

# Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

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**@BrocherieF**





# Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

Elite Sport  
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Researcher



CEP CENTRE D'EXPERTISE  
DE LA PERFORMANCE  
GILLES COMETTI



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مستشفى جراحة العظام والطب الرياضي قطر





# Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



frontiers  
in Sports and Active Living

OPINION  
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**All Alone We Go Faster, Together We Go Further: The Necessary Evolution of Professional and Elite Sporting Environment to Bridge the Gap Between Research and Practice**

Franck Brocherie<sup>1\*</sup> and Adam Beard<sup>2</sup>

<sup>1</sup> Laboratory Sport, Expertise and Performance (EA 2073), French Institute of Sport (INSEP), Paris, France; <sup>2</sup> High Performance Unit, Chicago Cubs Major League Baseball, Chicago, IL, United States







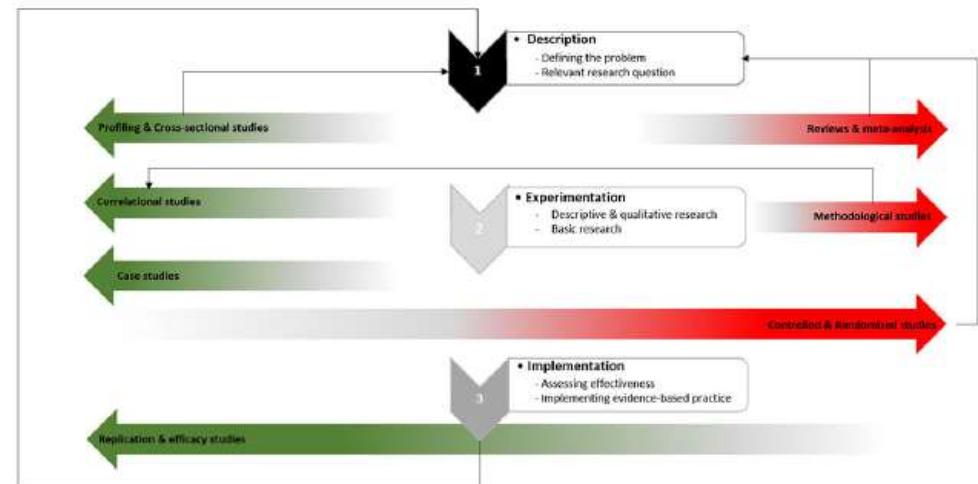
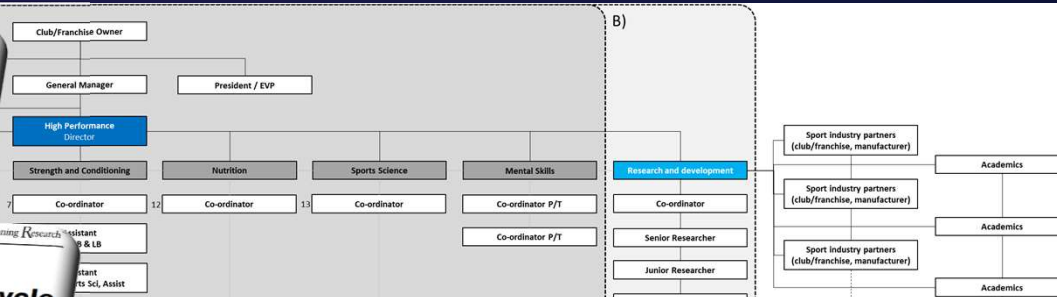
# Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

**Original Research**  
**Wales Anaerobic Test: Reliability and Fitness Profiles of International Rugby Union Players**  
 Adam Beard,<sup>1</sup> John Ashby,<sup>2</sup> Ryan Chambers,<sup>2</sup> Grégoire P. Millet,<sup>1</sup> and Franck Brocherie<sup>3</sup>  
<sup>1</sup>Faculty of Biology and Medicine, ISSUL, Institute of Sport Sciences, University of Lausanne, Lausanne, Switzerland; <sup>2</sup>Welsh Rugby Union, National Centre of Excellence, Vale of Glamorgan, Wales; and <sup>3</sup>Laboratoire Sport, Expertise and Performance, Research Department, French Institute of Sport, Paris, France

**Original Research**  
**Effects of a 14-Day High-Intensity Shock Microcycle in High-Level Ice Hockey Players' Fitness**  
 Franck Brocherie,<sup>1</sup> Jérôme Perez,<sup>1,2</sup> and Gaël Guilhem<sup>1</sup>  
<sup>1</sup>Laboratory Sport, Expertise and Performance (EA 7370), French Institute of Sport (INSEP), Paris, France; and <sup>2</sup>French Women Academy of Ice Hockey, French Federation of Ice Hockey, Cergy, France

**Original research**  
**Shock microcycle of repeated-sprint training in hypoxia and tennis performance: Case study in a rookie professional player**  
 Cyril Brechbuhl<sup>1,2</sup>, Laurent Schmitt<sup>2,3</sup>, Grégoire P Millet<sup>2</sup> and Franck Brocherie<sup>1</sup>  
 International Journal of Sports Science & Coaching  
 2018, Vol. 13(5) 723–728  
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 DOI: 10.1177/1747954118783586  
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**International Journal of Sports Physiology and Performance, (Ahead of Print)**  
**Effects of 2 Different Protocols of Repeated-Sprint Training in Hypoxia in Elite Female Rugby Sevens Players During an Altitude Training Camp**  
 Janne Bouten,<sup>1</sup> Maxime Brick,<sup>2</sup> Antoine Saboua,<sup>2</sup> Jean-Loup Hadjadj,<sup>2</sup> Julien Placcone,<sup>2</sup> Chloé Margot,<sup>2</sup> Gregory Doucende,<sup>4,5</sup> Nicolas Bourret,<sup>4,5</sup> Grégoire P. Millet,<sup>2</sup> and Franck Brocherie<sup>1</sup>  
<sup>1</sup>Laboratory of Sport, Expertise and Performance, French Institute of Sport (INSEP), Paris, France; <sup>2</sup>Research Department, French Rugby Union, Marcoussis, France; <sup>3</sup>Institute of Sport Sciences, University of Lausanne, Lausanne, Switzerland; <sup>4</sup>Centre National d'Entraînement en Altitude, Font Romeu, France; <sup>5</sup>Laboratoire Interdisciplinaire Performance Santé et Environnement de Marseille (LIPSE), Université de Perpignan Via Domitia, Font Romeu, France; <sup>6</sup>Institut National du Sport (INS), Montreal, QC, Canada

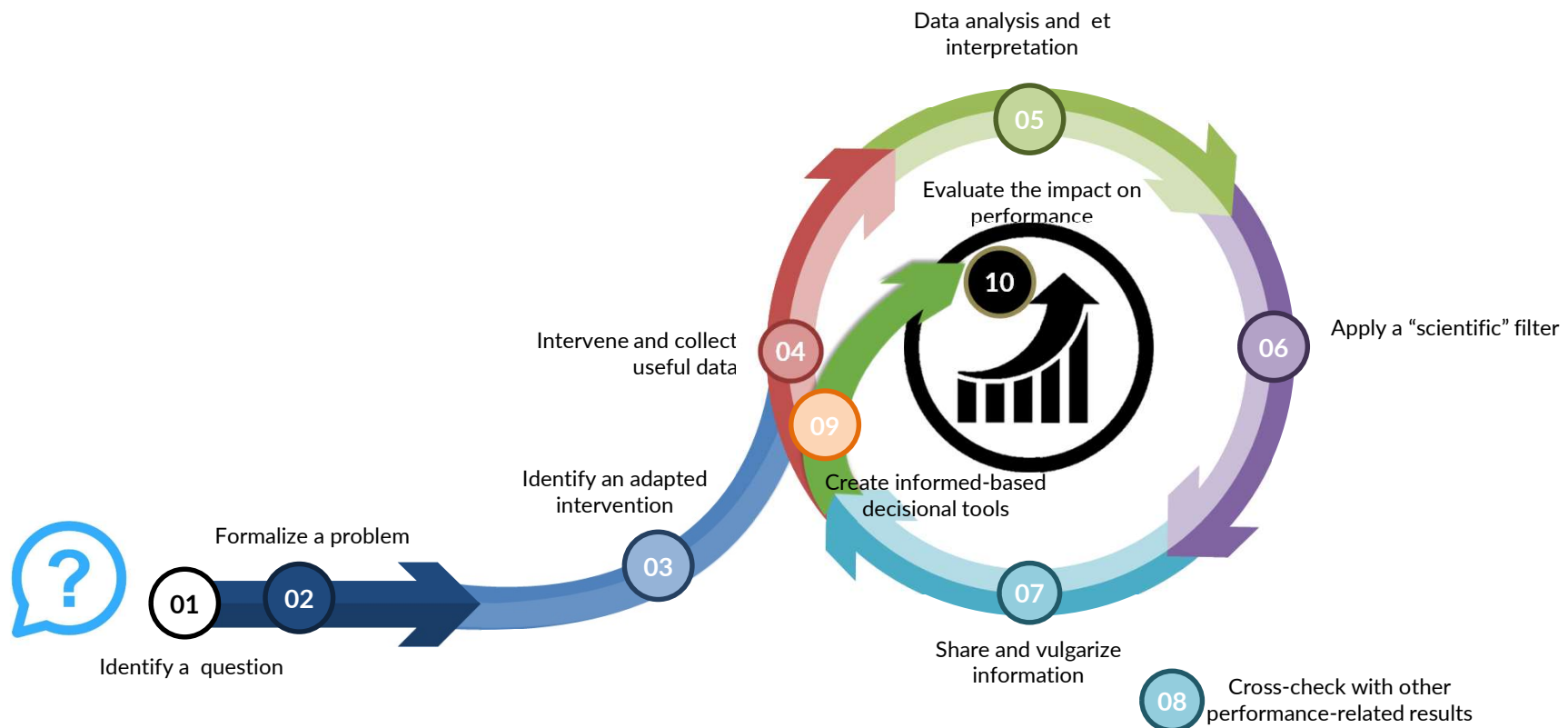


Club/federation environment  
 (applied setting)

Academic environment  
 (laboratory setting)



## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?





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Testing



Renf.  
musc.



Stress  
env.



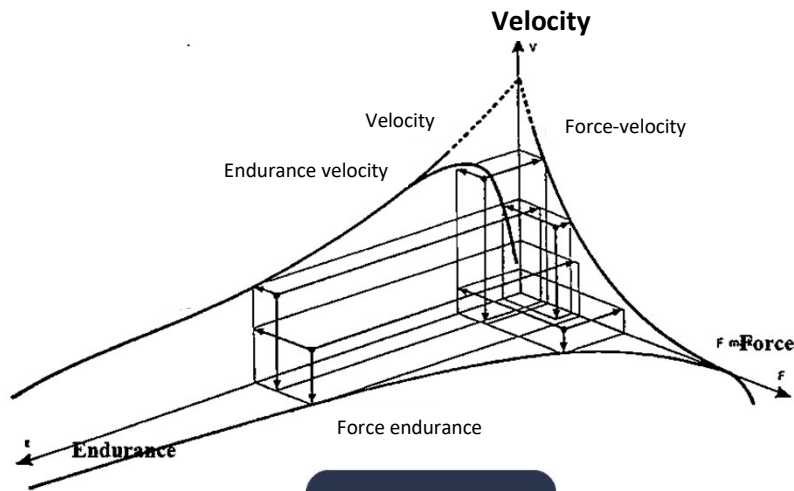
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FONT-ROMEUE

RÉSEAU  
GRAND  
INSEP

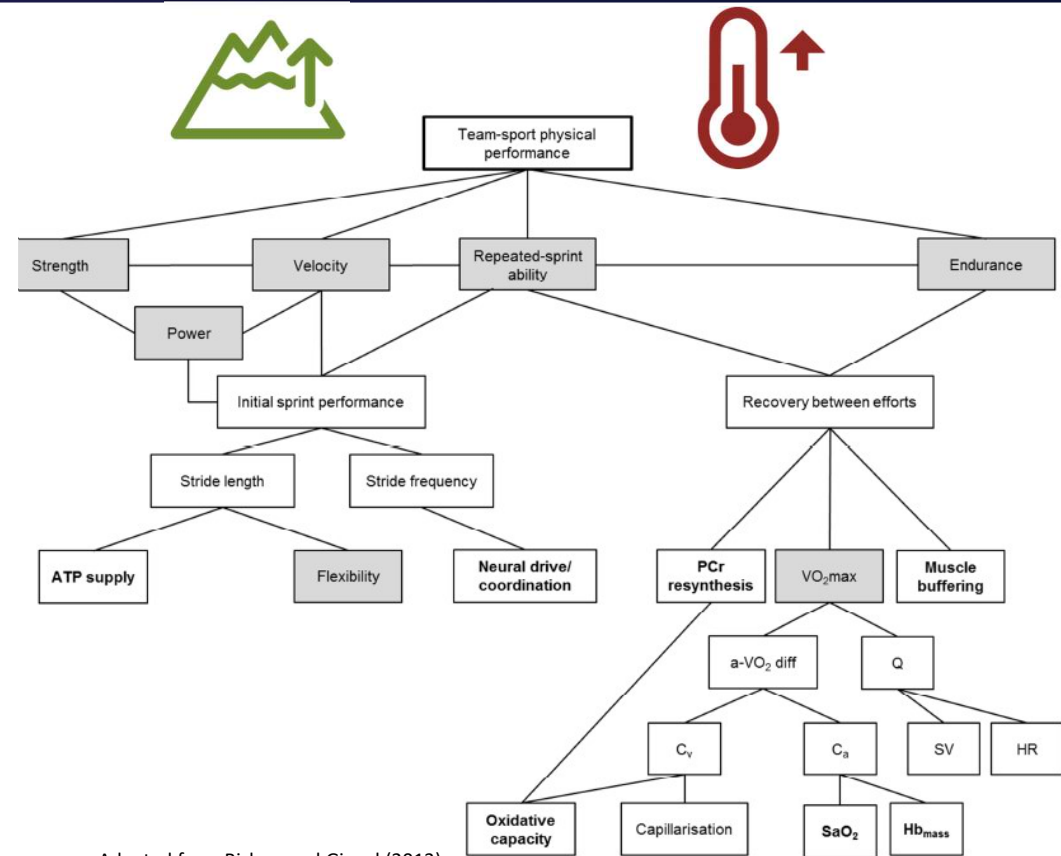
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# Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



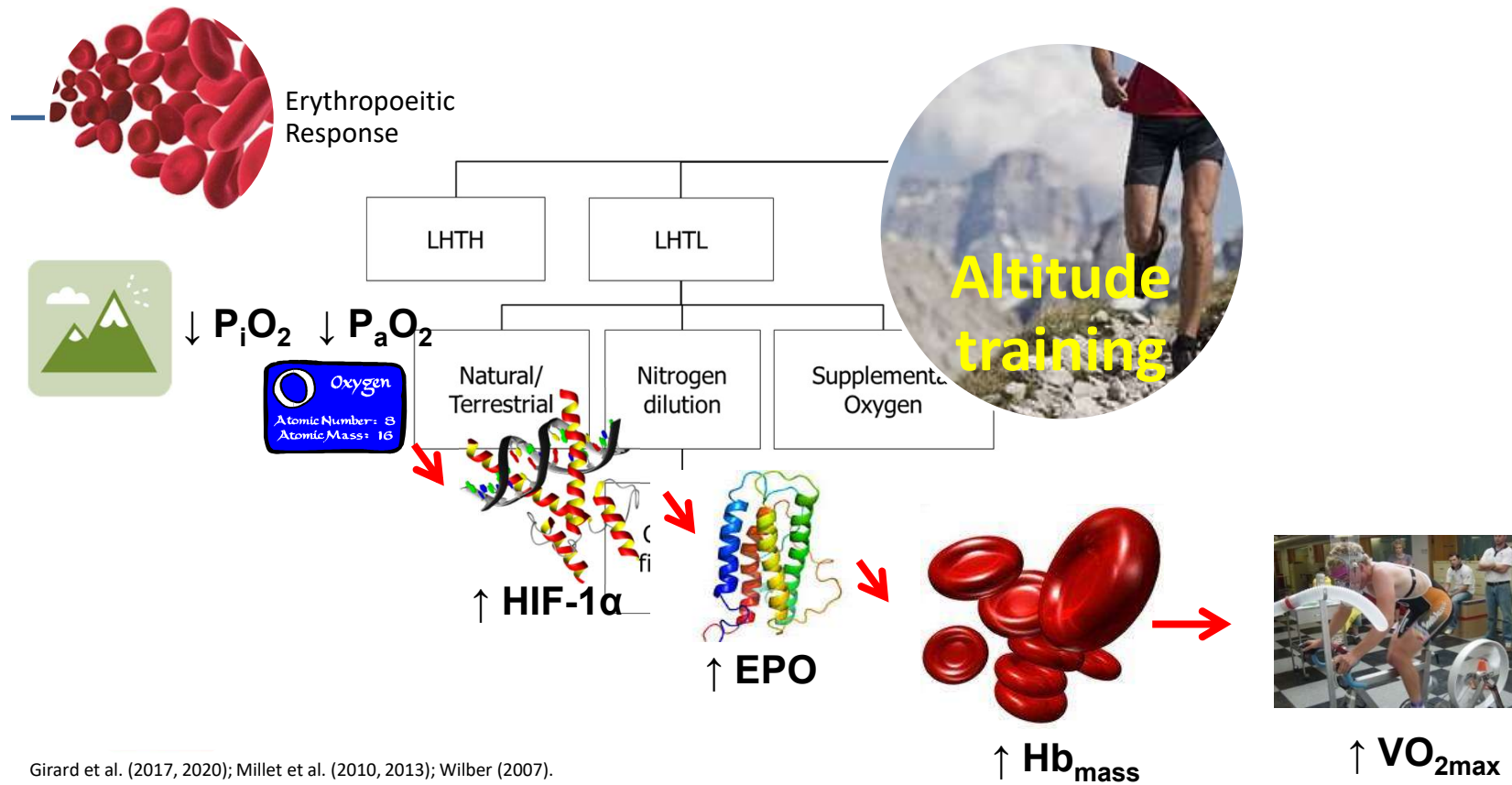
Gundlach (1968).



Adapted from Bishop and Girard (2013).



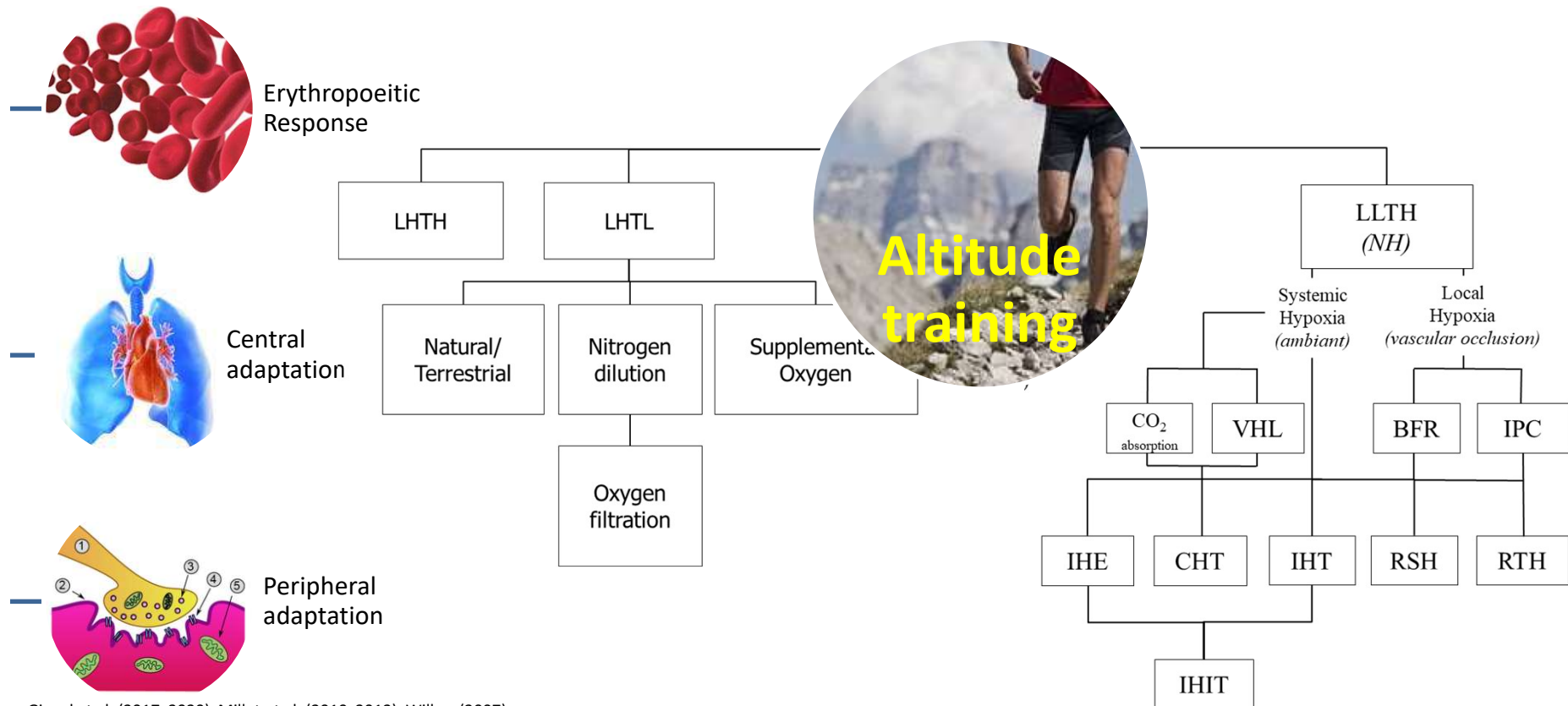
## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



Girard et al. (2017, 2020); Millet et al. (2010, 2013); Wilber (2007).



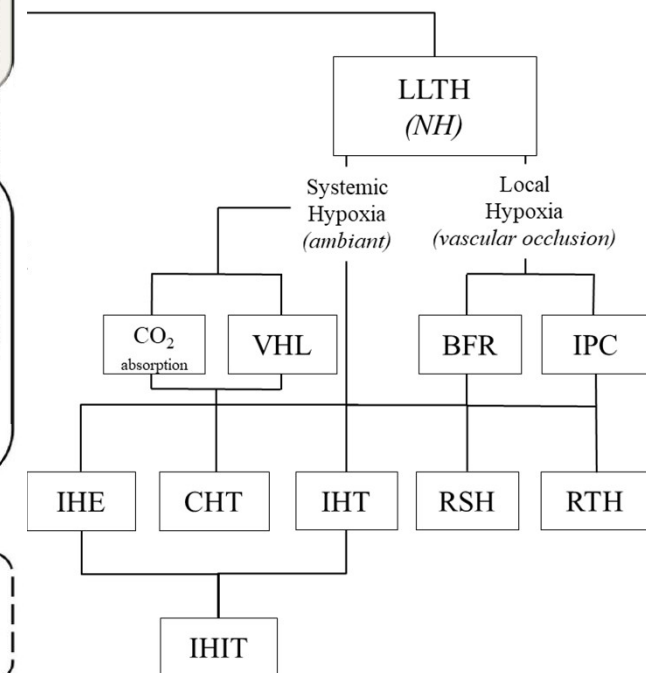
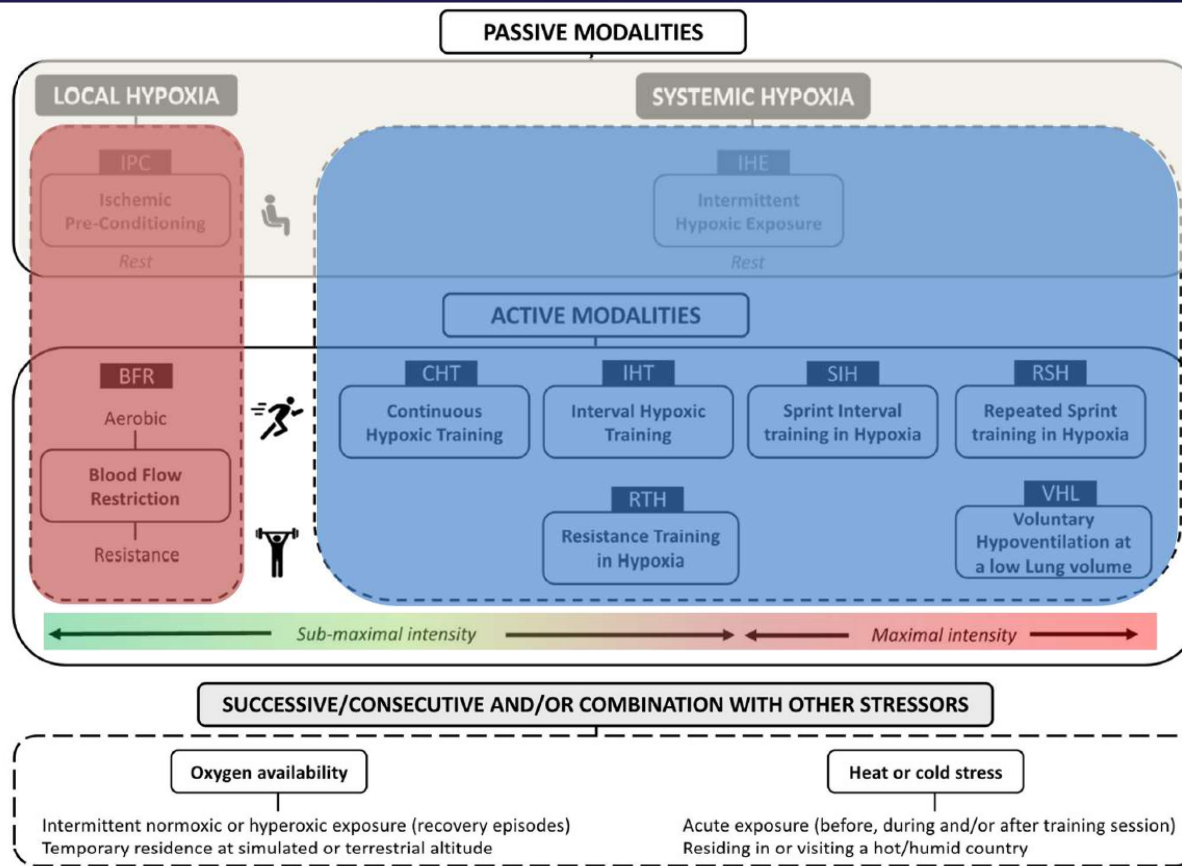
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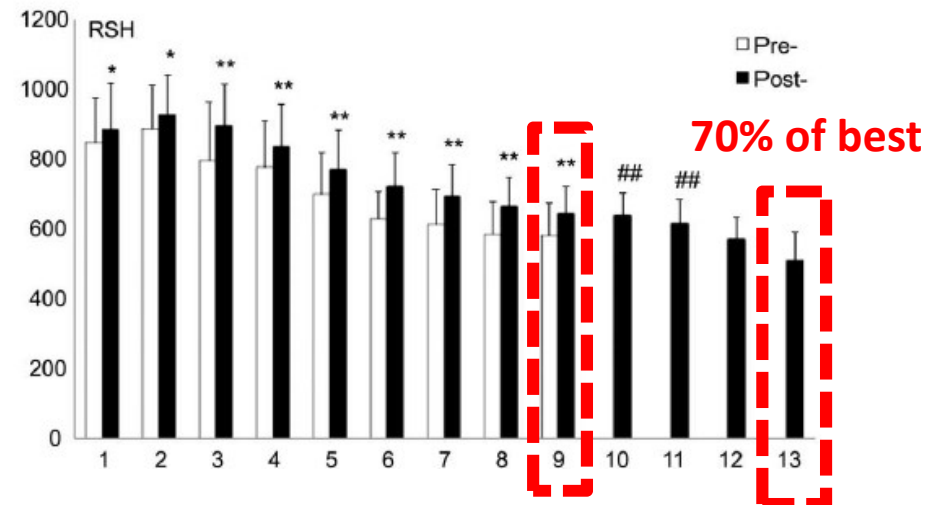
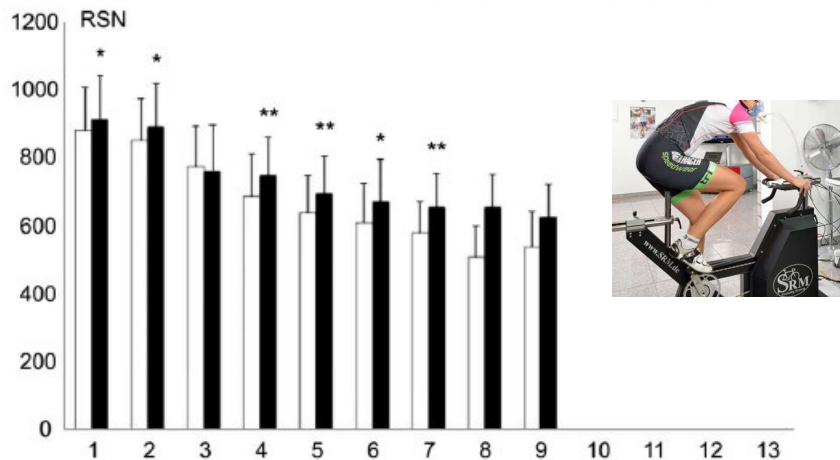
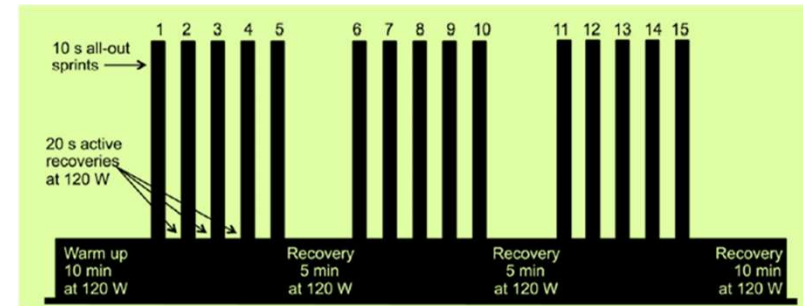
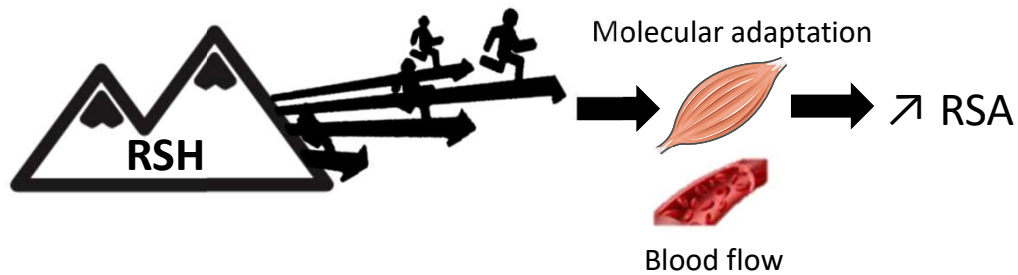
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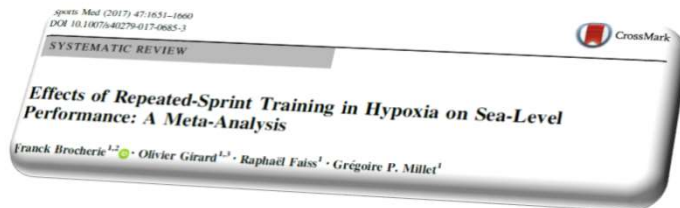
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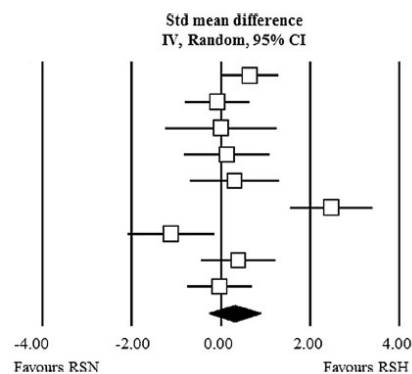


## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

### Repeated-Sprint training in Hypoxia (RSH): An innovative method for performance optimisation



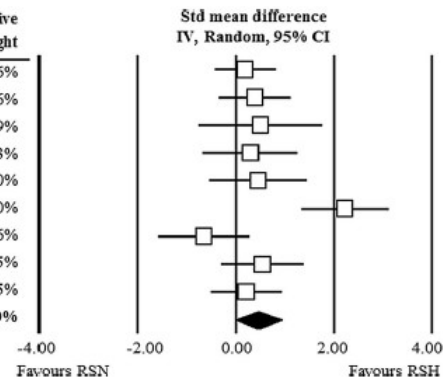
#### → RSA best time



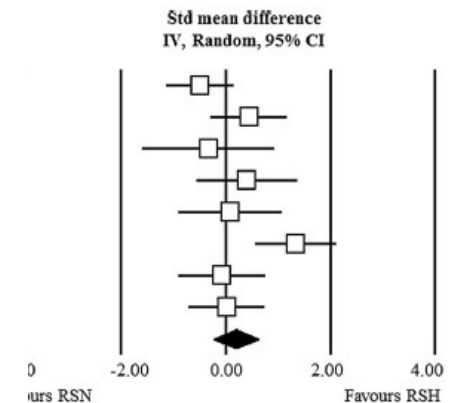
Study	SMD	[95% CI]	Relative weight
Faiss et al. [9]	0.192	[-0.430, 0.813]	13.6%
Galvin et al. [36]	0.389	[-0.334, 1.111]	12.6%
Gatterer et al. [37]	0.500	[-0.759, 1.759]	7.9%
Faiss et al. [39]	0.293	[-0.664, 1.250]	10.3%
Brocherie et al. [35]	0.456	[-0.536, 1.449]	10.0%
Kasai et al. [38]	2.222	[1.341, 3.103]	11.0%
Goods et al. [32]	-0.651	[-1.563, 0.273]	10.6%
Brocherie et al. [34]	0.546	[-0.287, 1.379]	11.5%
Montero & Lundby [33]	0.213	[-0.804, 1.230]	12.5%
<b>Combined</b>	<b>0.455</b>	<b>[-0.017, 0.927]</b>	<b>100.0%</b>

Heterogeneity:  $\tau^2 = 0.00$ ;  $df = 8$  ( $P = 0.21$ );  $I^2 = 6.19$   
 Test for overall effect:  $Z = 1.89$  ( $P = 0.05$ )

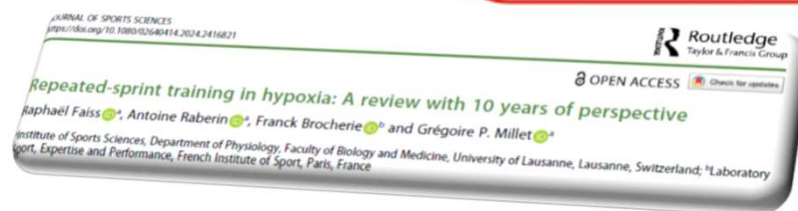
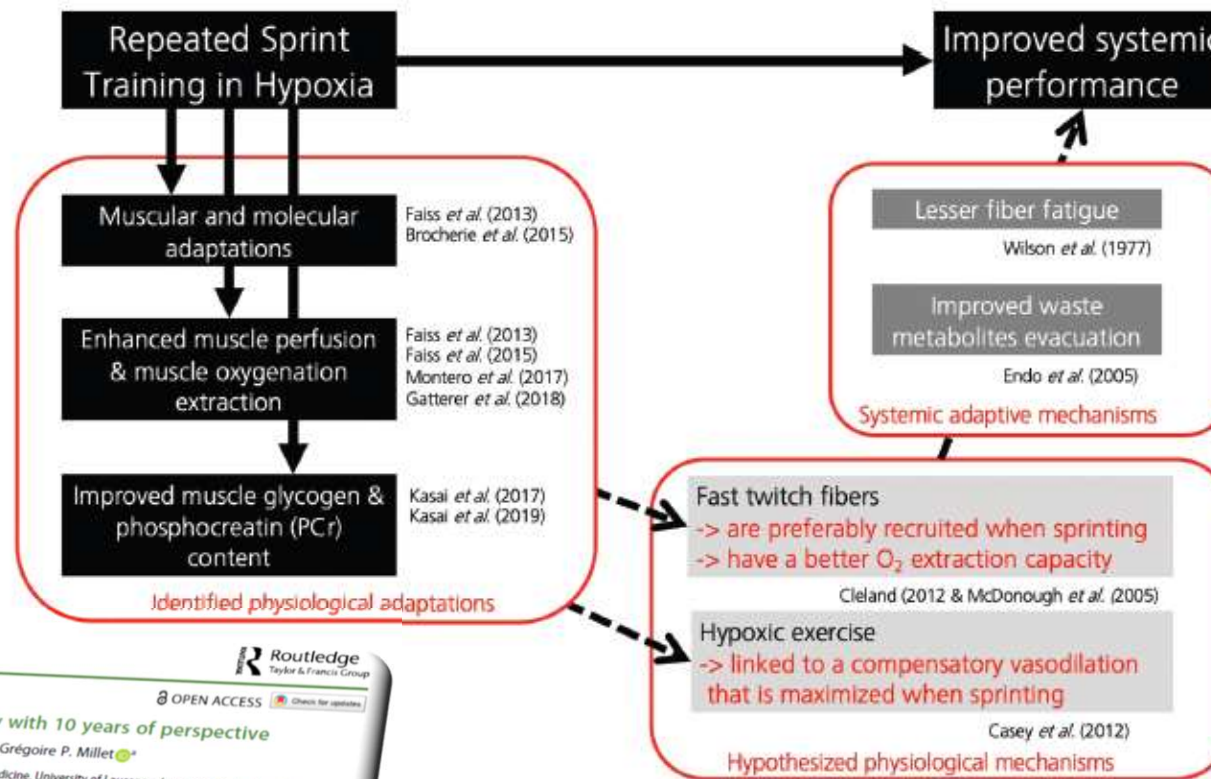
#### → RSA mean time



#### → RSA VO<sub>2</sub>max



## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?







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**RSH (n = 8)**  
**FIO<sub>2</sub> = 14.3%**  
**~2900 m**

**RSN (n = 8)**  
**FIO<sub>2</sub> = 21.0%**  
**~0 m**



**5 sem. Courses intermittente à haute intensité, RSA et force explosive / agilité / sprint**

Day	1	2	3	4	5	6	7
Morning Activity	Football (skills + tactics)	Football (skills + tactics)	Football (skills + tactics)	Football (tactics)	Recovery/ skills	Football (agility + skills)	Off
Duration, min	60	60	60	30	45	30	
Intensity, %	~60	~60	~70	~50	~50	~70	
HR <sub>max</sub>							
Afternoon Activity	<b>Conditioning</b>	Football (skills + tactics)	<b>Conditioning</b>	Friendly match (or training)	Football (skills + tactics)	Domestic match	Off
Duration, min	<b>60</b>	75	<b>60</b>	90	75	90	
Intensity, %	<b>~90-100</b>	~70	<b>~90-100</b>	~80	~70	~85-90	
HR <sub>max</sub>							

\*% HR<sub>max</sub> = % of maximal heart rate.

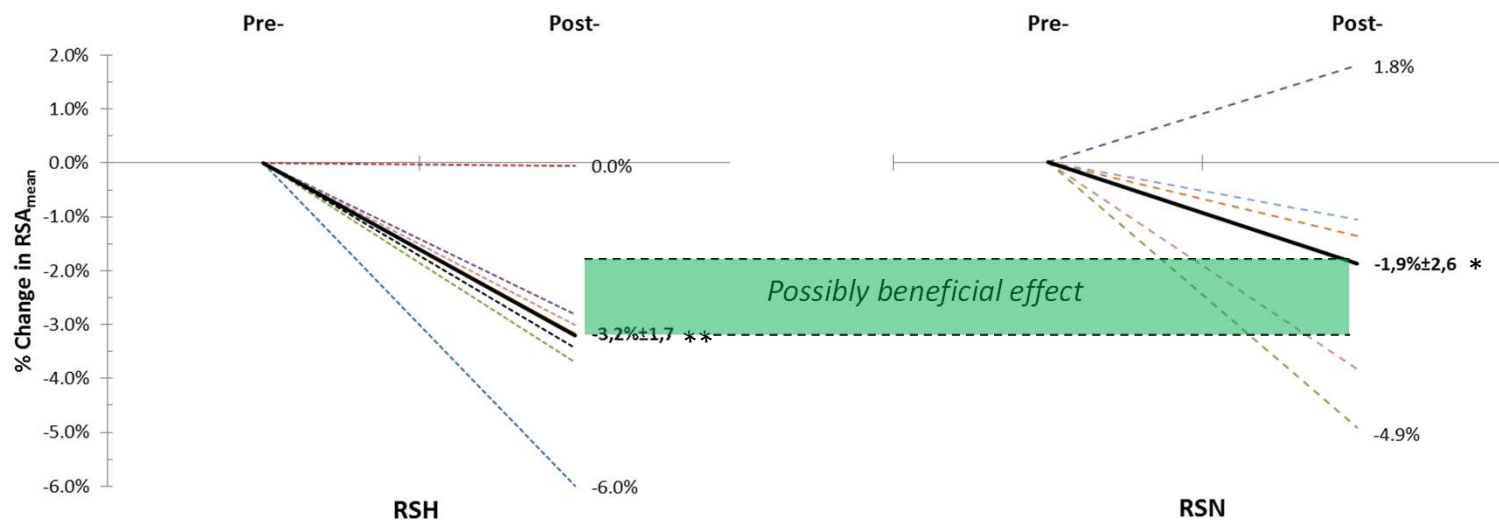
†Cells in bold refer to activities performed in hypoxic environment.



## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



### Repeated-Sprint Ability (10 x 30 m – 30 s)



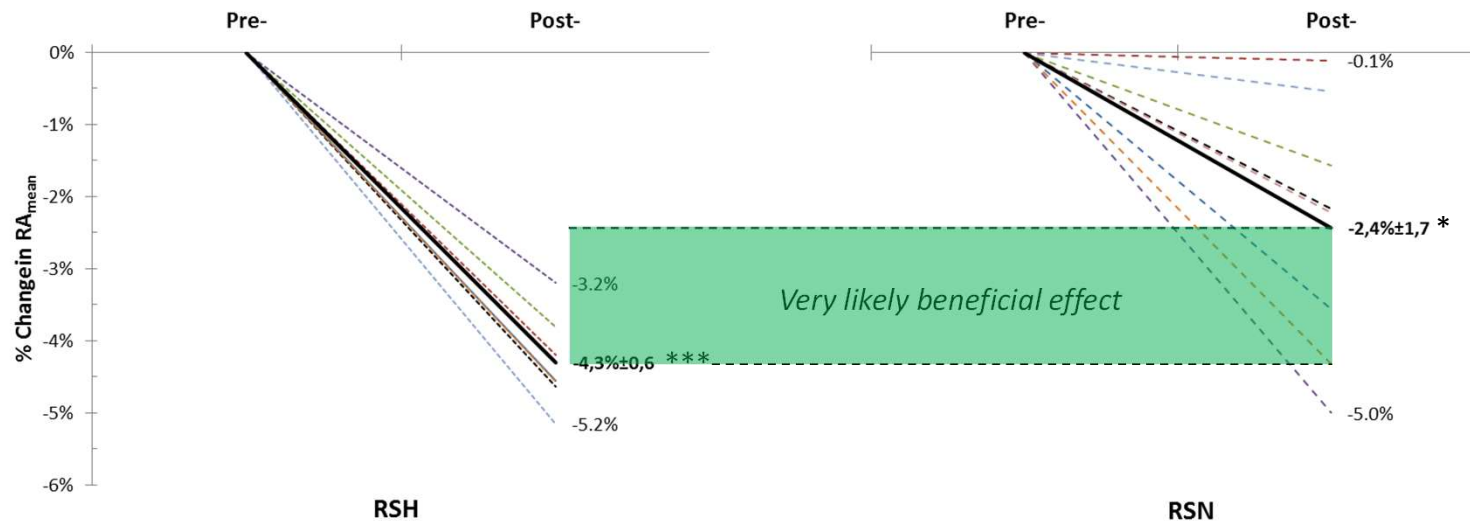
Brocherie et al., 2015.



## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



Repeated-Agility Ability (6 x 20 m with L-shape COD – 30 s)



Brocherie et al., 2015. → Results confirmed (↑RSA and YYIR2 after 5-wks RSH (3300 m) vs. control (Gatterer et al., 2014; 2015)). 16

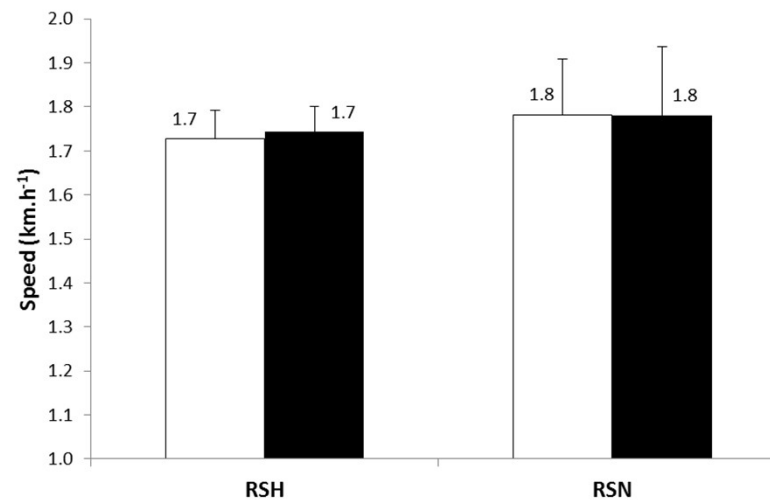




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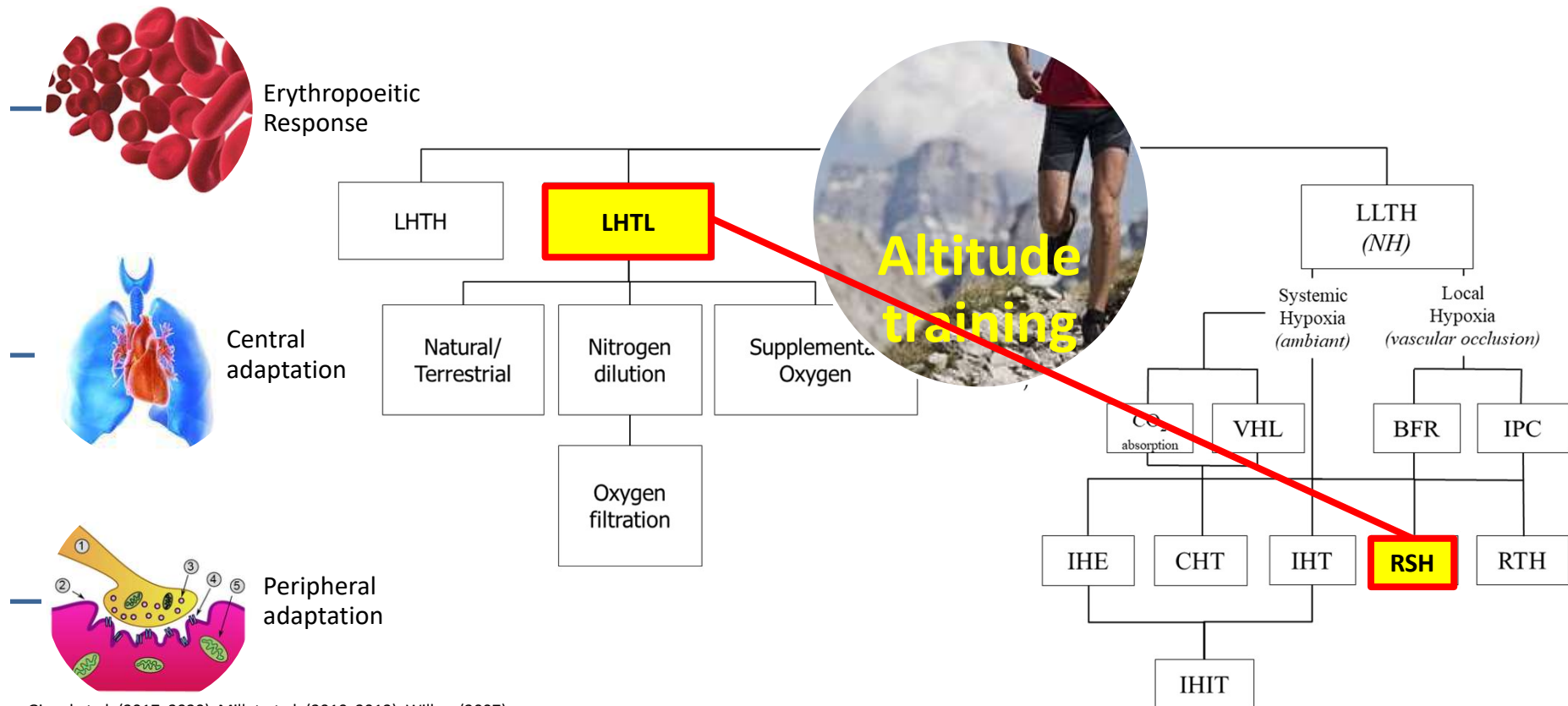


Maximal aerobic speed (VAMEVAL)





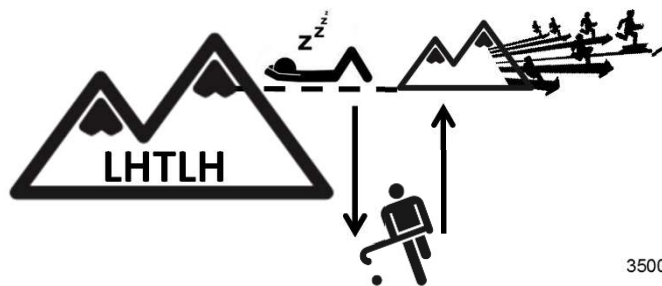
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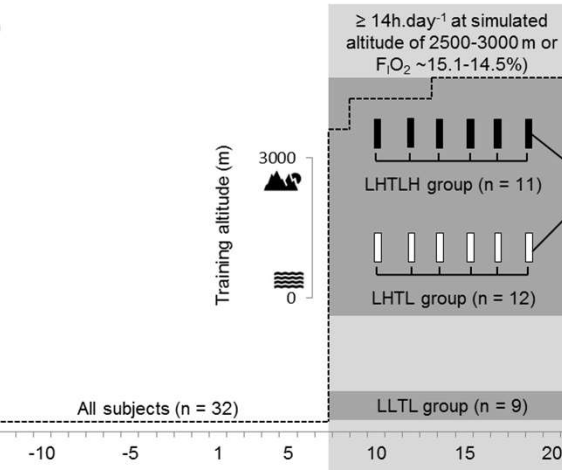


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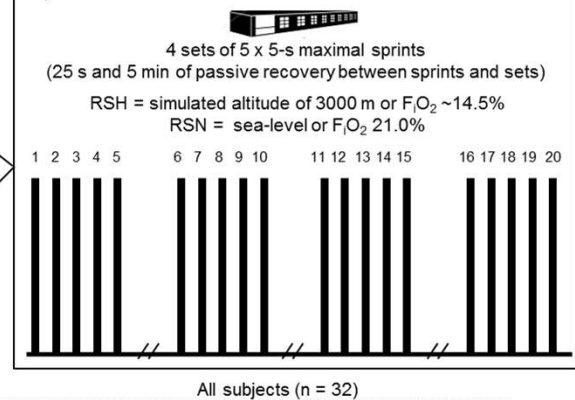


Living altitude (m)

A)

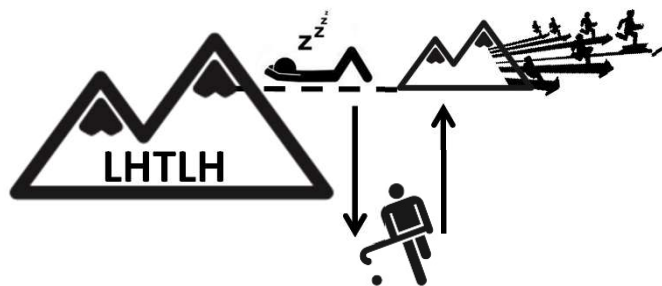


B) 6 X ~50 min additional repeated sprint training sessions

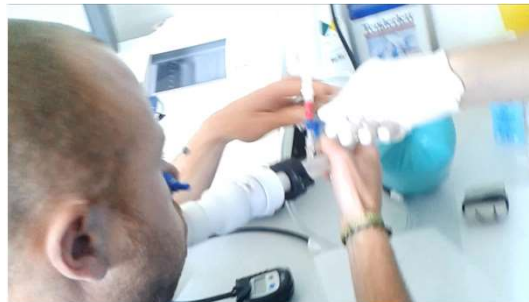




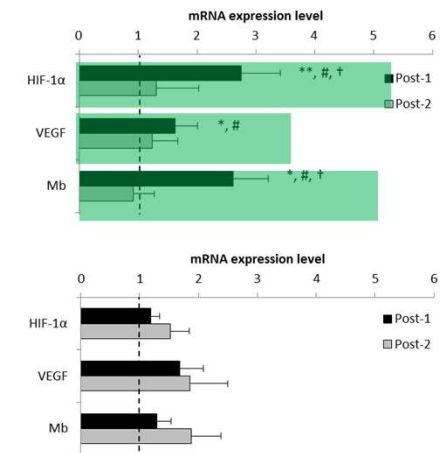
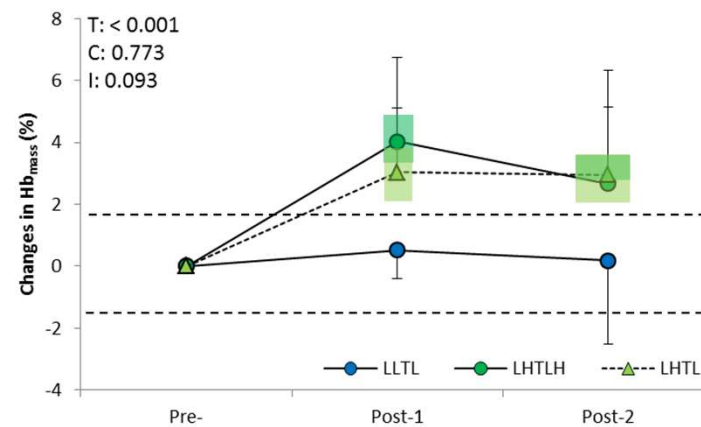
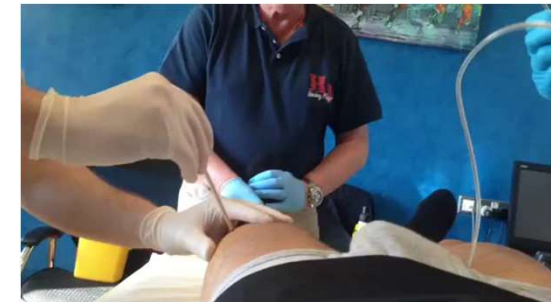
## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



### Hb<sub>mass</sub> - Co Rebreathing

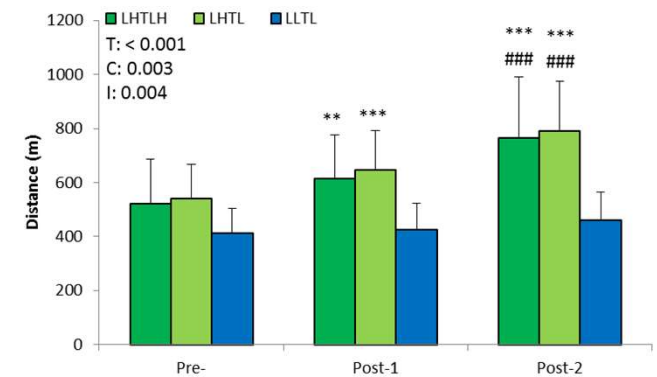
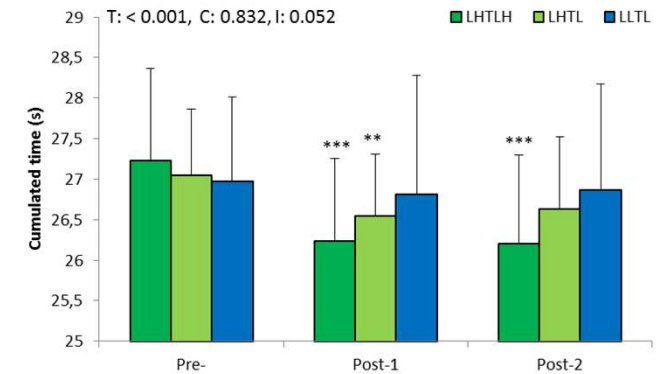
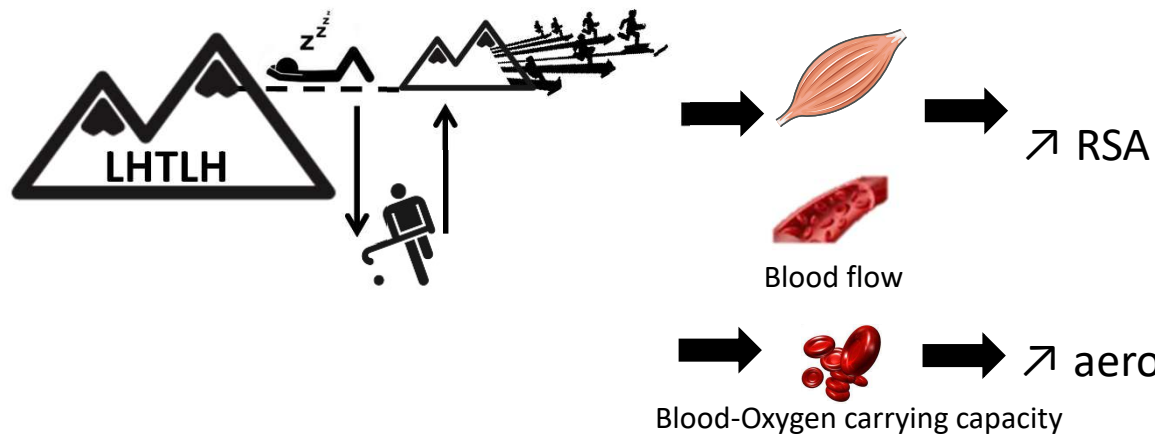


### Biopsies





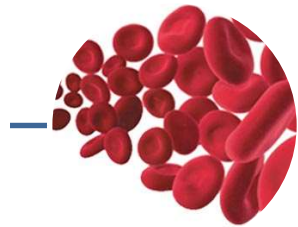
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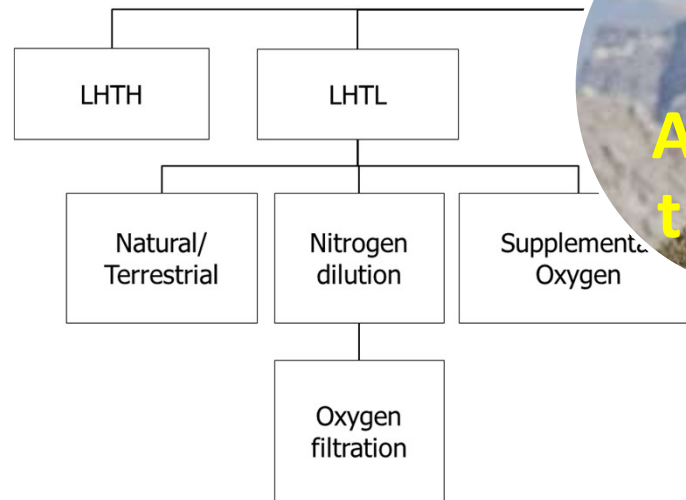




## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



Erythropoietic Response



### Training in Heat to Prepare for Altitude

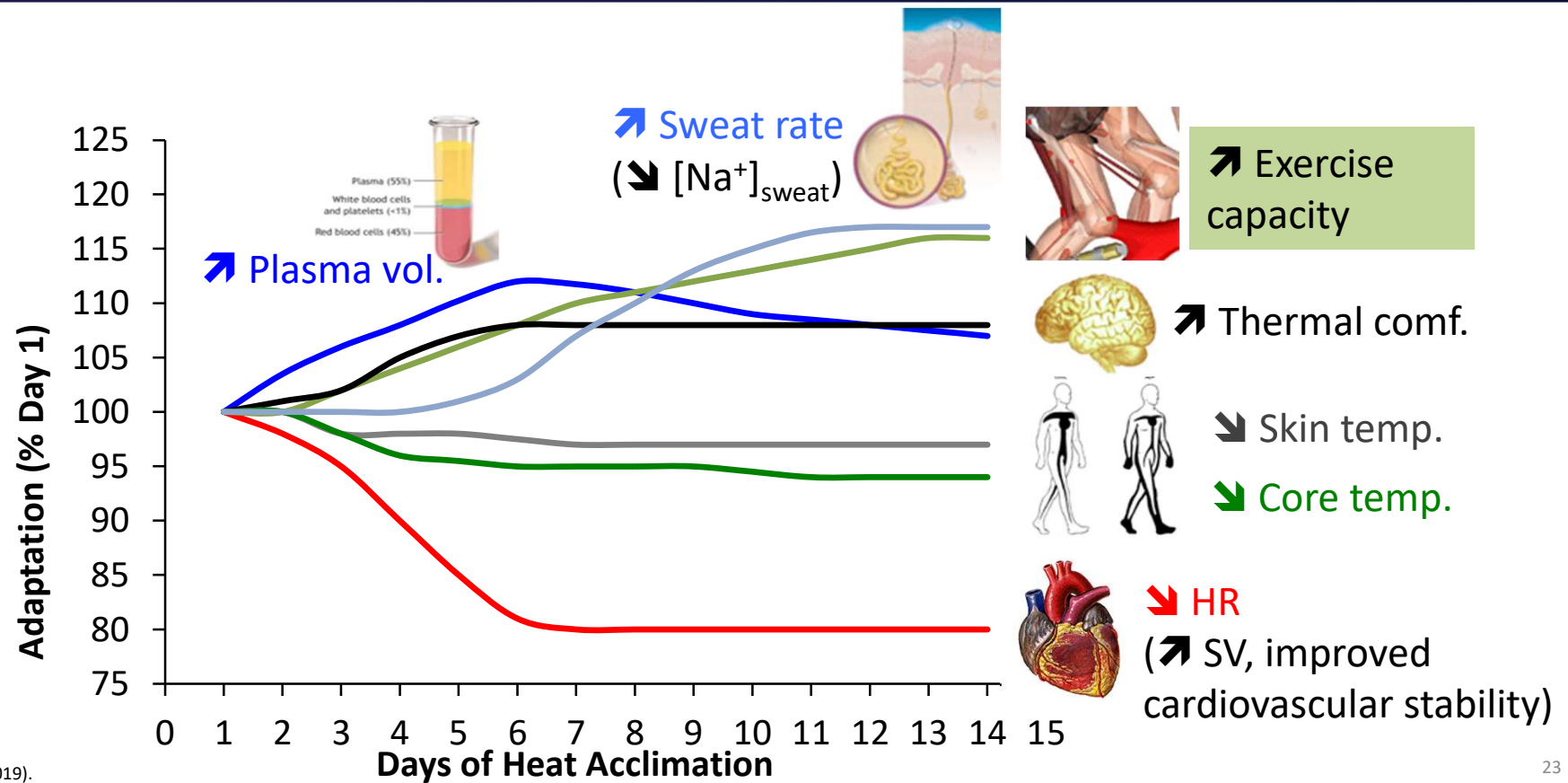
Study finds that hot weather and thin air trigger similar adaptations.

BY ALEX HUTCHINSON APR 12, 2016

Sports

ARE HEAT TRAINING CAMPS REPLACING ALTITUDE TRAINING?

## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



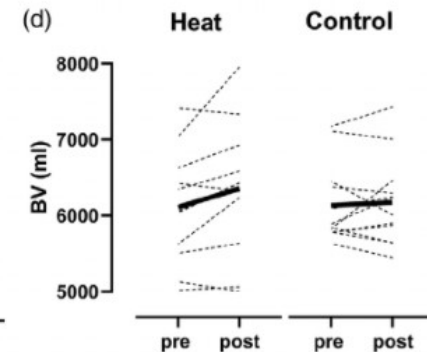
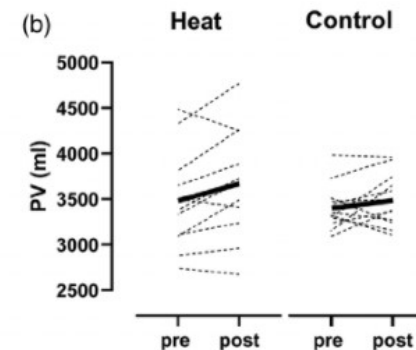
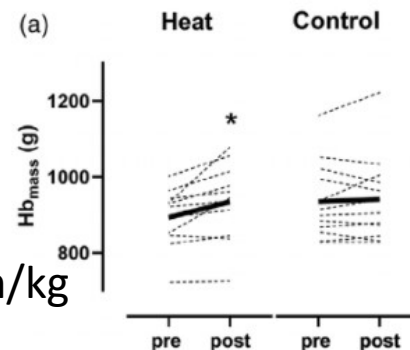
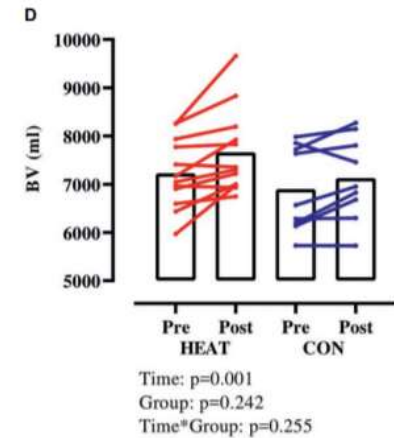
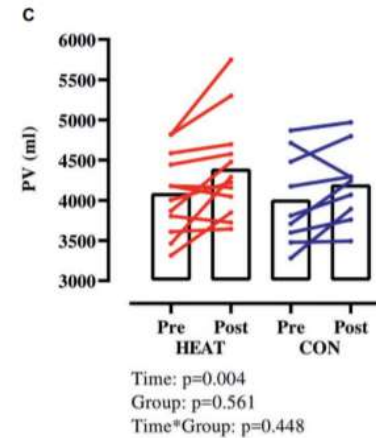
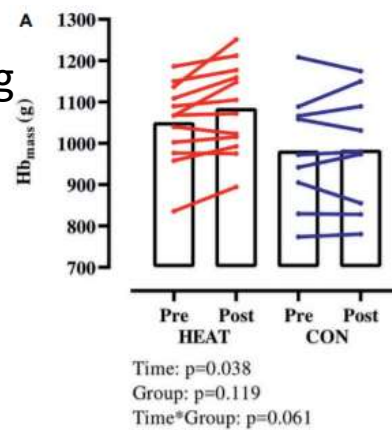


## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

Well-trained male cyclists  
 $VO_{2peak}$ :  $59.1 \pm 5.2$  ml/min/kg

1 h cycling at 60%  $VO_{2peak}$   
 in 40°C for 5 days/week in  
 addition to regular training  
 during 5-5½ weeks.

Elite male cyclists  
 $VO_{2peak}$ :  $76.2 \pm 7.6$  ml/min/kg



Oberholzer et al. (2020);  
 Ronnestad et al. (2020).



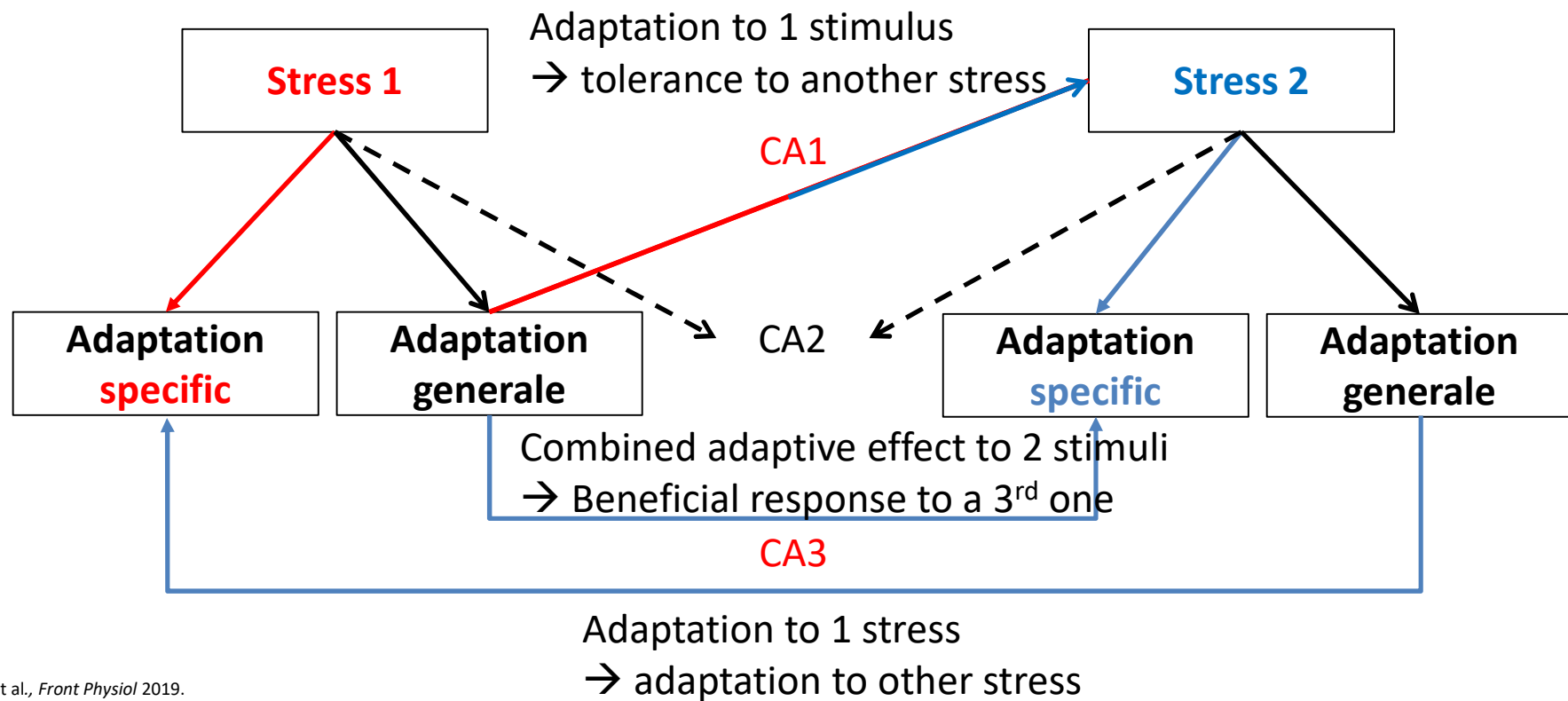


## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



ANR-20- STH-002







# Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

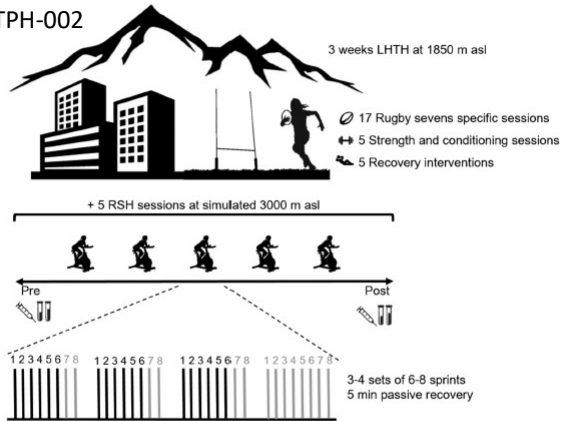


HYPOX  
PERF 2024



LHTH<sup>2</sup>

ANR-20- STPH-002

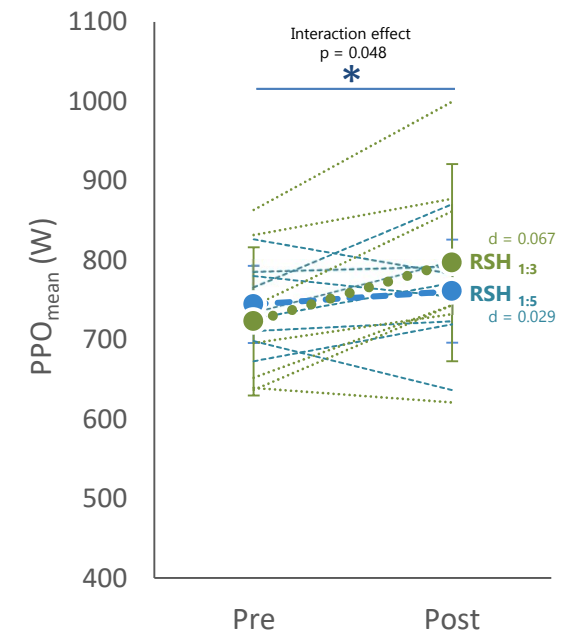
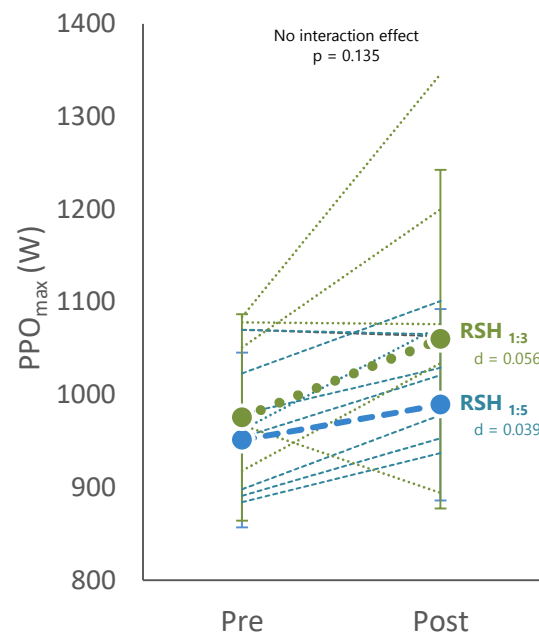


**RSH<sub>1:3</sub>**  
(n = 9)  
Exercise-to-rest ratio ranging 1:2 to 1:3  
Sprint duration: 10 s – 8 s – 10 s – 8 s – 10 s – 8 s – 10 s – 8 s  
Passive rest: 30 s – 22 s – 20 s – 22 s – 30 s – 22 s – 20 s – 22 s

**RSH<sub>1:5</sub>**  
(n = 7)  
Exercise-to-rest ratio ranging 1:2 to 1:5  
Sprint duration: 10 s – 5 s – 15 s – 5 s – 10 s – 5 s – 15 s – 5 s  
Passive rest: 20 s – 25 s – 30 s – 25 s – 20 s – 25 s – 30 s – 25 s

**RSH 1:3**  
N = 9

**RSH 1:5**  
N = 7

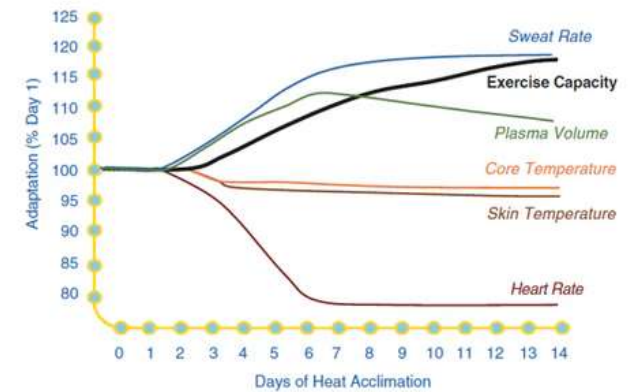
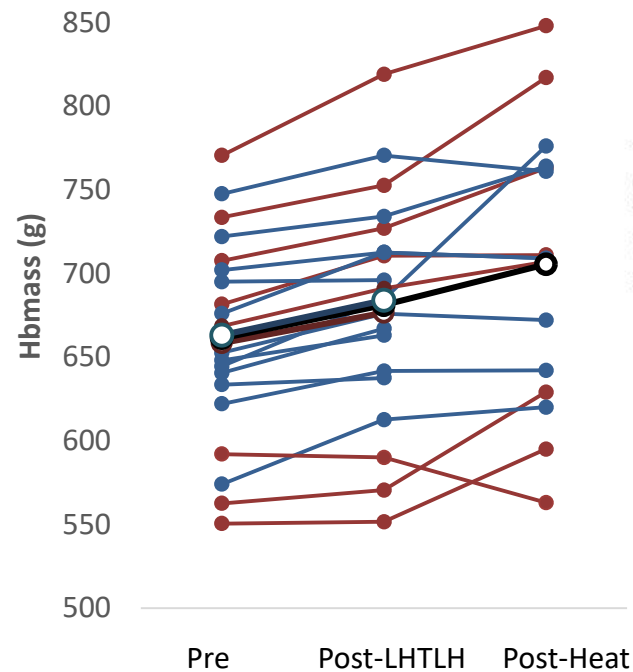
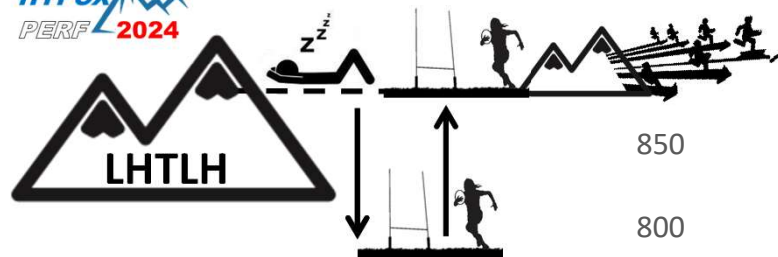




## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



HYPOX  
PERF 2024



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## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



Phase 1

(3000 m, 25°C, 40% rH)



(0 m, 35°C, 40% rH)



(0 m, 25°C, 40% rH)



RSHyp

RSHot

RSCon



Week 1

Week 2

Week 3

Week 4

Week 5

Week 6

Lead-in  
period

Pre-

Intervention  
period

Post-1

**HYPOX**  
**PERF 2024**



ANR-20- STPH-002





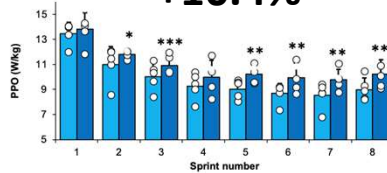
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**HYPOX**  
**PERF 2024**

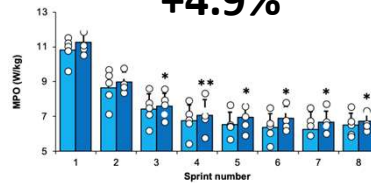
**RSHyp**

**+10.4%**



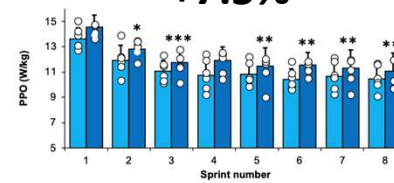
**RSHyp**

**+4.9%**



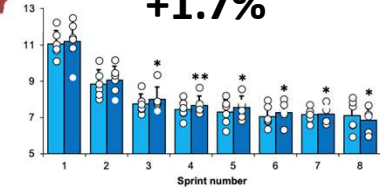
**RSHot**

**+7.5%**

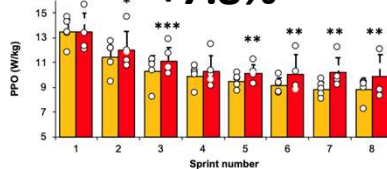


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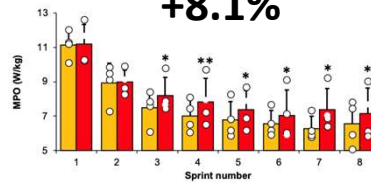
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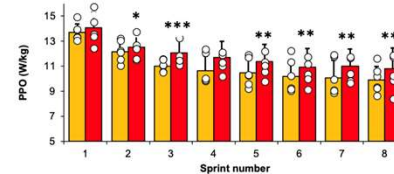
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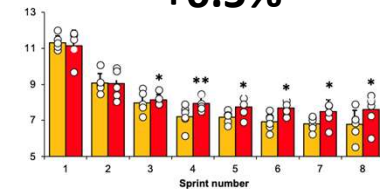
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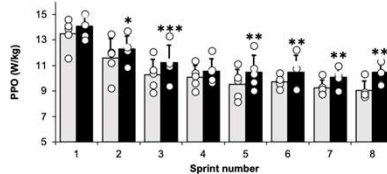
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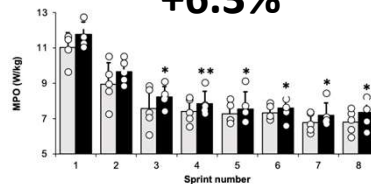
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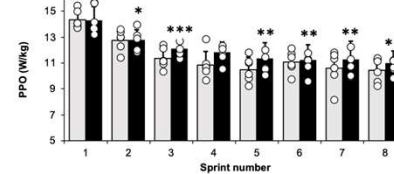
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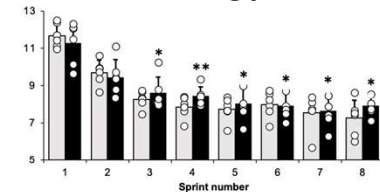
**+6.3%**



**+4.6%**



**+2.6%**

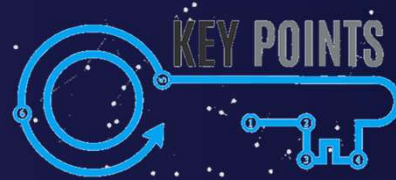


ANR-20-STPH-002





## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



Using “Living Low-Training High” paradigm alone or in combination with other hypoxic methods offers many opportunities to boost performance.



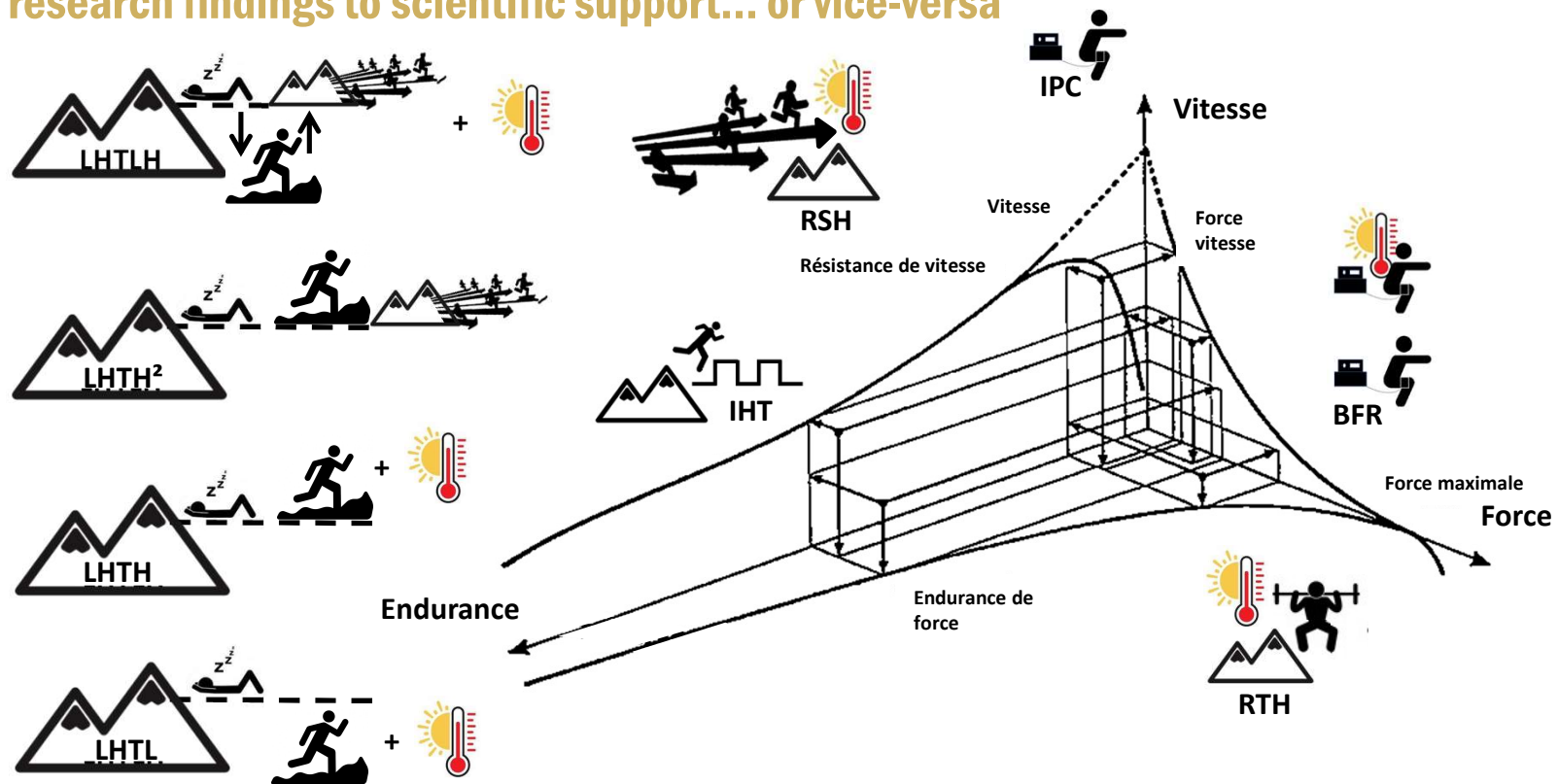
Adding heat stress may complete the strength and conditioning toolbox, through acclimation or training with cross-talk or combination effect...



Some avenues to answer specific questions (interaction/interference, dosage, individual response, delayed effects...) and improve evidence-based practices.

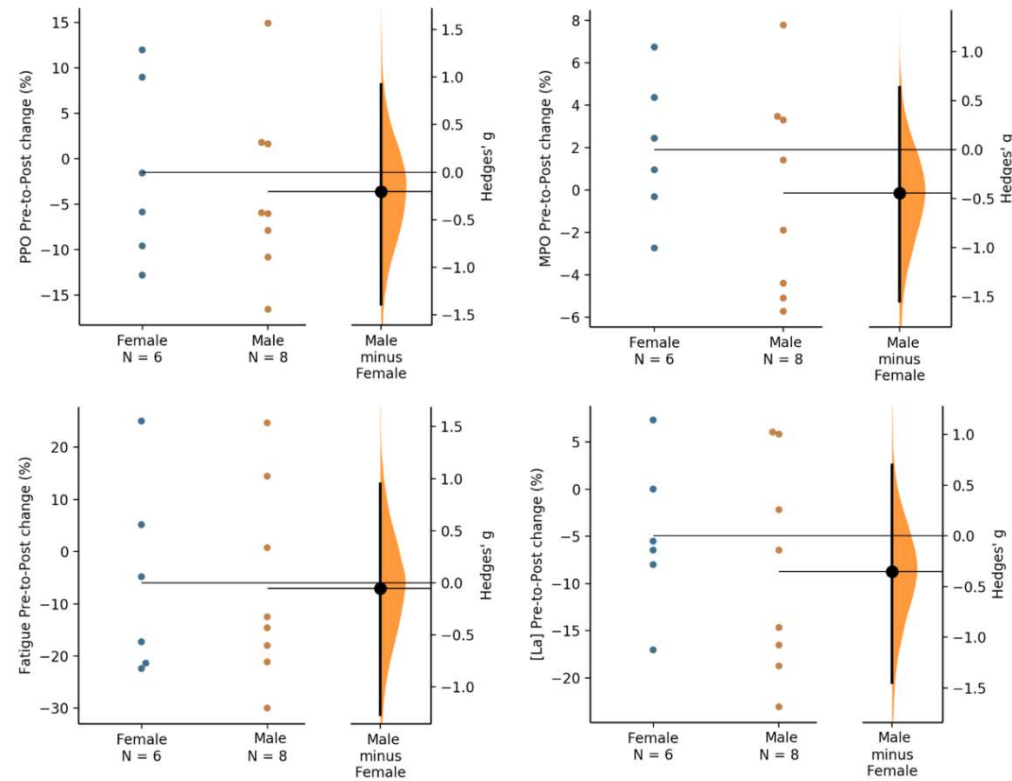
## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

From research findings to scientific support... or vice-versa



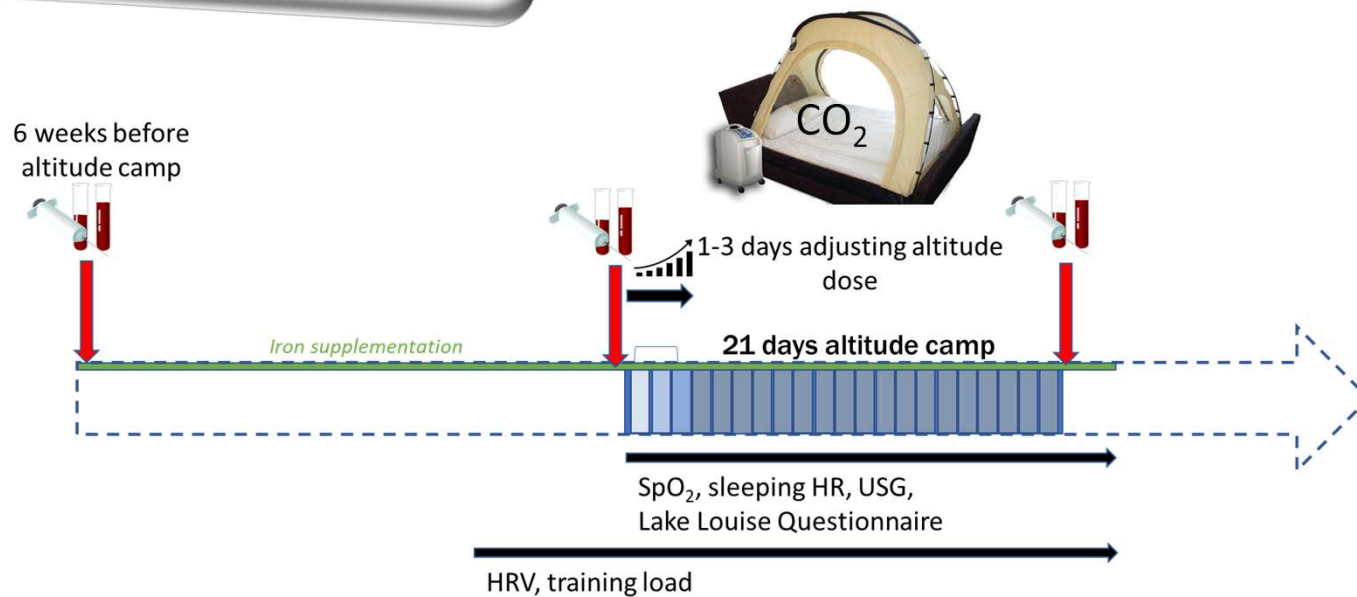
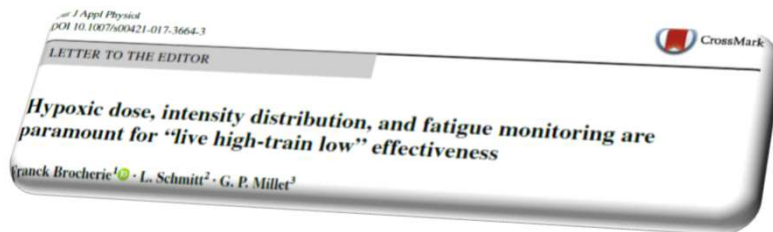


## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

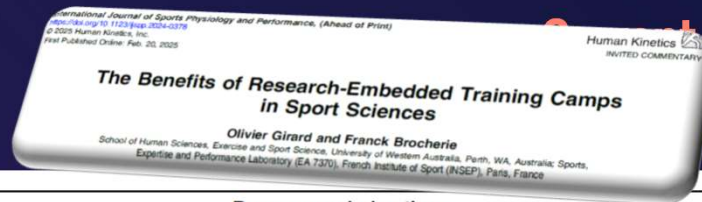




## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



Brocherie et al. (2017);  
@Nbourel (2020).

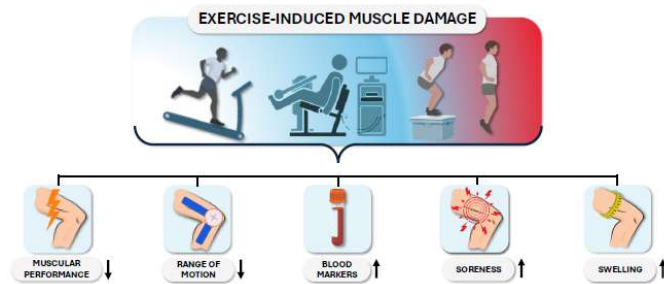


## Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

Item	Recommended actions
Customized research design	Tailor the research design to suit the specific athlete cohort, the research questions you aim to answer, and the available resources. Consider the unique characteristics and needs of the athletes to ensure the study is relevant and applicable to them.
Comprehensive documentation	Thoroughly document all aspects of the research process, including the study design, data collection/analysis methods, athlete characteristics, and any adjustments made during the camp (although they should be kept minimal). Clear documentation is essential for transparency, reproducibility, and addressing potential reviewer queries.
Practical monitoring, scientifically validated	Monitor athletes' daily training loads, including physical and psychological aspects, using submaximal tests, validated questionnaires, or technology. This helps identify injury or burnout risks. For female athletes, tracking menstrual status and phase is essential for optimizing performance, recovery, and injury prevention. Additionally, monitoring sleep, diet, medications, and timing ensures a holistic approach, enabling tailored interventions.
Environmental conditions	Take note of environmental factors that might influence athlete performance, such as temperature, humidity, altitude, carbon dioxide, or pollution levels. These variables should be factored into the research design and data analysis.
Balanced training and research	Strive to strike the right balance between the demands of the research and the needs of the athletes. If the research requirements become too burdensome or intrusive, it may lead to decreased compliance and interest from the participants.
Cultivating a positive culture	Foster a positive and collaborative atmosphere between the research team and the athletes. Building trust and rapport enhances participant engagement, cooperation, and adherence to study protocols.
Effective communication	Provide feedback and relevant information to the athletes during the camp. Share expertise and findings with them so they can benefit from the knowledge gained and understand the significance of their involvement.
Mix of researchers	Assemble a research team that comprises both experienced and junior researchers. This not only distributes the workload more effectively but also allows for the transfer of knowledge and skill development among team members.
Data management and analysis	Implement robust data management protocols to safeguard the accuracy and integrity of the data. Analyze the data rigorously and consider involving statistical experts to ensure sound interpretation of the results.
Long-term follow-up	Consider the possibility of conducting long-term follow-up studies to assess the lasting impact of the camp and the effectiveness of any interventions.
Dissemination of results	When not restricted by embargo or cultural issues, share relevant research findings through publications, conferences, and other appropriate channels. Disseminating results contributes to the broader sport sciences' community and can also benefit other stakeholders by enhancing training practices and performance strategies.
Continuous improvement	Reflect on the intervention's strengths and limitations after its completion. Use this feedback to improve future iterations and optimize the research design for subsequent studies.



## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?





## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



RESOURCE CENTRE

MULTIDISCIPLINARY  
APPROACH



RESSOURCE GROUP

Federations and Grand INSEP institutes :  
- using environmental stress  
- employing certified personal (CCS)  
- Providing scientific support to athletes

ENLARGED GROUP

Federations' head of performance,  
scientific referents...

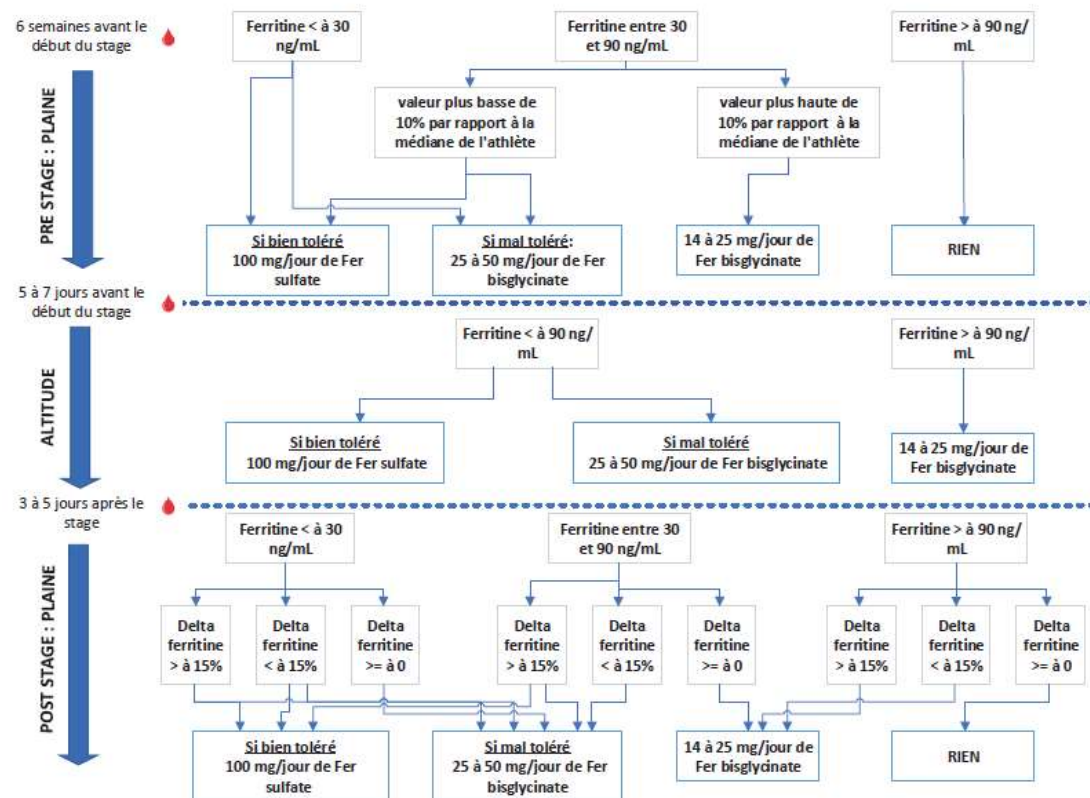
STEERING GROUP

INSEP - Paris  
CNSMM - Prémamanon  
CNEA - FONT-ROMEUE

14  
centres  
ASTRE



## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?







## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?





## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



**CCS INSEP**  
« entraînement  
sous stress  
environnemental »

**Qualiopi**  
processus certifié

REPUBLIQUE FRANÇAISE

La certification qualité est délivrée au titre de la catégorie  
suivante : actions de formation







# Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

Document clé

Déclaration de consensus du Comité International Olympique portant sur les défis de thermorégulation et d'altitude chez les athlètes de haut niveau

MF Bergeron,<sup>1,2</sup> R Bahr,<sup>3</sup> P Bartsch,<sup>4</sup> L Bourdon,<sup>5</sup> JAL Calbet,<sup>6</sup> KH Carlsen, O Castagna,<sup>7,8</sup> Gonzalez-Alonso,<sup>9</sup> C Lundby,<sup>11</sup> RJ Maughan,<sup>12</sup> G Millet,<sup>13</sup> M Mountjoy,<sup>14,15</sup> S Racinais,<sup>17</sup> P Rasmussen,<sup>11,18</sup> DG Singh,<sup>19,21</sup> AW Subudhi,<sup>22</sup> AJ Young,<sup>23</sup> T Soligard,<sup>24</sup> L Engebretsen<sup>24</sup>

## Défis de la Thermorégulation et de l'Altitude

Position de consensus du Comité International Olympique

Référence: Bergeron et al. BJSM 2012

Produit par eYLM SportScience

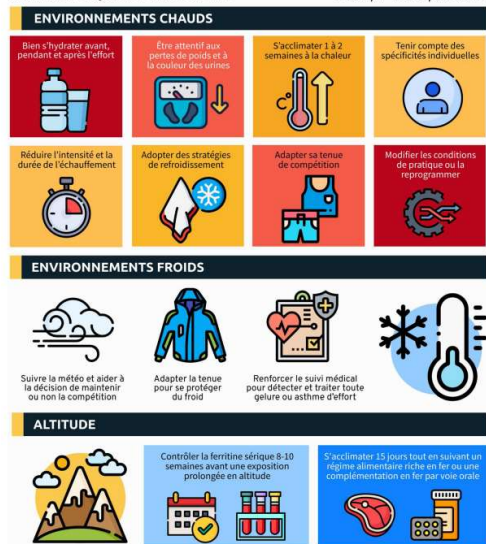


Figure 1 Synthèse graphique des recommandations face aux défis liés à la thermorégulation et à l'altitude.



Déclaration de consensus



OPEN ACCESS

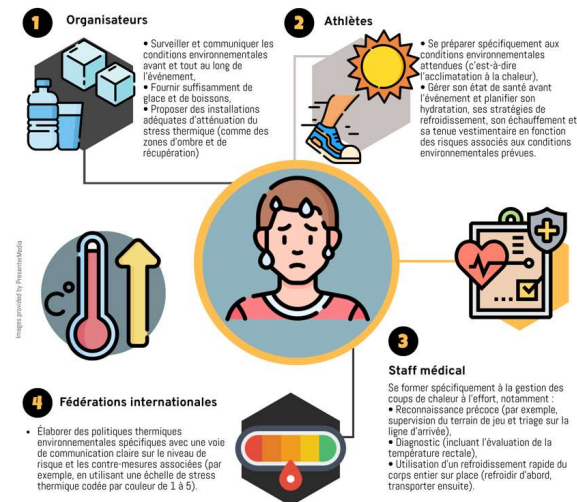
Déclaration de consensus du CIO sur les recommandations et les réglementations pour les événements sportifs par temps chaud

Sebastien Racinais<sup>1</sup>, Yuri Hosokawa<sup>2</sup>, Takao Akama<sup>2</sup>, Stephane Bermon<sup>3</sup>, Xavier Bigard<sup>4</sup>, Douglas J Casa<sup>5</sup>, Andrew Grundstein<sup>6</sup>, Ollie Jay<sup>7</sup>, Andrew Massey<sup>8</sup>, Sergio Migliorini<sup>9</sup>, Margo Mountjoy<sup>10</sup>, Nebosa Nikolic<sup>11</sup>, Yannis P Pitsiladis<sup>12</sup>, Wolfgang Schoberberger<sup>13,14</sup>, Juergen Michael Steinacker<sup>15</sup>, Fumihiko Yamasawa<sup>16</sup>, David Anthony Zideman<sup>17</sup>, Lars Engebretsen<sup>18</sup>, Richard Budgett<sup>19</sup>

## Protéger les athlètes qui performant en condition chaude

Référence: Racinais et al. BJSM 2022

Produit par eYLM SportScience





## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



### Symposiums

Symposium  
Performance et  
Stress  
Environnemental



De Tokyo à Paris 2024  
21 et 22 OCTOBRE 2021  
CREPS CNEA FONT-ROMEUE

Contact : performance360@cneafontromeu.fr  
Tel : 04 68 30 86 60



**SAVE THE DATE**

SYMPOSIUM  
ASTRE/HYPOXPERF  
SUR LE STRESS  
ENVIRONNEMENTAL

03 juillet  
2023

INSEP  
De 9h à 12h30 et de 14h à 18h  
11, avenue de Trumbly - 75012 Paris  
Contact : rg@insep.fr



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USING ENVIRONMENTAL  
STRESSORS TO ACHIEVE PEAK  
PERFORMANCE  
From evidence to avenues to explore



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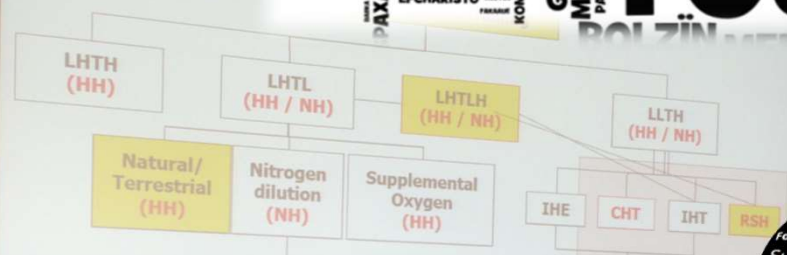
## Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?



- **Because performance is multifactorial,**
- **Scientific support must be multidisciplinary,**
- **Evidence-based approach must be preferred,**
- **and applied in ecological setting (whenever possible),**
- **With an athlete-centered focus, to optimize performance...**



GRACIAS  
ARIGATO  
SHUKURIA  
THANK  
YOU



Submit a Manuscript to the Journal of Sports Sciences

For a Special Issue on  
Supporting athletes in/with environmental stress: From training-related intervention to regeneration

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frank.brocherie@insep.fr  
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