specific performance [10], it seems that the shuttle-sprinting mode used for RSH may play a different role than straight-line sprinting mode on transient fatigue development. Based on our data, we assume that the inclusion of change of direction with successive deceleration/acceleration phases during repeated sprints is likely to increase the mechanical (*i.e.*, stride patterns and/or leg stiffness) and peripheral [*i.e.*, active bi-articular leg and core muscles] demands resulting in greater metabolic load (*e.g.*, lactate accumulation) [19]. Overall, this may slightly have altered RSH tolerance [13] without compromising long-term physiological adaptations (*i.e.*, upregulation of the glycolytic activity, higher ability to resynthesize phosphocreatine and higher oxygen utilization) and physical fitness enhancement [4, 9].

Despite our limited understanding of the dose-response relationships between the training load and training-induced changes in physical fitness and tennis performance, the additional effects of RSH on official tennis performance highlights its potential effectiveness to improve tennis fatigue resistance [20]. The use of repeated shuttle sprints likely mimicking on-court movements could have led to positive changes in match performance, with a possible transfer of fitness gains [*i.e.*, RSA-related outcomes, agility and power (not measured here) and aerobic capacity] on technical skill (*i.e.*, advanced shots and stroke efficiency maintenance). Without undermining the importance of fitness attributes, tennis performance is multifactorial and integrates an array of complex physical, physiological, cognitive and psychological processes [21]. As such, further tennis-related RSH research is encouraged to employ robust performance measures and a multi-dimensional approach to tennis performance. The inclusion of on-court tennis specific test [22] and perceptual-cognitive skills (e.g., anticipatory and decision-making capacities) deserve future examination.

From a practical point of view, this case report can be used as a handy script for tennis players preparing for competition. Detailed and periodized repeated-sprint training in hypoxia (RSH) microcycle for 14-day "in-season" period is provided and can be used by staff involved in highly-trained athletes. By focusing on RSH as described with combination of both conditioning and tennis training, an increase in performance can be expected. In addition, relevant tests and related reference values are provided for individual adjustments to be done according to the needs and capacity analysis.

Conclusion

In summary, a 14-day "in-season" shock microcycle including 6 sessions of repeated-sprint training in hypoxia revealed interesting effects in physical fitness and tennis performance in a rookie professional tennis player. However, gains in physical fitness were observed 21 days after cessation of the last session, while remaining unaltered or even negatively affected shortly (3 days) post-intervention. The long-term effect on specific fitness suggests a greater fatigue resistance which may have resulted in greater tennis performance after intervention. Future investigations on special focused hypoxic training block periodization in intermittent sports are warranted.

Acknowledgements

The authors would like to sincerely thank the player for participating in this case study and consenting to its publication.

Declaration of Conflicting Interests

No potential conflict of interest was reported by the authors.

Funding

The authors have no sources of funding to disclose.

References

1. Fernandez-Fernandez J, Sanz-Rivas D, Sanchez-Munoz C, et al. Physiological Responses to On-Court vs Running Interval Training in Competitive Tennis Players. *J Sports Sci Med* 2011; 10: 540-545. 2011/01/01.

2. Christensen PM, Krustrup P, Gunnarsson TP, et al. VO2 kinetics and performance in soccer players after intense training and inactivity. *Med Sci Sports Exerc* 2011; 43: 1716-1724. DOI: 10.1249/MSS.0b013e318211c01a.

3. Fernandez-Fernandez J, Sanz-Rivas D, Sarabia JM, et al. Preseason Training: The Effects of a 17-Day High-Intensity Shock Microcycle in Elite Tennis Players. *J Sports Sci Med* 2015; 14: 783-791.

4. Faiss R, Girard O and Millet GP. Advancing hypoxic training in team sports: from intermittent hypoxic training to repeated sprint training in hypoxia. *British journal of sports medicine* 2013; 47 Suppl 1: i45-50. Review 2013/12/07. DOI: 10.1136/bjsports-2013-092741.

5. Girard O, Amann M, Aughey R, et al. Position statement--altitude training for improving team-sport players' performance: current knowledge and unresolved issues. *Br J Sports Med* 2013; 47 Suppl 1: i8-16. 2013/12/07. DOI: 10.1136/bjsports-2013-093109.

6. Gatterer H, Klarod K, Heinrich D, et al. Effects of a 12-day maximal shuttle-run shock microcycle in hypoxia on soccer specific performance and oxidative stress. *Applied physiology, nutrition, and metabolism = Physiologie appliquee, nutrition et metabolisme* 2015; 40: 842-845. Randomized Controlled Trial

Research Support, Non-U.S. Gov't 2015/07/28. DOI: 10.1139/apnm-2014-0479.

7. Faiss R, Leger B, Vesin JM, et al. Significant molecular and systemic adaptations after repeated sprint training in hypoxia. *PLoS One* 2013; 8: e56522. 2013/02/26. DOI: 10.1371/journal.pone.0056522 PONE-D-12-39698 [pii].

8. Galvin HM, Cooke K, Sumners DP, et al. Repeated sprint training in normobaric hypoxia. *British journal of sports medicine* 2013; 47 Suppl 1: i74-79. Randomized Controlled Trial

Research Support, Non-U.S. Gov't 2013/12/07. DOI: 10.1136/bjsports-2013-092826.

9. Brocherie F, Millet GP, Hauser A, et al. "Live High-Train Low and High" hypoxic training improves team-sport performance. *Med Sci Sports Exerc* 2015; 47: 2140-2149. 2015/02/11. DOI: 10.1249/MSS.0000000000000630.

10. Brocherie F, Girard O, Faiss R, et al. Effects of Repeated-Sprint Training in Hypoxia on Sea-Level Performance: A Meta-Analysis. *Sports Med* 2017. Review 2017/02/15. DOI: 10.1007/s40279-017-0685-3.

11. Pereira TJ, Nakamura FY, de Jesus MT, et al. Analysis of the distances covered and technical actions performed by professional tennis players during official matches. *Journal of sports sciences* 2017; 35: 361-368. 2016/03/31. DOI: 10.1080/02640414.2016.1165858.

12. Girard O, Racinais S, Kelly L, et al. Repeated sprinting on natural grass impairs vertical stiffness but does not alter plantar loading in soccer players. *Eur J Appl Physiol* 2011; 111: 2547-2555. 2011/03/04. DOI: 10.1007/s00421-011-1884-5.

13. Brocherie F, Millet GP and Girard O. Psychophysiological Responses to Repeated-Sprint Training in Normobaric Hypoxia and Normoxia. *Int J Sports Physiol Perform* 2017; 12: 115-123. 2016/05/04. DOI: 10.1123/ijspp.2016-0052.

14. Foster C, Florhaug JA, Franklin J, et al. A new approach to monitoring exercise training. *J Strength Cond Res* 2001; 15: 109-115. 2001/11/16.

15. Batterham AM and Hopkins WG. Making meaninful inferences about magnitudes. *Int J Sports Physiol Perform* 2006; 1: 50-57.

16. Foster C. Monitoring training in athletes with reference to overtraining syndrome. *Med Sci Sports Exerc* 1998; 30: 1164-1168. 1998/07/15.

17. Schmitt L, Hellard P, Millet GP, et al. Heart rate variability and performance at two different altitudes in well-trained swimmers. *Int J Sports Med* 2006; 27: 226-231. 2006/03/17. DOI: 10.1055/s-2005-865647.

18. Millet GP, Roels B, Schmitt L, et al. Combining hypoxic methods for peak performance. *Sports Med* 2010; 40: 1-25. 2009/12/22. DOI: 10.2165/11317920-000000000-00000.

19. Brocherie F, Millet GP and Girard O. Neuro-mechanical and metabolic adjustments to the repeated anaerobic sprint test in professional football players. *Eur J Appl Physiol* 2015; 115: 891-903. 2014/12/08. DOI: 10.1007/s00421-014-3070-z.

20. Smekal G, Pokan R, von Duvillard SP, et al. Comparison of laboratory and "on-court" endurance testing in tennis. *International journal of sports medicine* 2000; 21: 242-249. Comparative Study 2000/06/15. DOI: 10.1055/s-2000-310.

21. Hornery DJ, Farrow D, Mujika I, et al. Fatigue in tennis: mechanisms of fatigue and effect on performance. *Sports Med* 2007; 37: 199-212. 2007/03/01.

22. Brechbuhl C, Girard O, Millet GP, et al. On the Use of a Test to Exhaustion Specific to Tennis (TEST) with Ball Hitting by Elite Players. *PLoS One* 2016; 11: e0152389. 2016/04/02. DOI: 10.1371/journal.pone.0152389.

Conflict of interest

The authors report no conflicting interests.

Acknowledgments

The authors would like to express their gratitude to the participant, who voluntary agreed to contribute.

Figures Legend

Figure 1. Overview of the 14-day "in-season" intervention and description of a typical session of repeated-sprint training in hypoxia (RSH).

Figure 2. Comparison of opponent's ATP rankings (A) and participant's ATP points gained (B) before (pre) and after (+21 days) 14 days "in-season" of repeated-sprint training in hypoxia (RSH) intervention.

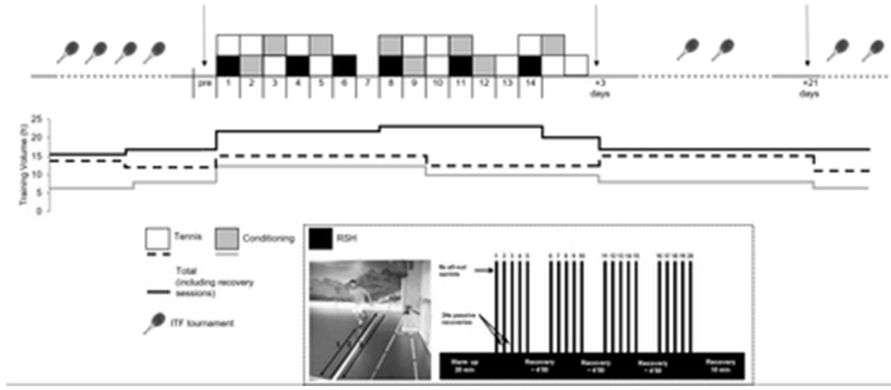

Figure 1. Overview of the 14-day "in-season" intervention and description of a typical session of repeated-sprint training in hypoxia (RSH).

37x16mm (300 x 300 DPI)

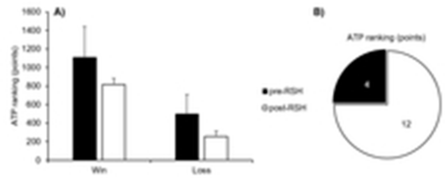

Figure 2. Comparison of opponent’s ATP rankings (A) and participant’s ATP points gained (B) before (pre) and after (+21 days) 14 days “in-season” of repeated-sprint training in hypoxia (RSH) intervention.

19x7mm (300 x 300 DPI)

Table 1. Physical fitness results before (pre) and after (+3 days and +21 days) 14 days "in-season" of repeated-sprint training in hypoxia (RSH) intervention.

	Pre	+3 days	+21 days
Single sprint time (s)	3.12	3.13	2.98
% of change from pre		+0.3%	-4.5%
% chances to be greater/similar/smaller than the SWC		39/39/22 *unclear* difference	97/1/2 *very likely* greater
RSA_{best} (s)	3.10	3.13	3.02
% of change from pre		+1.0%	-2.6%
% chances to be greater/similar/smaller than the SWC		10/12/78 *unclear* difference	96/1/3 *very likely* greater
RSA_{TT} (s)	25.65	25.79	24.85
% of change from pre		+0.6%	-3.1%
% chances to be greater/similar/smaller than the SWC		0/11/89 *trivial* difference	100/0/0 *almost certainly* greater
S_{dec} (%)	3.43	3.00	2.86
% of change from pre		-12.6%	-16.7%
% chances to be greater/similar/smaller than the SWC		96/2/2 *very likely* greater	98/1/1 *very likely* greater
YYIR2 distance (m)	560	440	680
% of change from pre		-21.4%	+21.4%
% chances to be greater/similar/smaller than the SWC		0/0/100 *almost certainly* greater	100/0/0 *almost certainly* greater