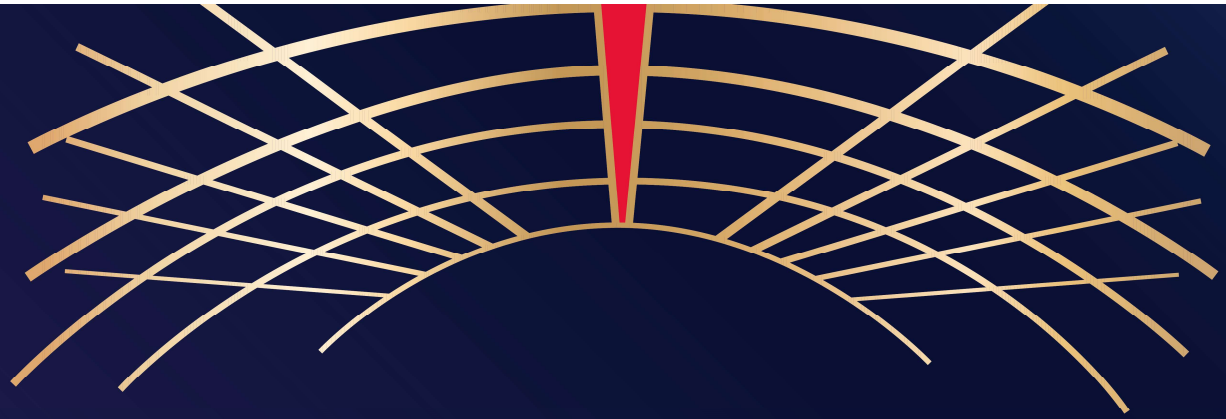

Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

F Brocherie
Laboratory Sport, Expertise and Performance (EA 7370),
French Institute of Sport (INSEP), Paris, France

LinkedIn ResearchGate @BrocherieF

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

Elite Sport Athlete → University (DESS) → Sport scientist → (Head of) strength and conditioning → Researcher → INSEP

CEP CENTRE D'EXPERTISE DE LA PERFORMANCE GILLES COMETTI

ASPETAR
Qatar Orthopaedic and Sports Medicine Hospital

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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[1] and Adam Beard[2]*

[1] Laboratory Sport, Expertise and Performance (EA 7370), French Institute of Sport (INSEP), Paris, France, [2] High Performance Unit, Chicago Cubs Major League Baseball, Chicago, IL, United States

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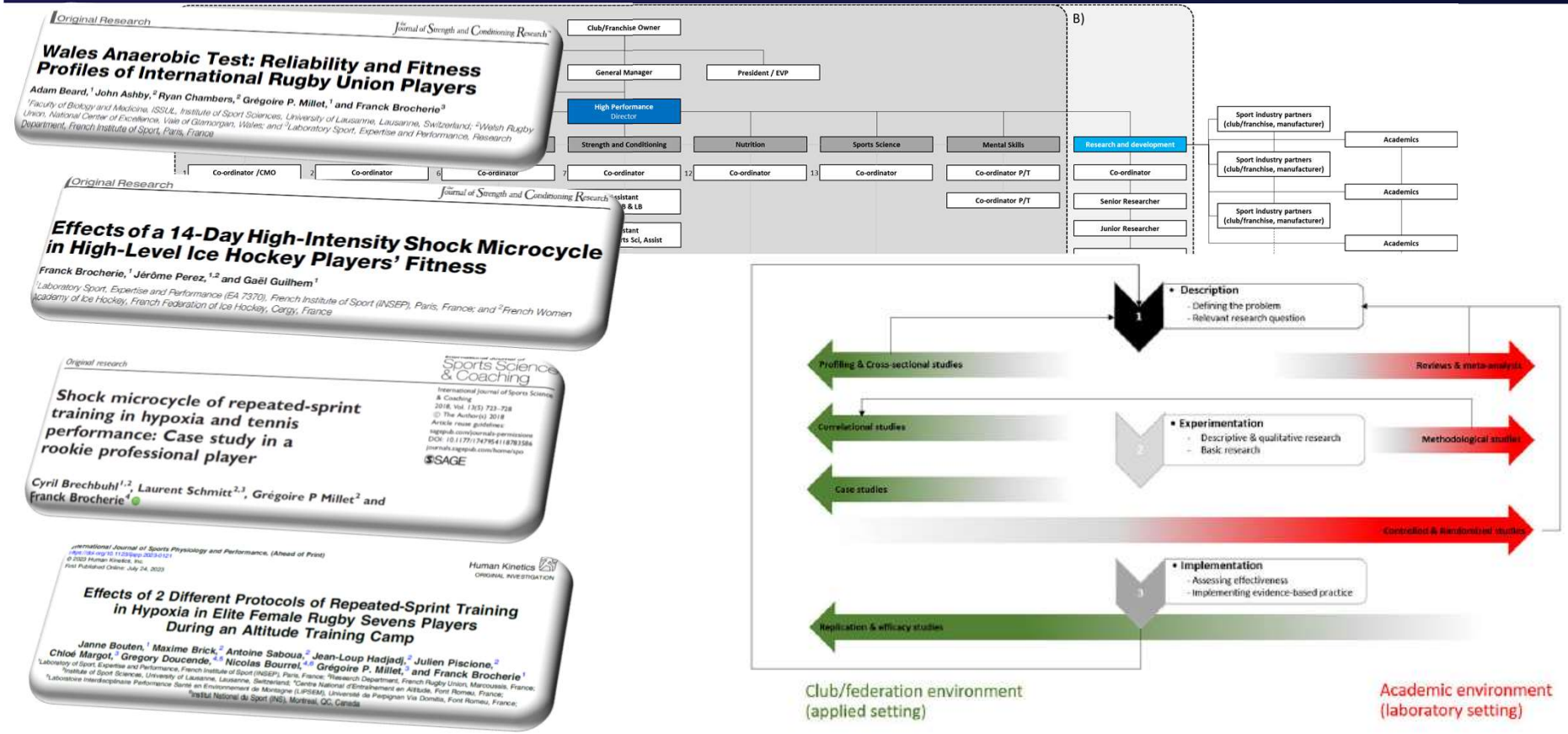

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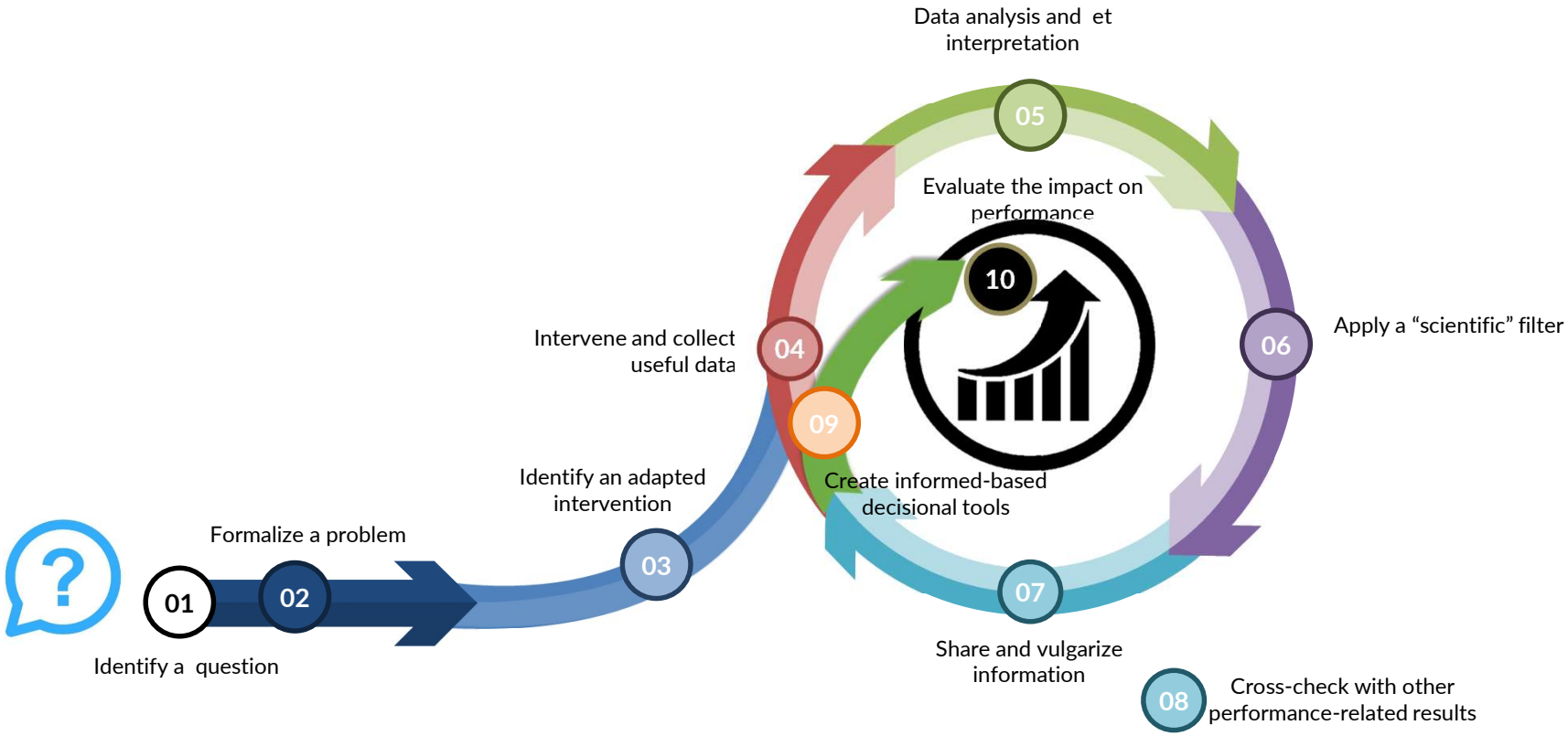

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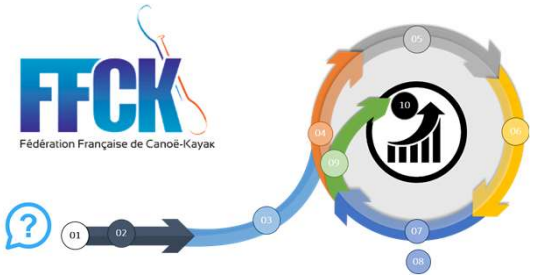

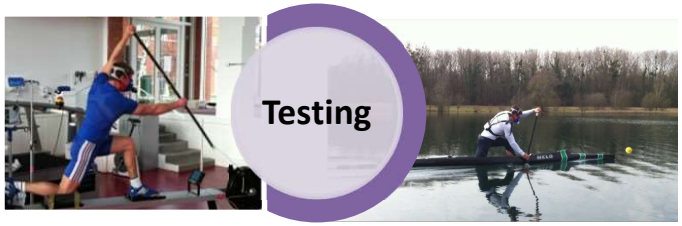

cnea FONT-ROMEU | RÉSEAU GRAND INSEP | C N S N M M

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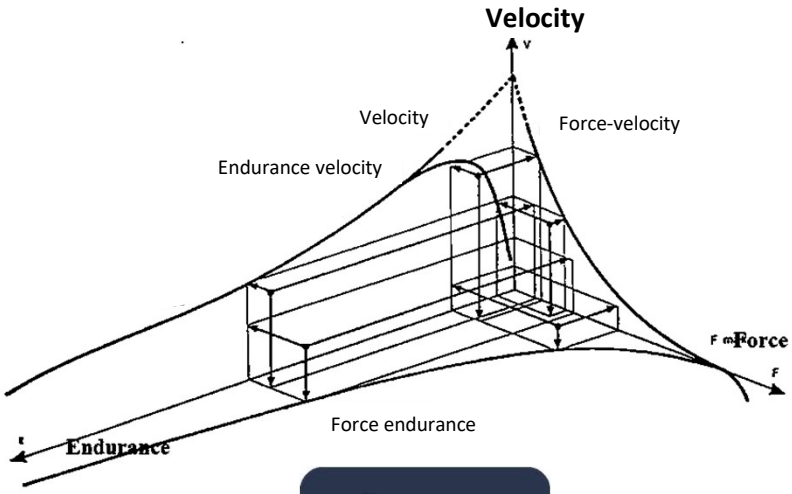
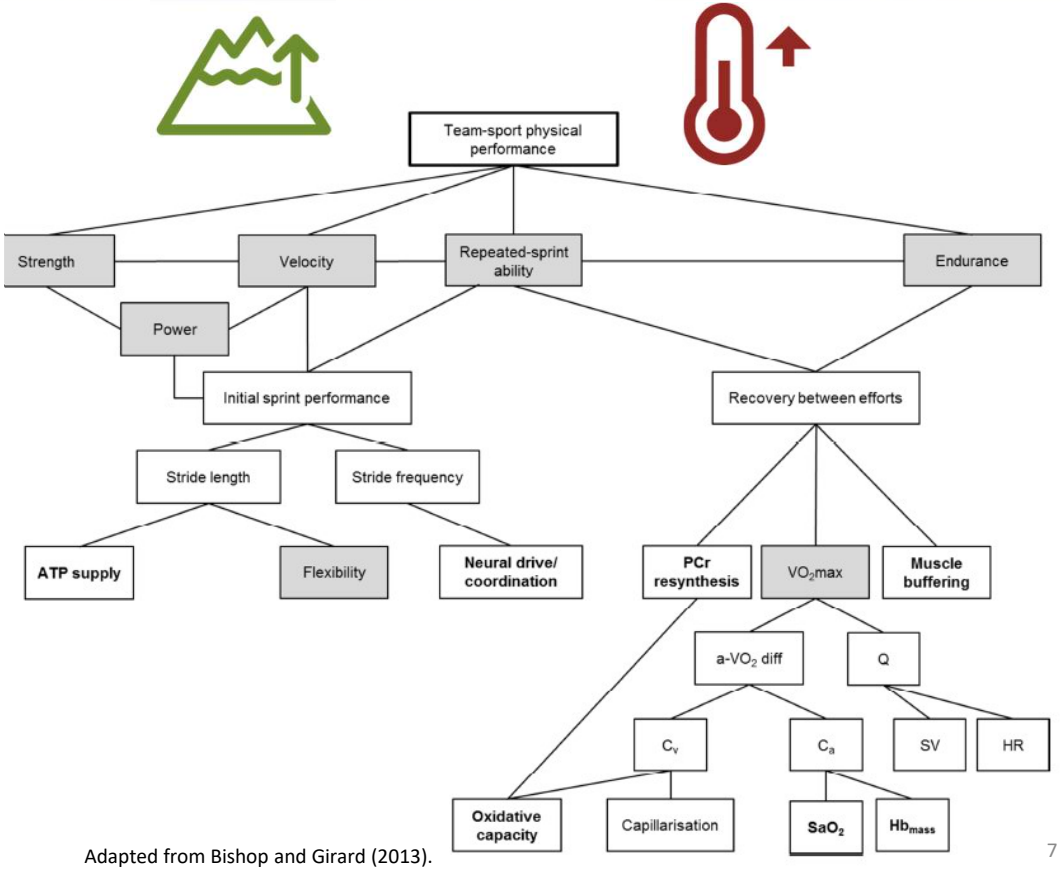


Gundlach (1968).



Adapted from Bishop and Girard (2013).

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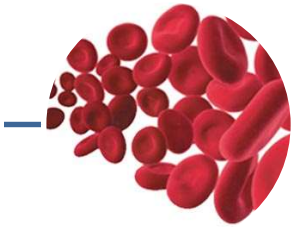
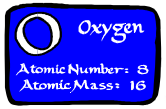


Erythropoeitic Response

↓ P_iO_2 ↓ P_aO_2



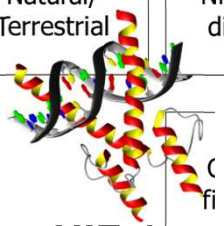
LHTH

LHTL

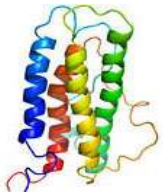
Natural/ Terrestrial

Nitrogen dilution

Supplemental Oxygen



↑ HIF-1α



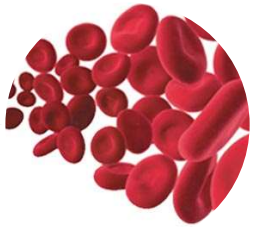
↑ EPO

↑ Hb_{mass}

↑ VO_{2max}

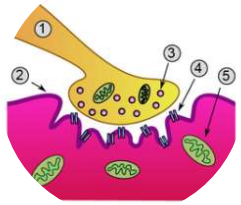
Girard et al. (2017, 2020); Millet et al. (2010, 2013); Wilber (2007).

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

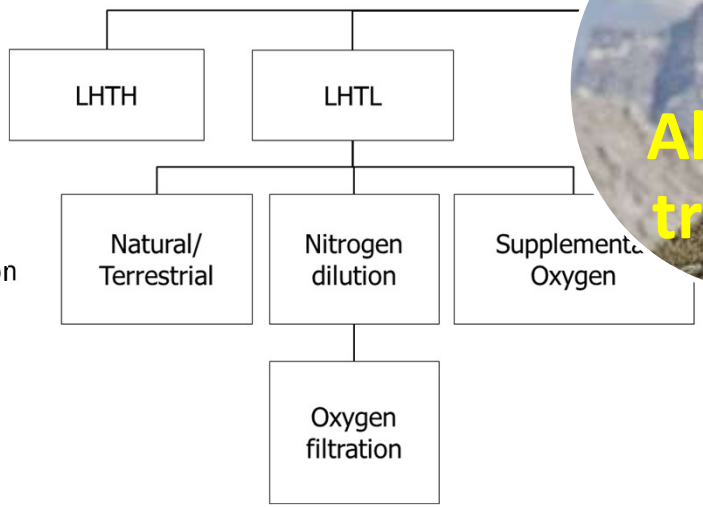


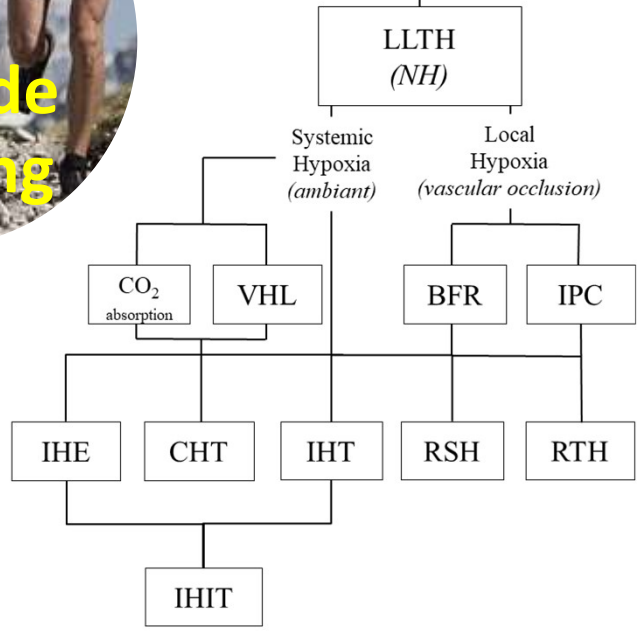
Erythropoeitic Response

Central adaptation



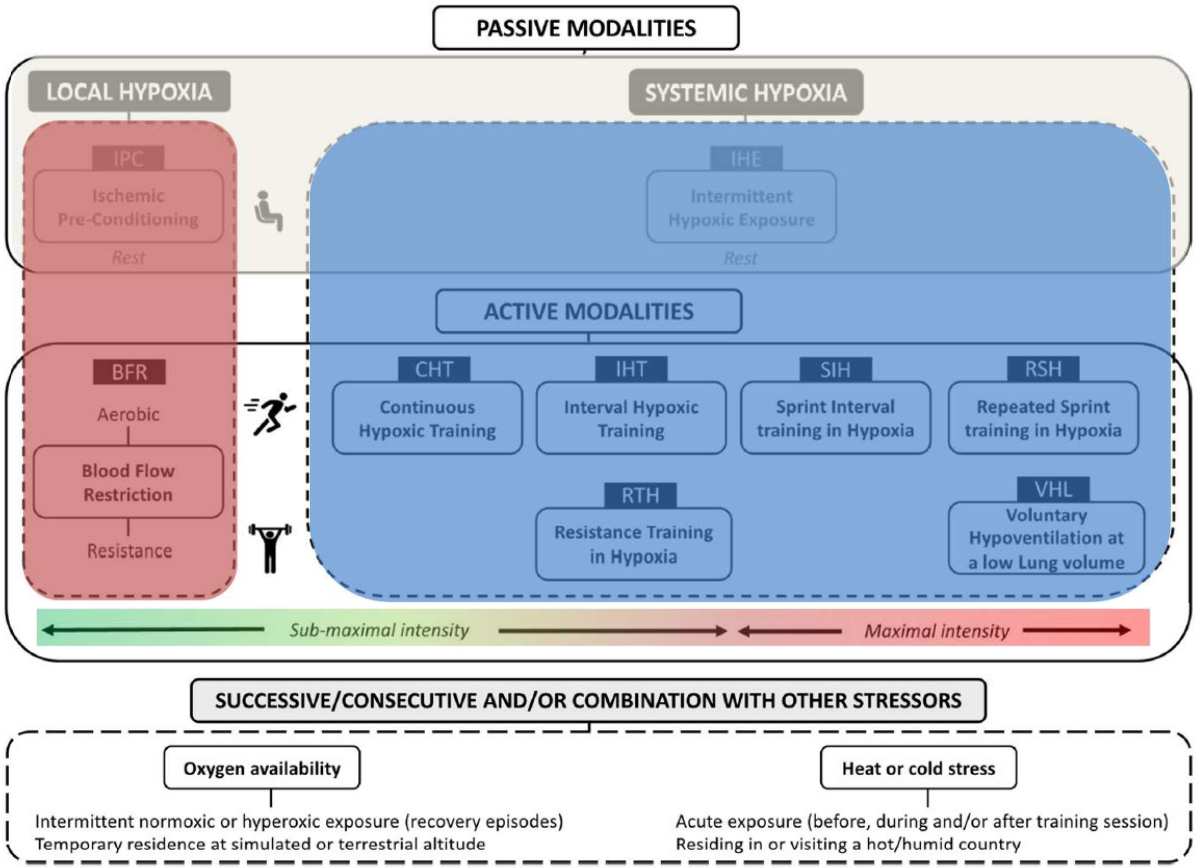
Peripheral adaptation

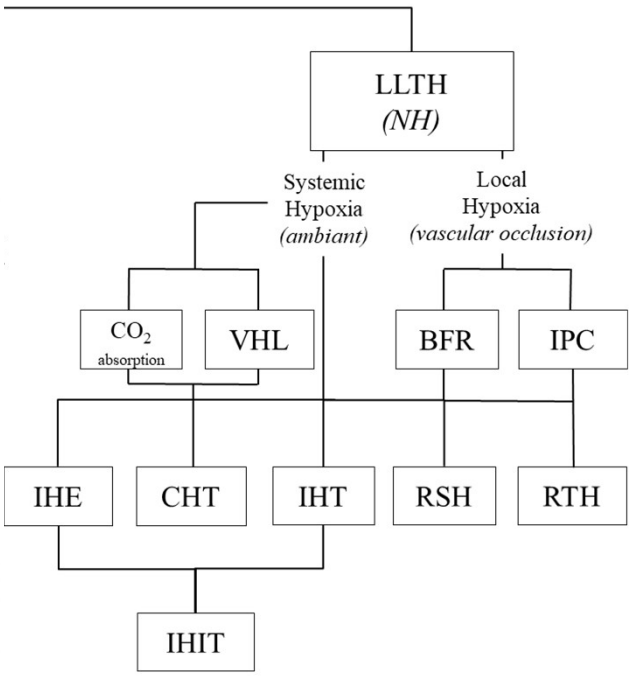




Girard et al. (2017, 2020); Millet et al. (2010, 2013); Wilber (2007).

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





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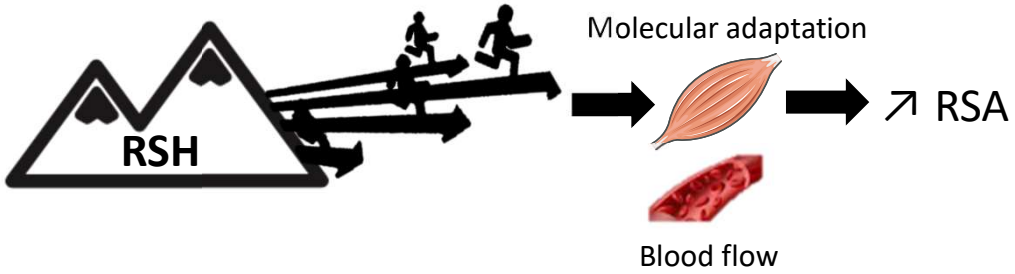
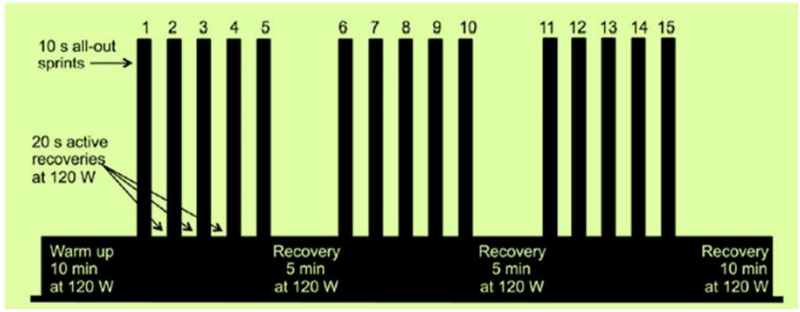
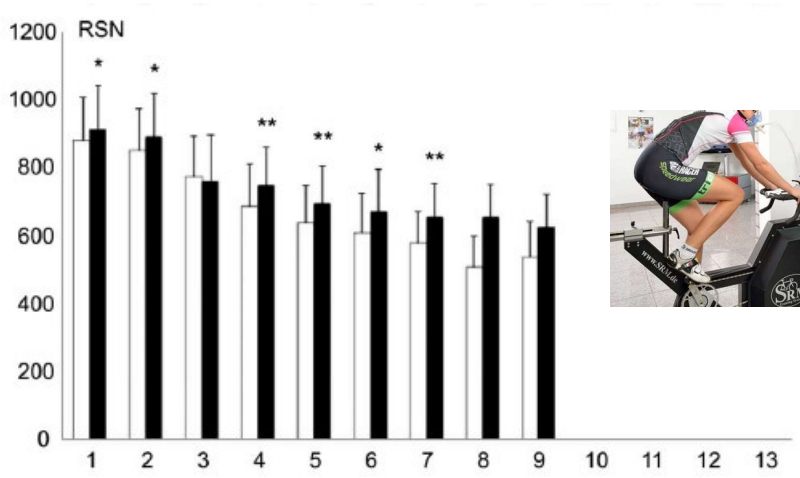
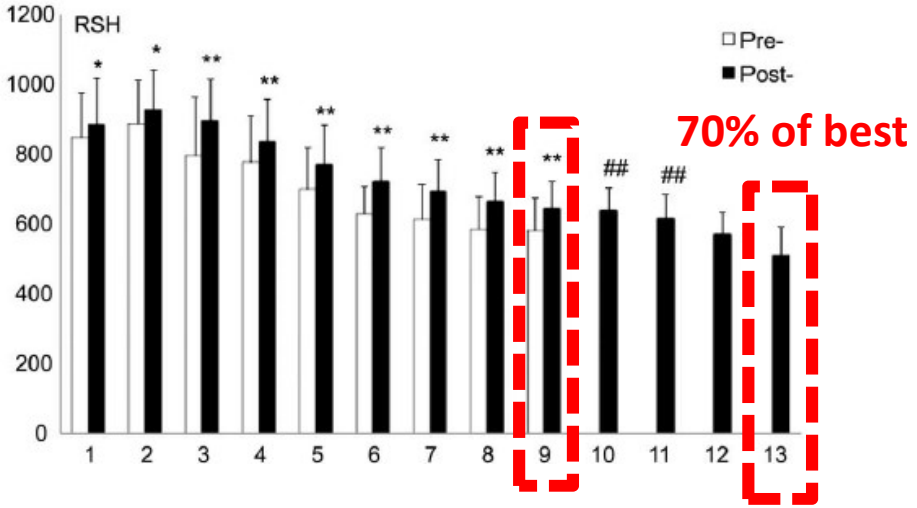


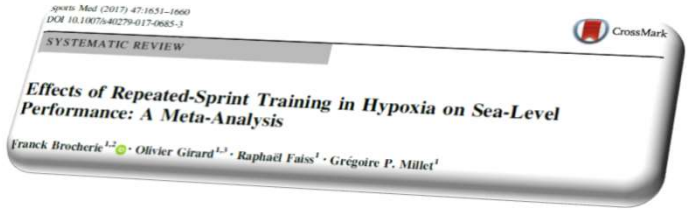




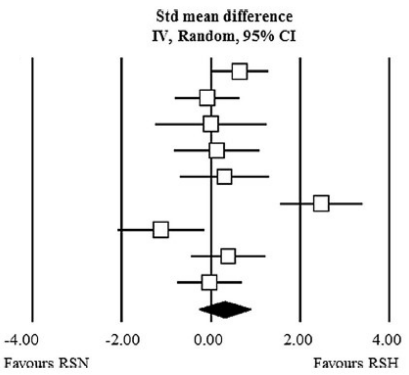


Faiss et al. (2013).

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



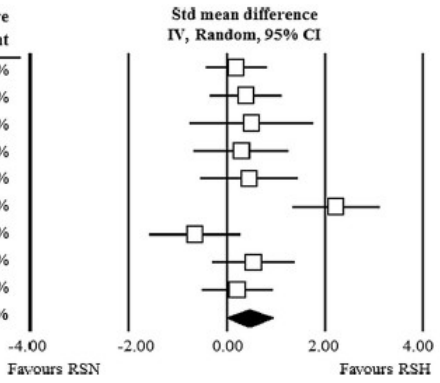
→ RSA best time



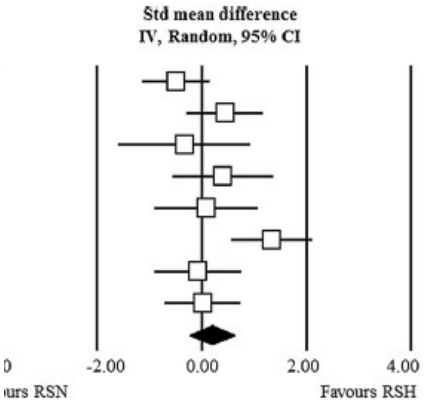
Study	SMD	[95% CI]	Relative weight
Faiss et al. [9]	0.192	[-0.430, 0.813]	13.6%
Galvin et al. [36]	0,389	[-0.334, 1.111]	12.6%
Gatterer et al. [37]	0.500	[-0.759, 1.759]	7.9%
Faiss et al. [39]	0.293	[-0.664, 1.250]	10.3%
Brocherie et al. [35]	0.456	[-0.536, 1.449]	10.0%
Kasai et al. [38]	2.222	[1.341, 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%
Combined	**0.455**	**[-0,017, 0.927]**	**100.0%**

Heterogeneity: Tau² = 0.00; df = 8 (P = 0.21); I² = 6.19
Test for overall effect: Z = 1.89 (P = 0.05)

→ RSA mean time

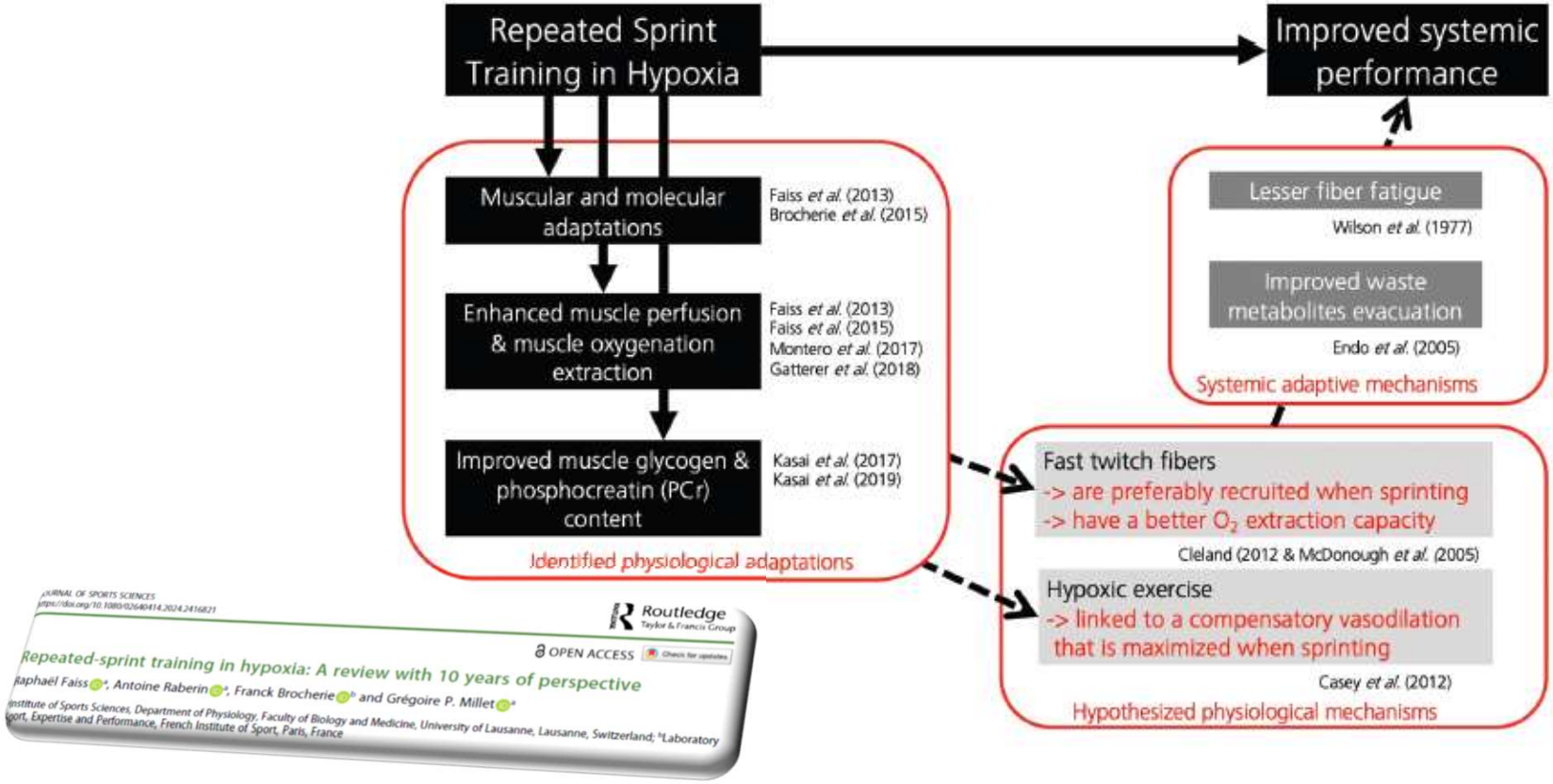


→ RSA VO_2max



Brocherie et al., *Sports Med.* (2017).

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



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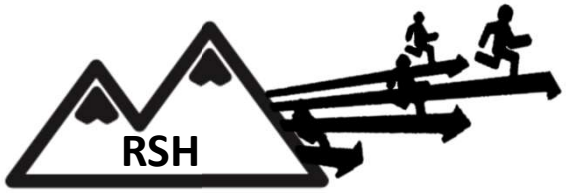


5 sem. Courses intermittente à haute intensité, RSA et force explosive / agilité / sprint

RSH (n = 8)
FIO2 = 14.3%
~2900 m

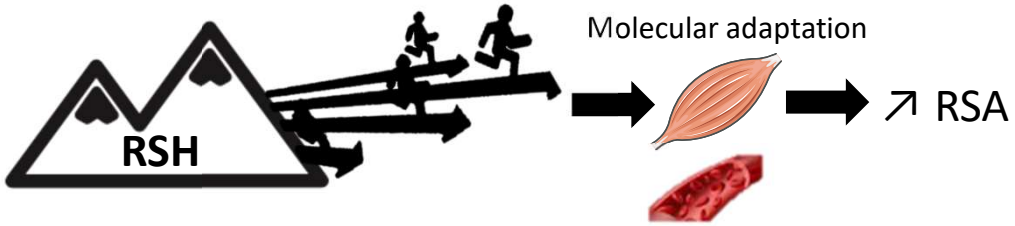
RSN (n = 8)
FIO2 = 21.0%
~0 m

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, % HR_{max}	~60	~60	~70	~50	~50	~70	
Afternoon							
Activity	**Conditioning**	Football (skills + tactics)	**Conditioning**	Friendly match (or training)	Football (skills + tactics)	Domestic match	Off
Duration, min	**60**	75	**60**	90	75	90	
Intensity, % HR_{max}	**~90–100**	~70	**~90–100**	~80	~70	~85–90	

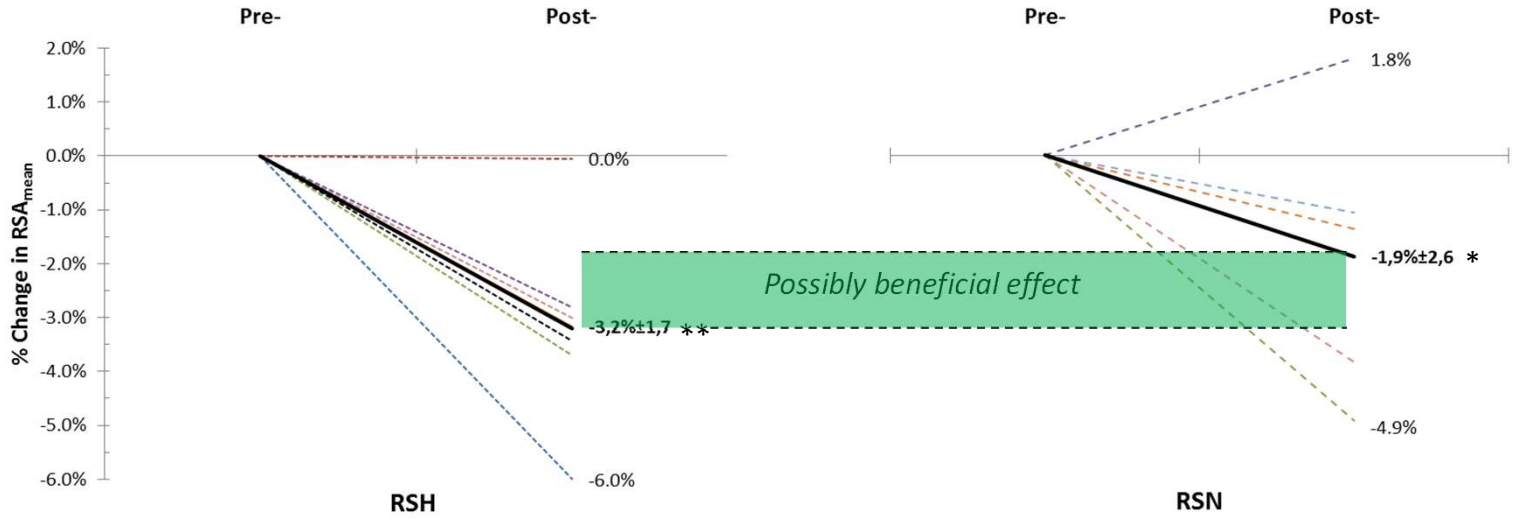
*% HRmax = % of maximal heart rate.
†Cells in bold refer to activities performed in hypoxic environment.

Brocherie et al. (2015).

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.

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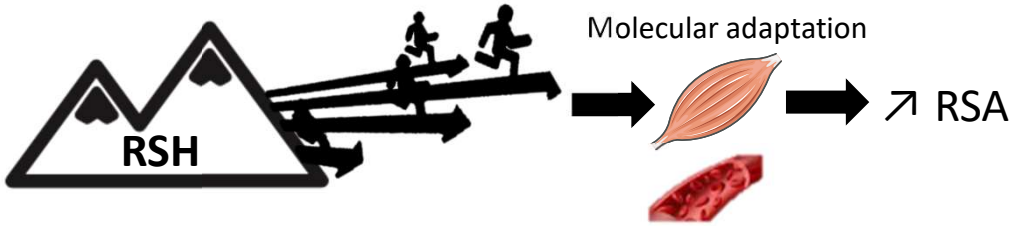
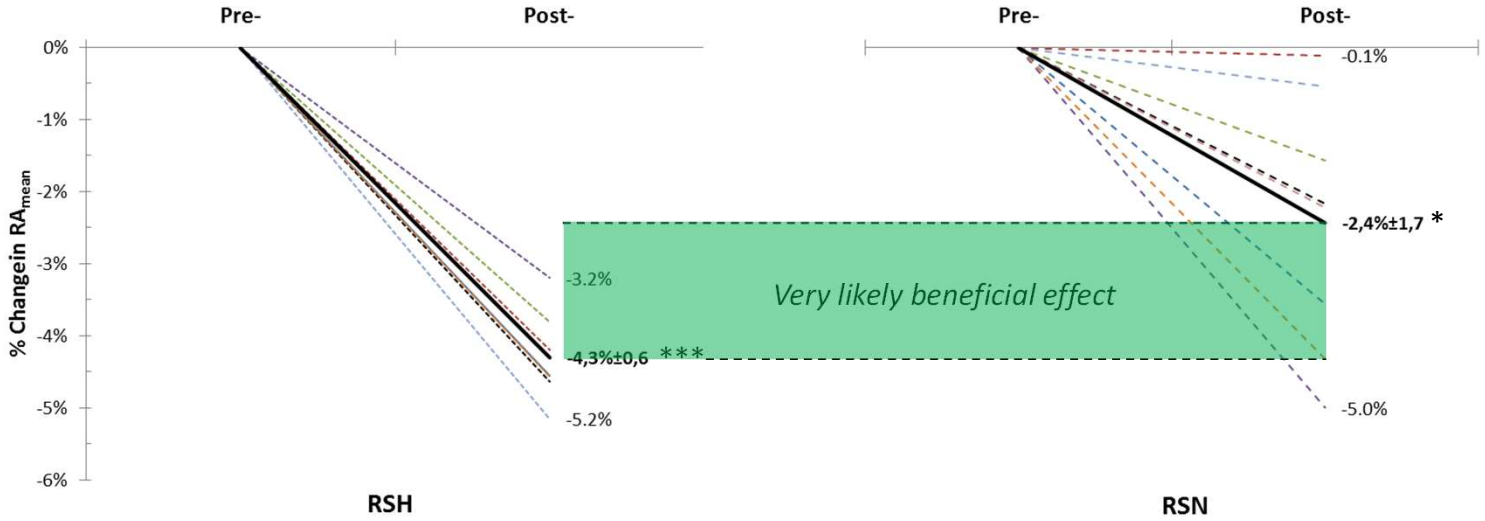
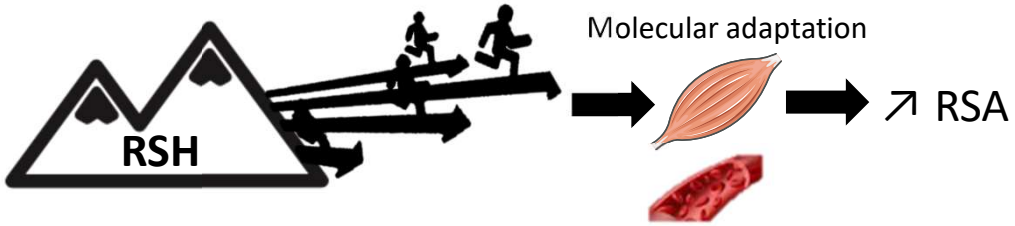


Repeated-Agility Ability (6 x 20 m with L-shape COD – 30 s)

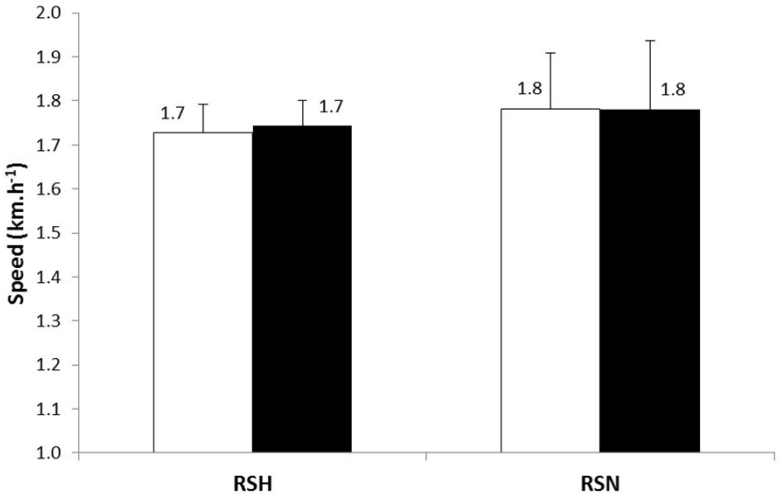


Brocherie et al., 2015. → Results confirmed (↑RSA and YYIR2 after 5-wks RSH (3300 m) vs. control (*Gatterer et al., 2014; 2015*).

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



Maximal aerobic speed (VAMEVAL)



Brocherie et al., 2015

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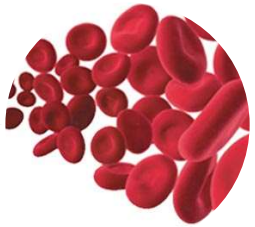
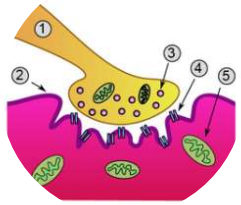


Erythropoeitic Response

Central adaptation



Peripheral adaptation

LHTH

LHTL

Natural/ Terrestrial

Nitrogen dilution

Supplemental Oxygen

Oxygen filtration

LLTH *(NH)*

Systemic Hypoxia *(ambiant)*

Local Hypoxia *(vascular occlusion)*

CO_2 absorption

VHL

BFR

IPC

IHE

CHT

IHT

RSH

RTH

IHIT

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

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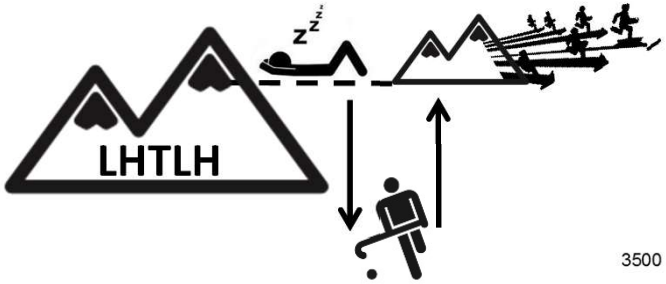

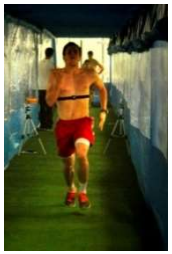

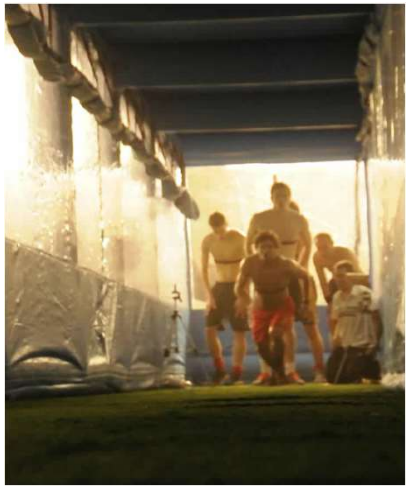

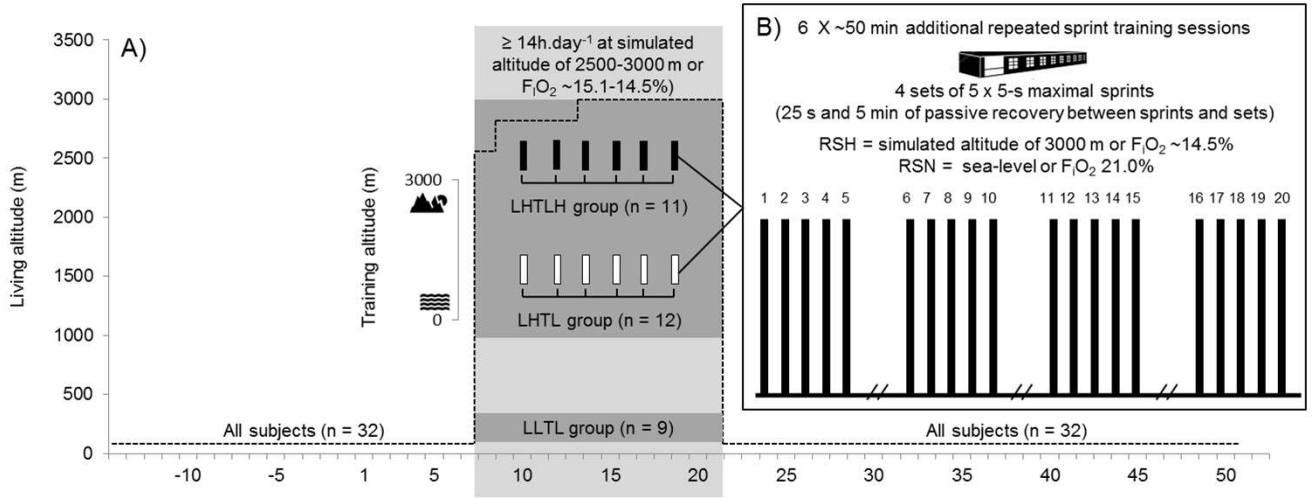

Brocherie et al. (2015, 2018).

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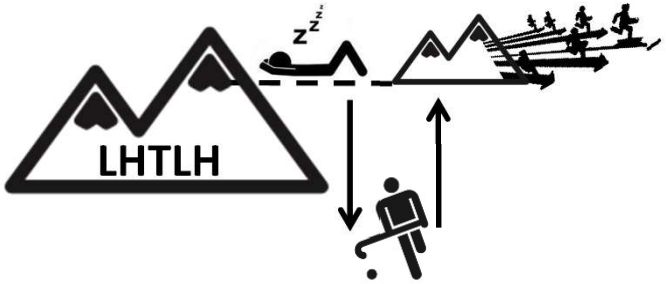
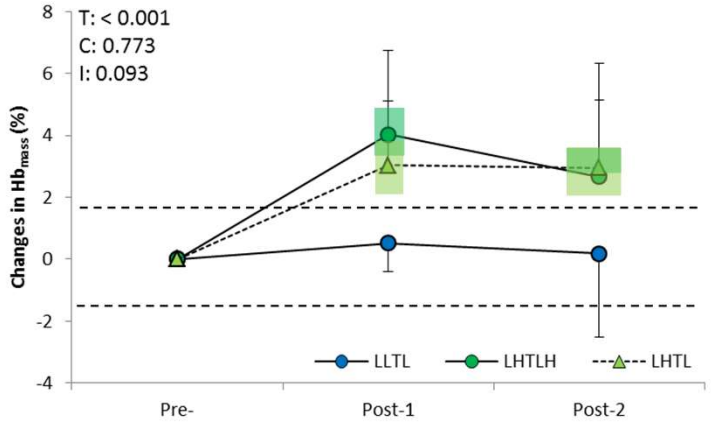
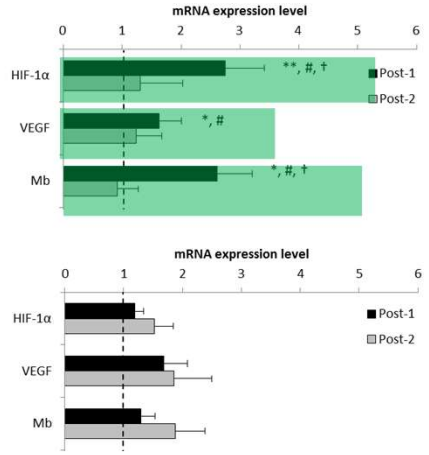


Hb_{mass} - Co Rebreathing



Biopsies



Brocherie et al. (2015, 2018).

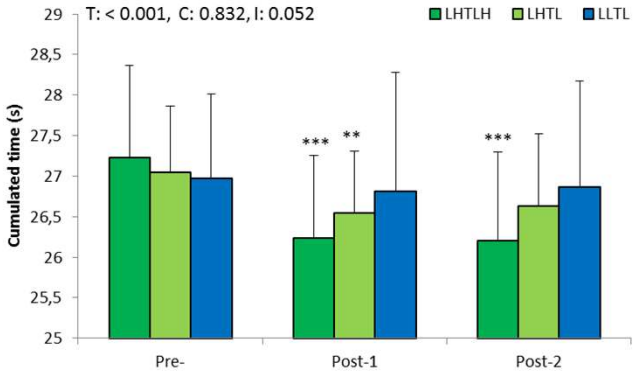
Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

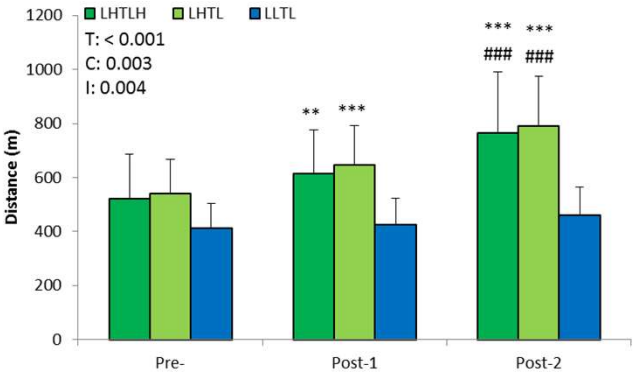
Blood flow

↗ RSA

↗ aerobic component

Blood-Oxygen carrying capacity





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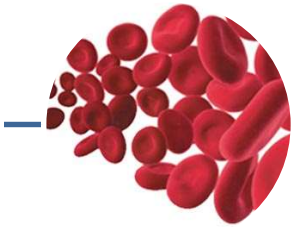
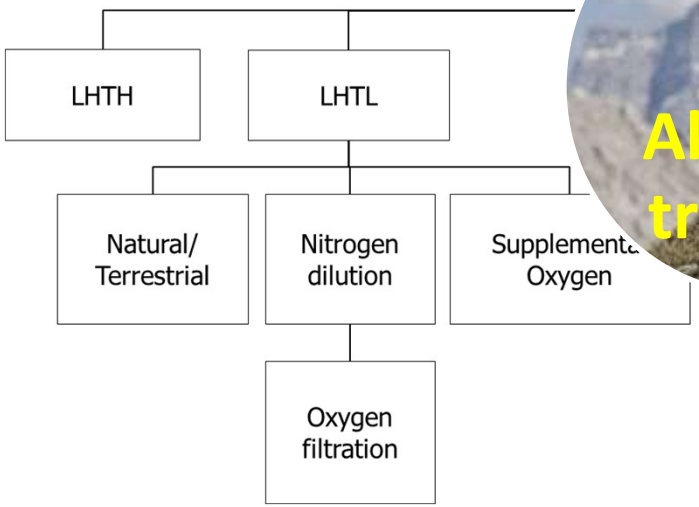


Erythropoeitic Response



Training in Heat to Prepare for Altitude

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

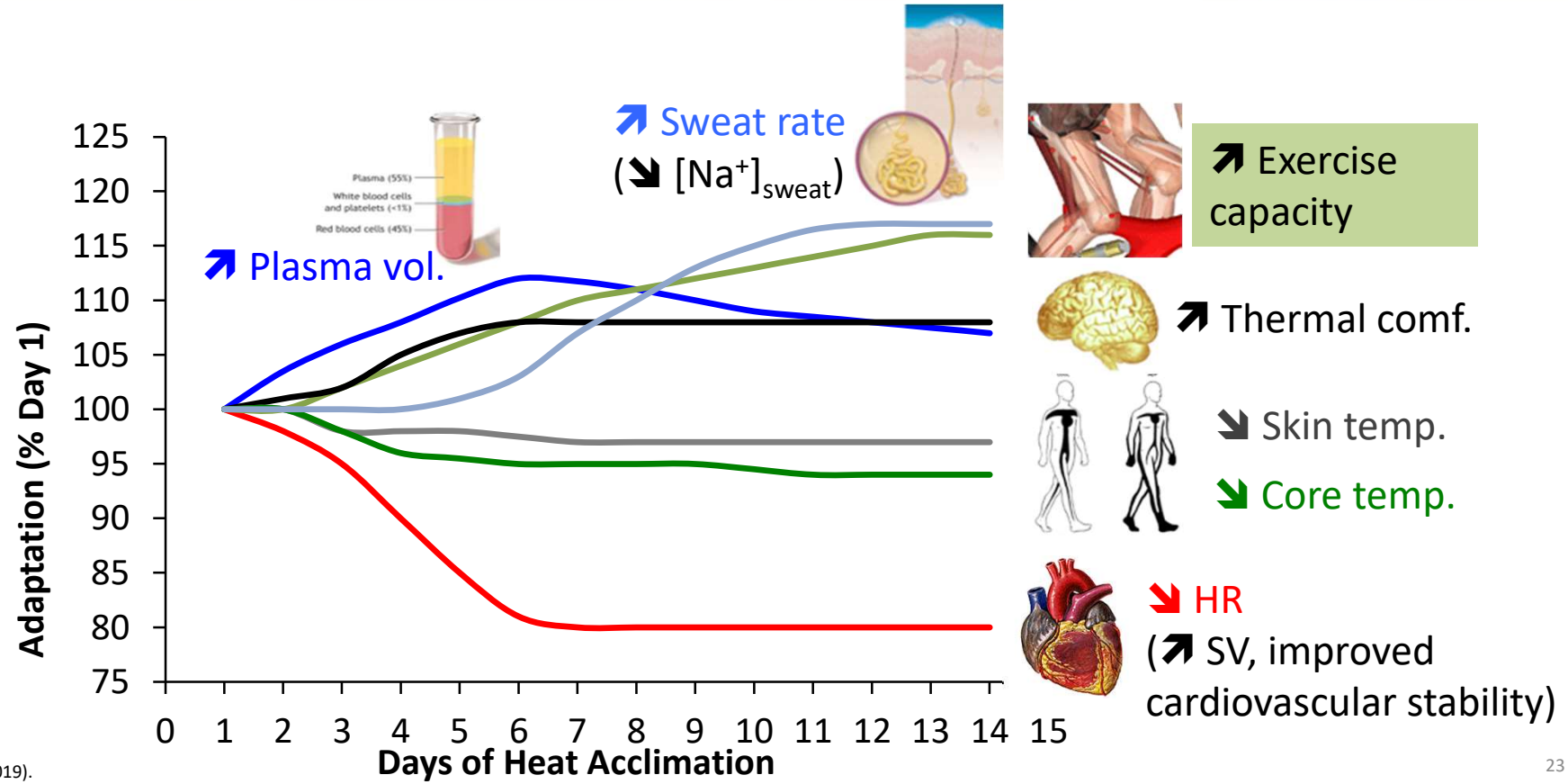
BY ALEX HUTCHINSON APR 13, 2016

Sports

ARE HEAT TRAINING CAMPS REPLACING ALTITUDE TRAINING?

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

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



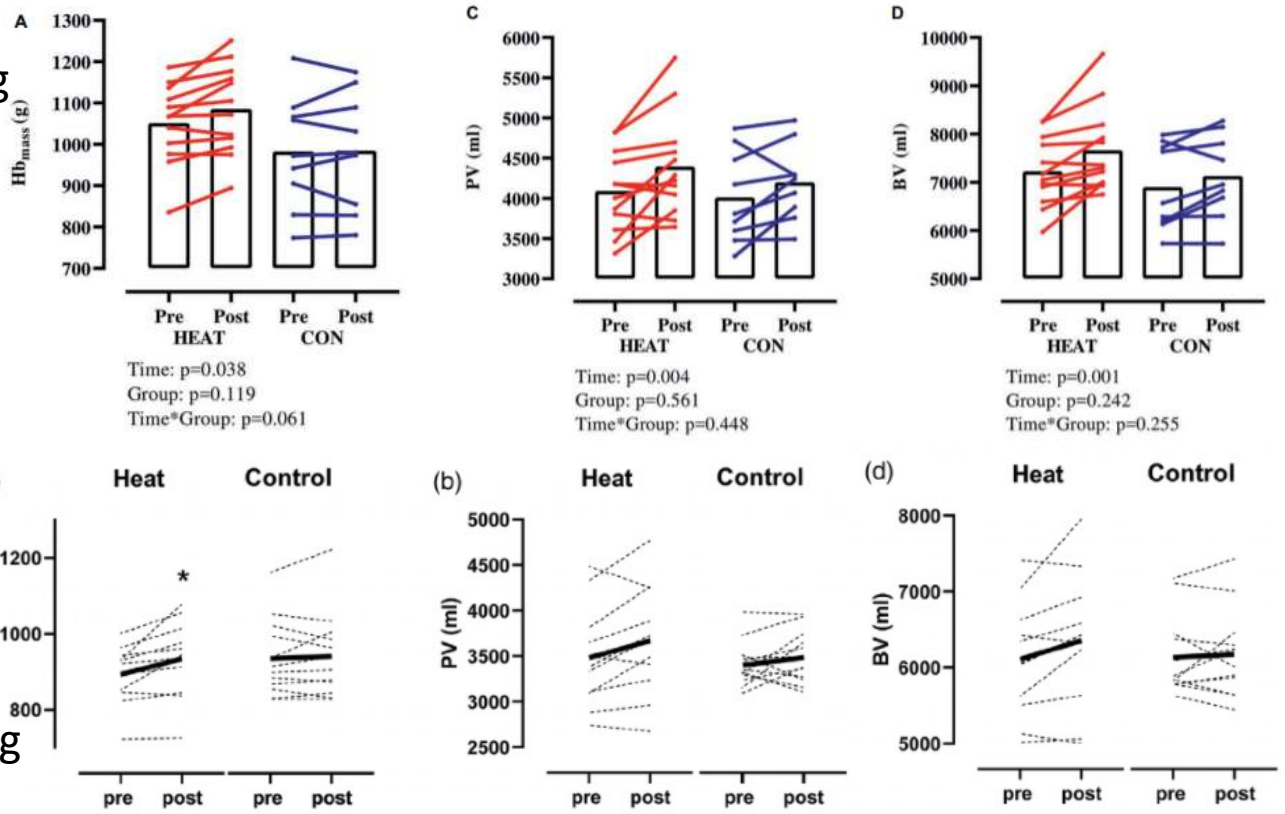
Périard et al. (2019).

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

Well-trained male cyclists
VO_2peak: 59.1 ± 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 ± 7.6 ml/min/kg



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

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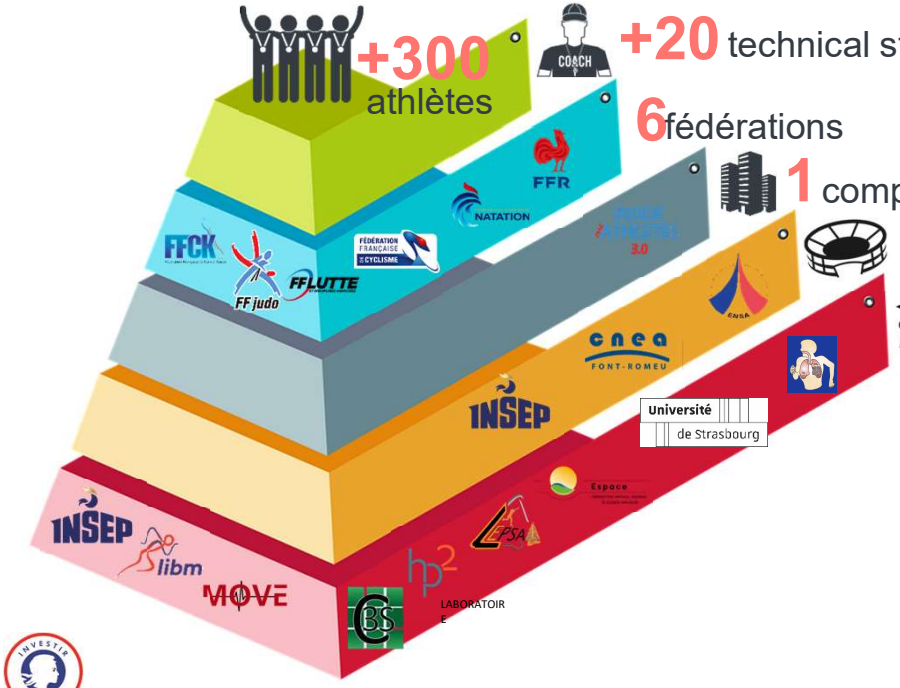

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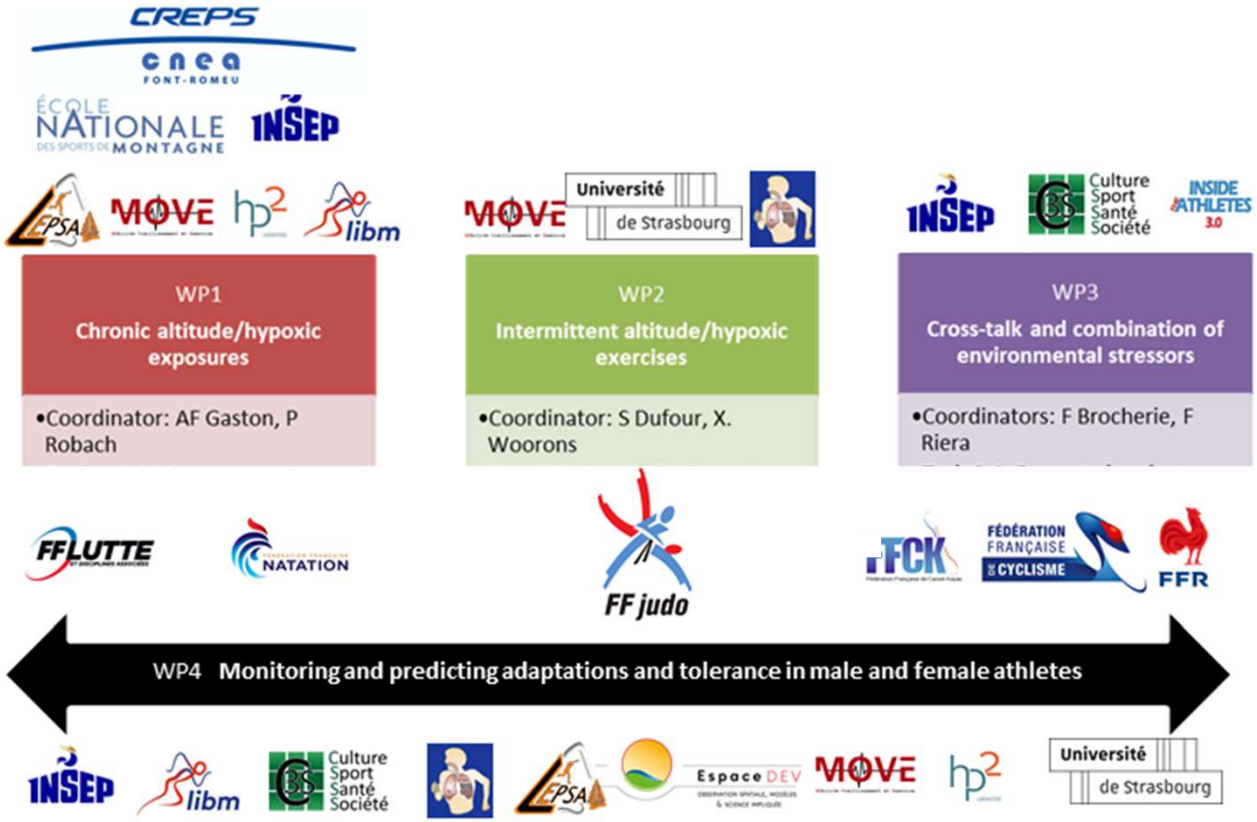

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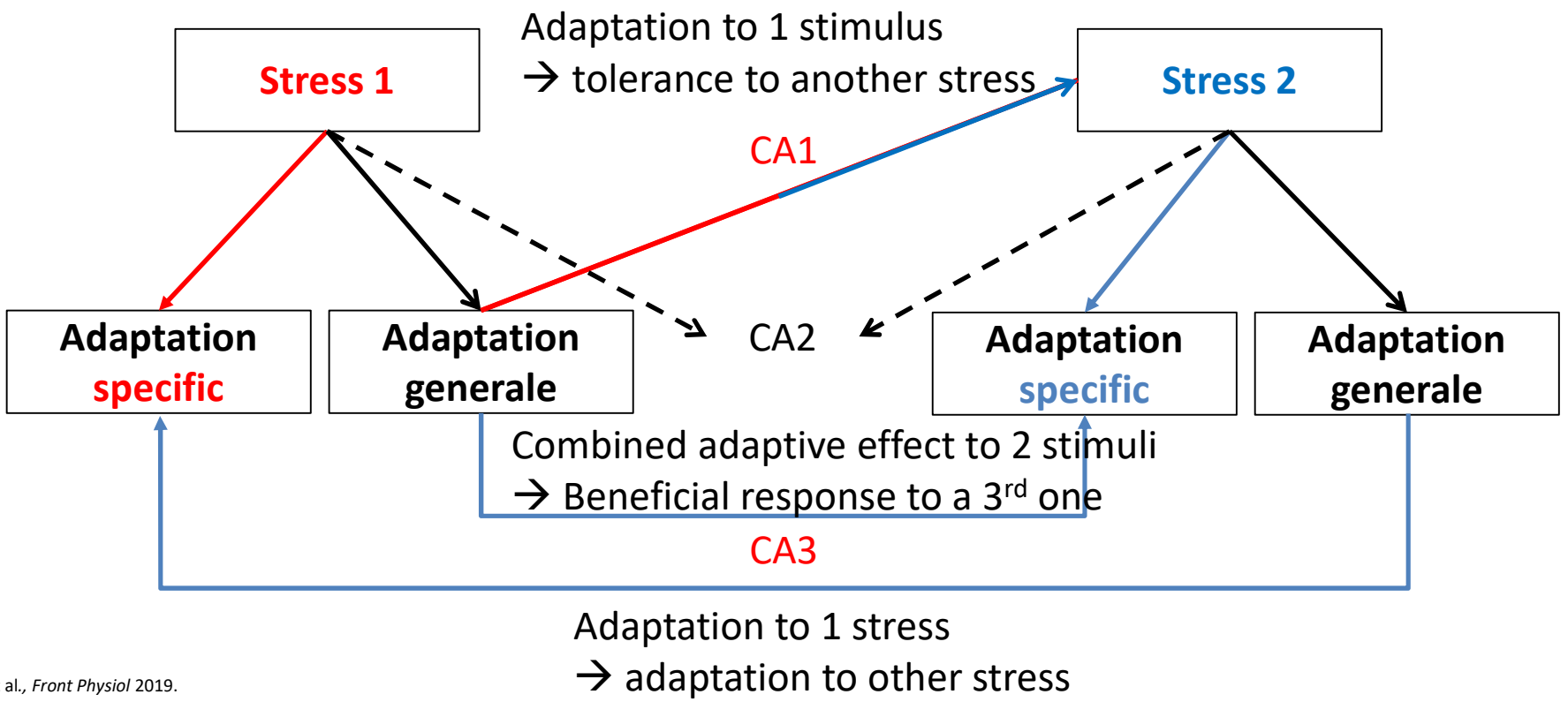
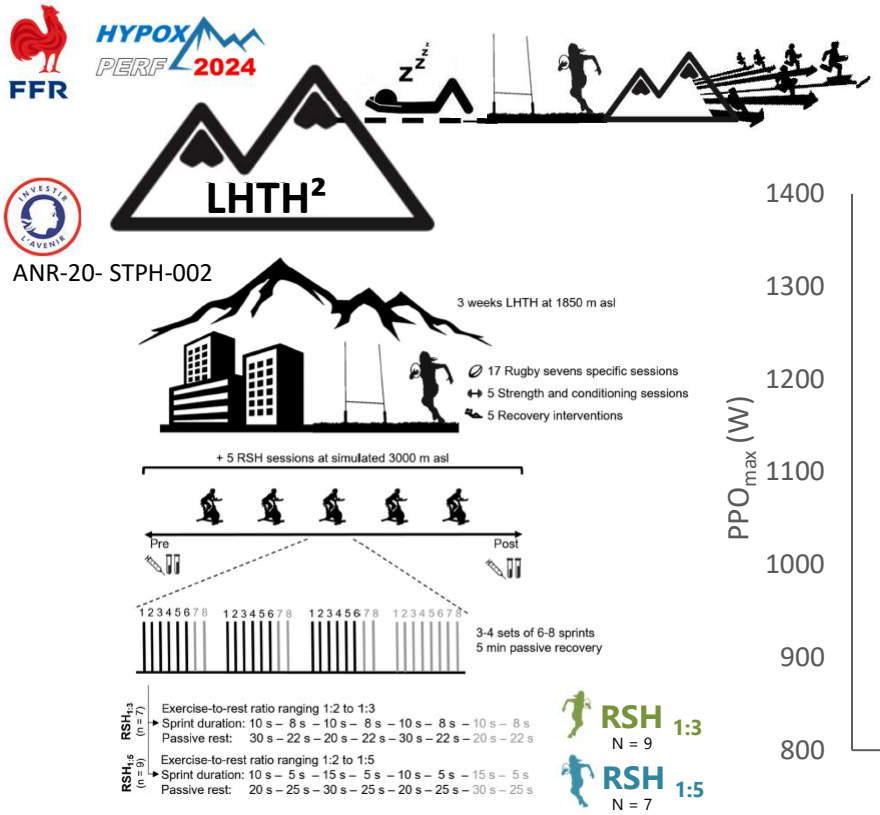
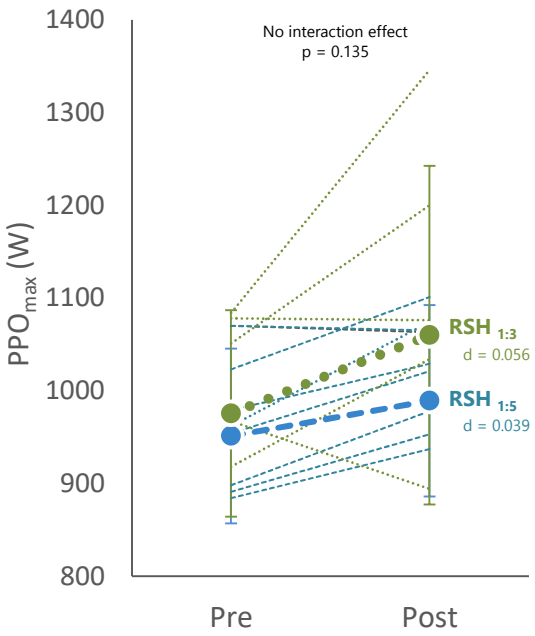
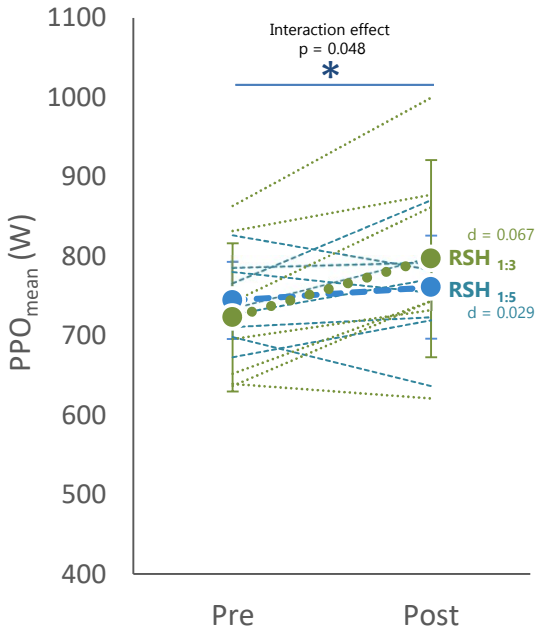


Lee et al., *Front Physiol* 2019.

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

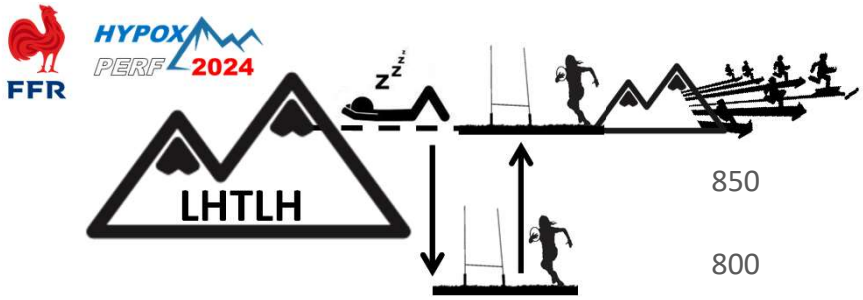


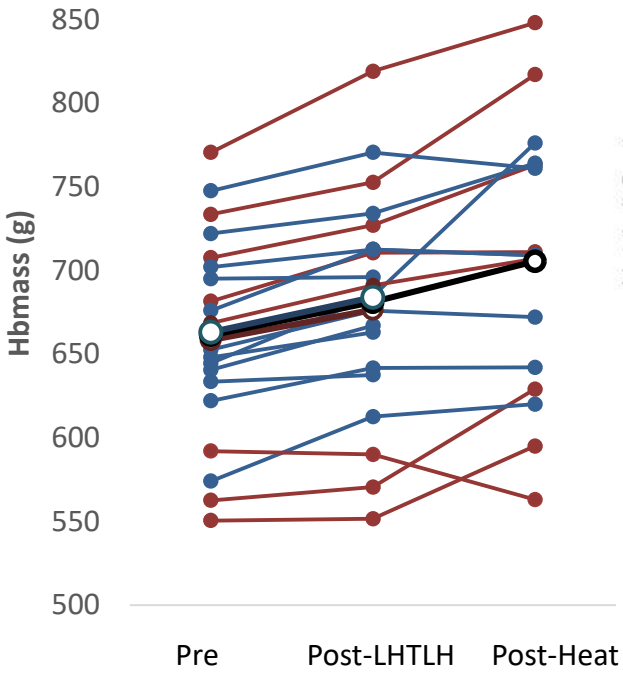


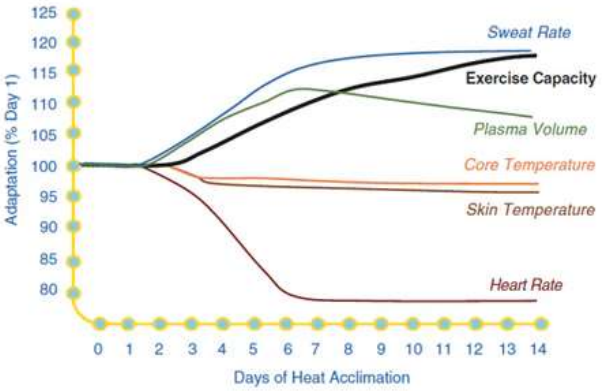


Bouten al. (2023).

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







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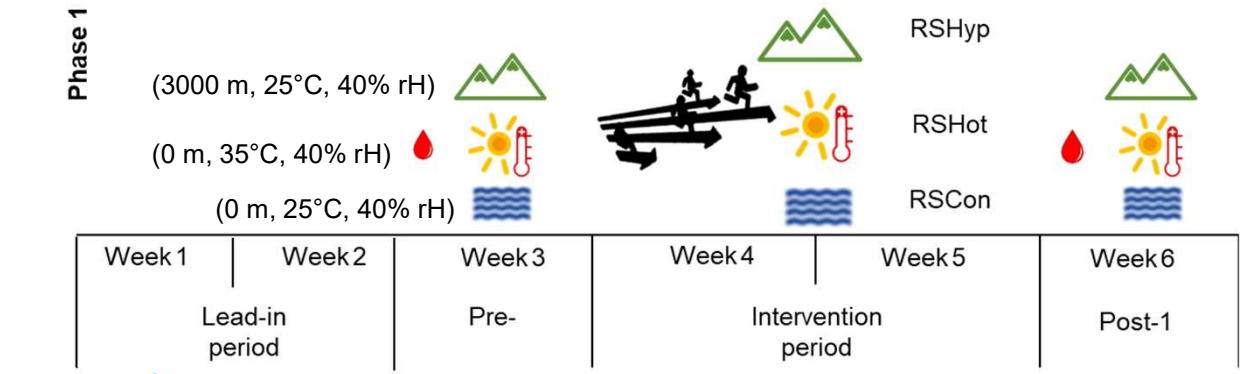

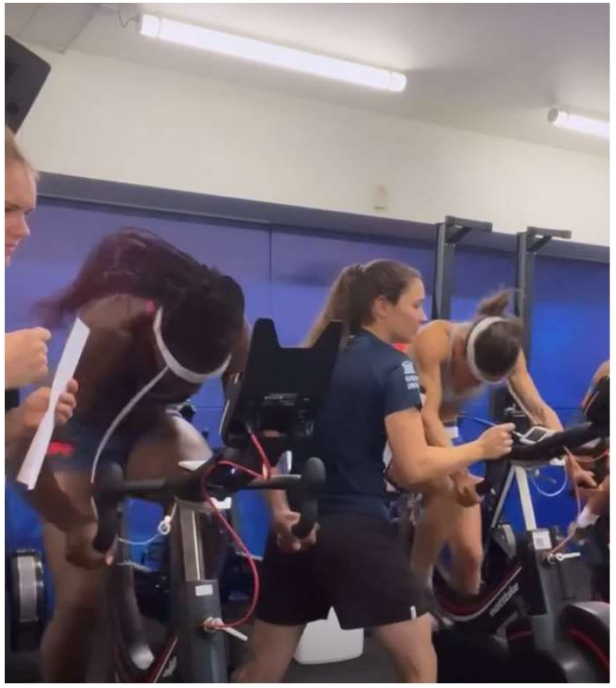

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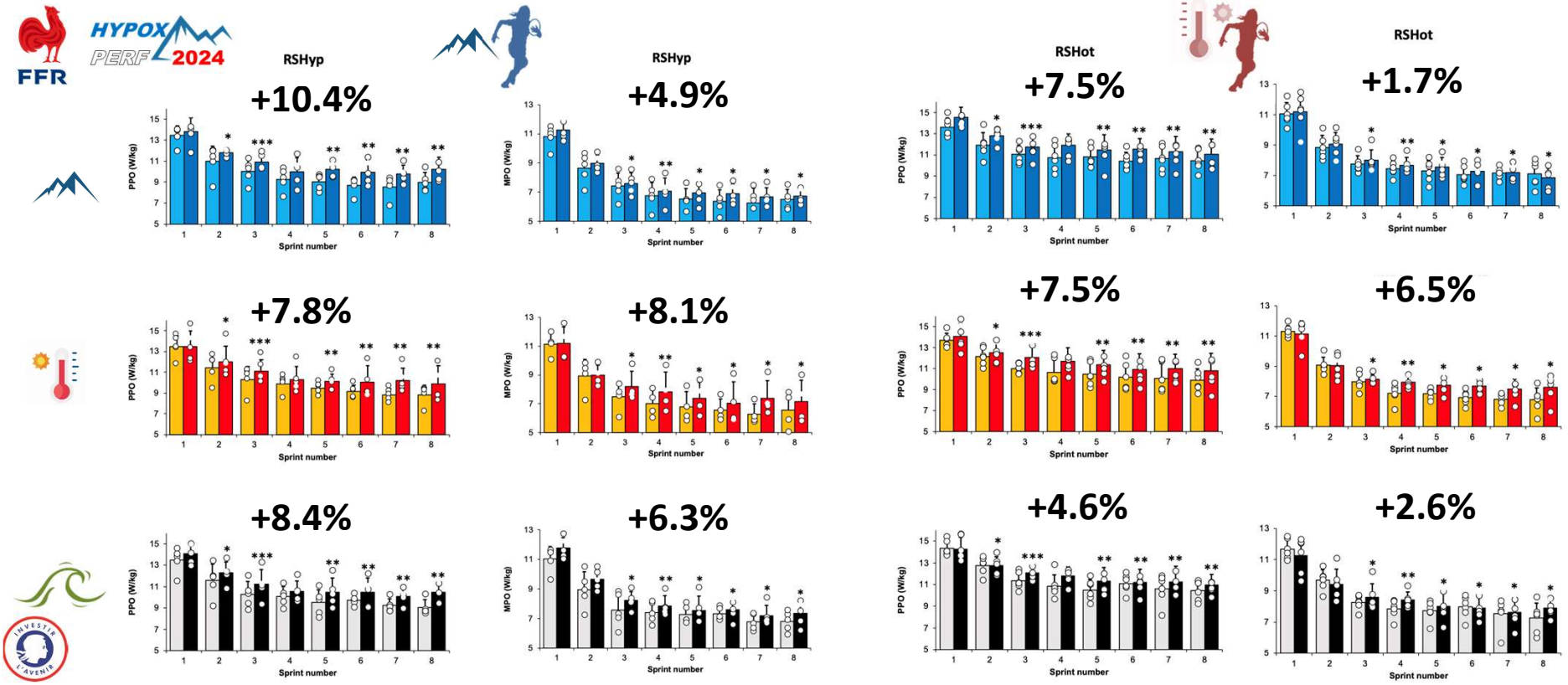

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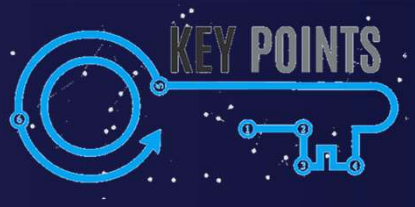


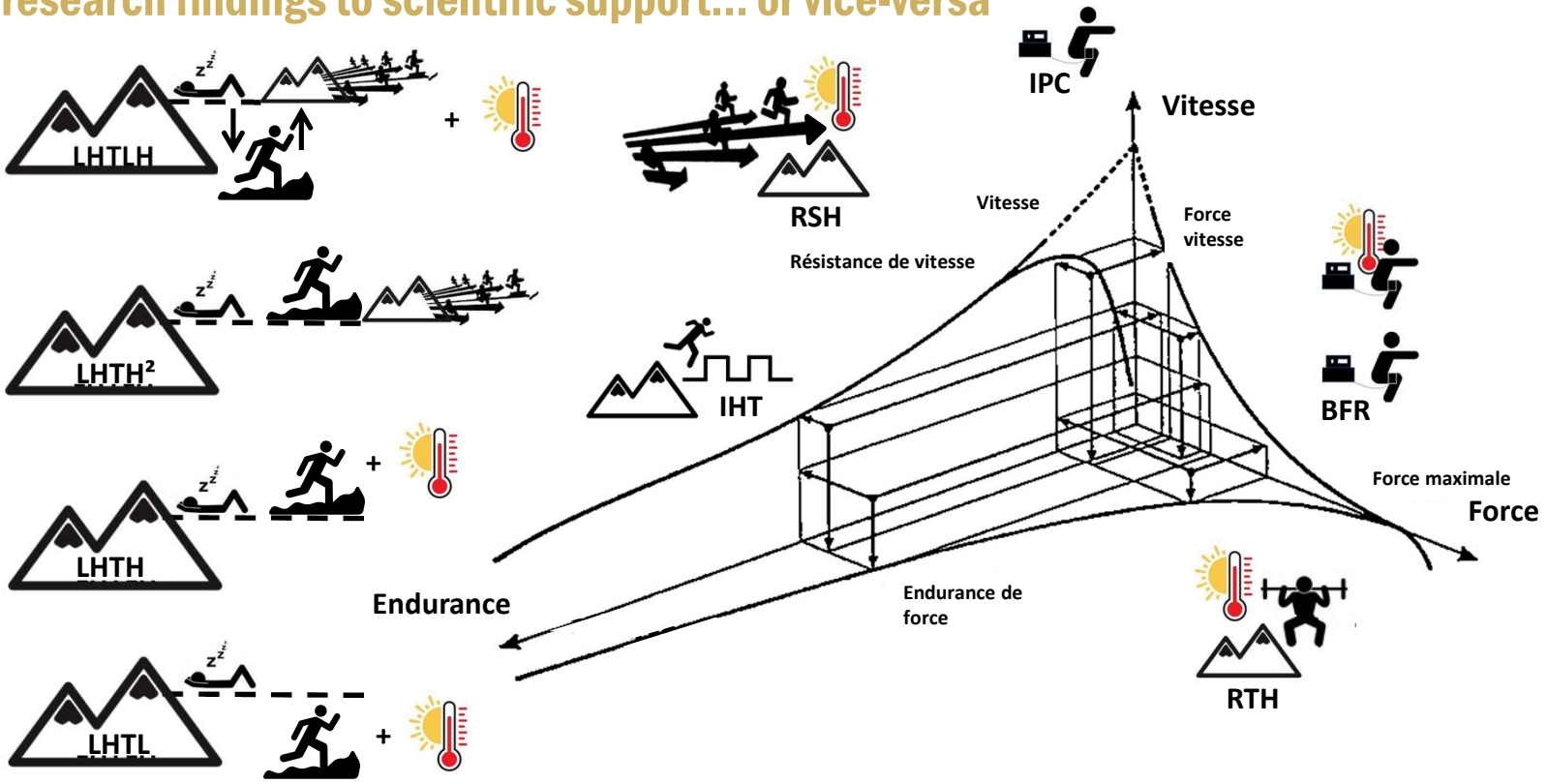
Using “Living Low-Training High” paradigm alone or in combination with other hypoxic methods offers many opportunities to boost performance.

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



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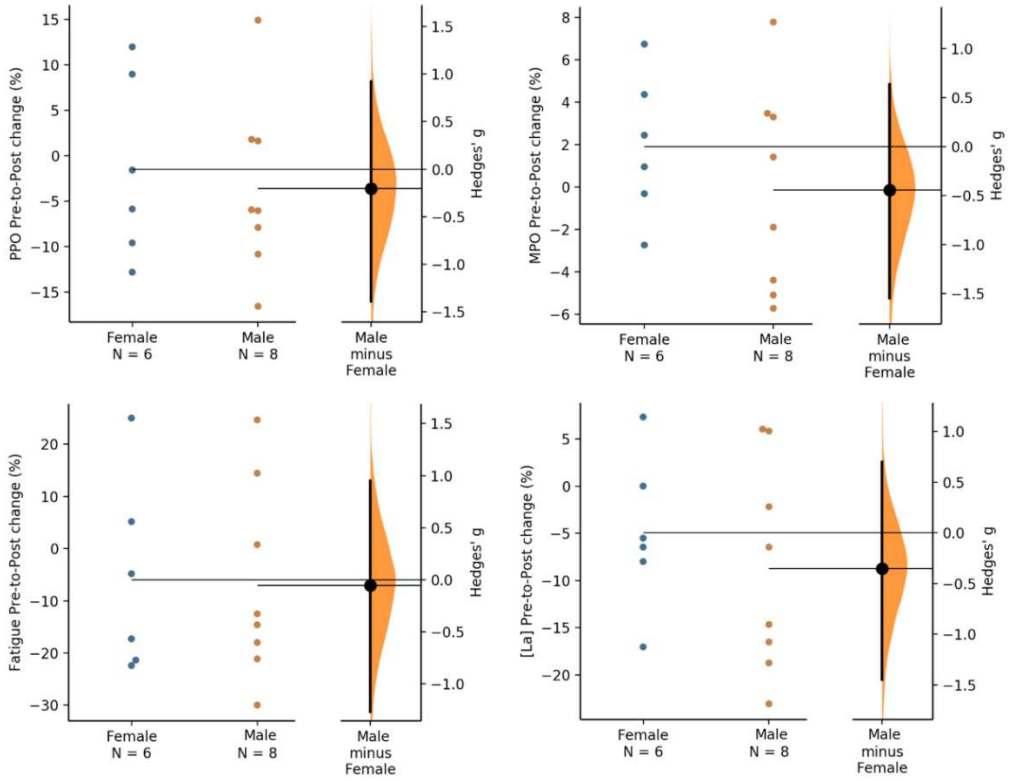

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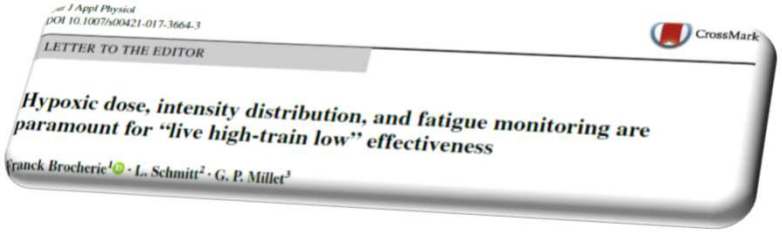
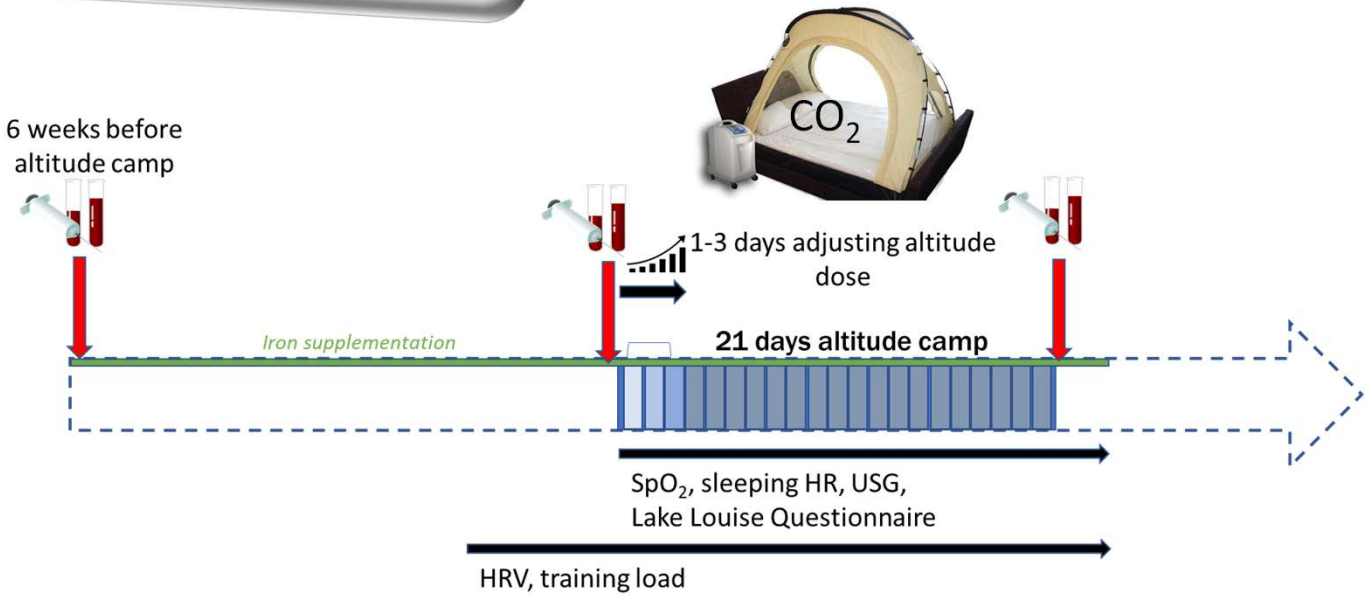


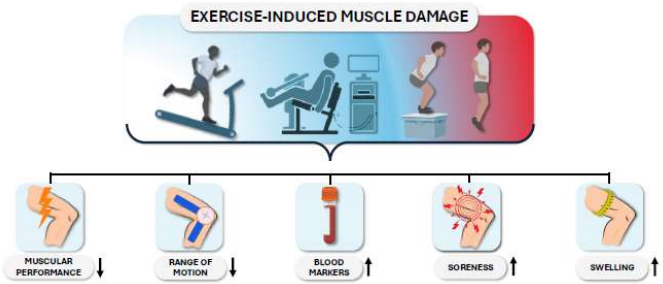


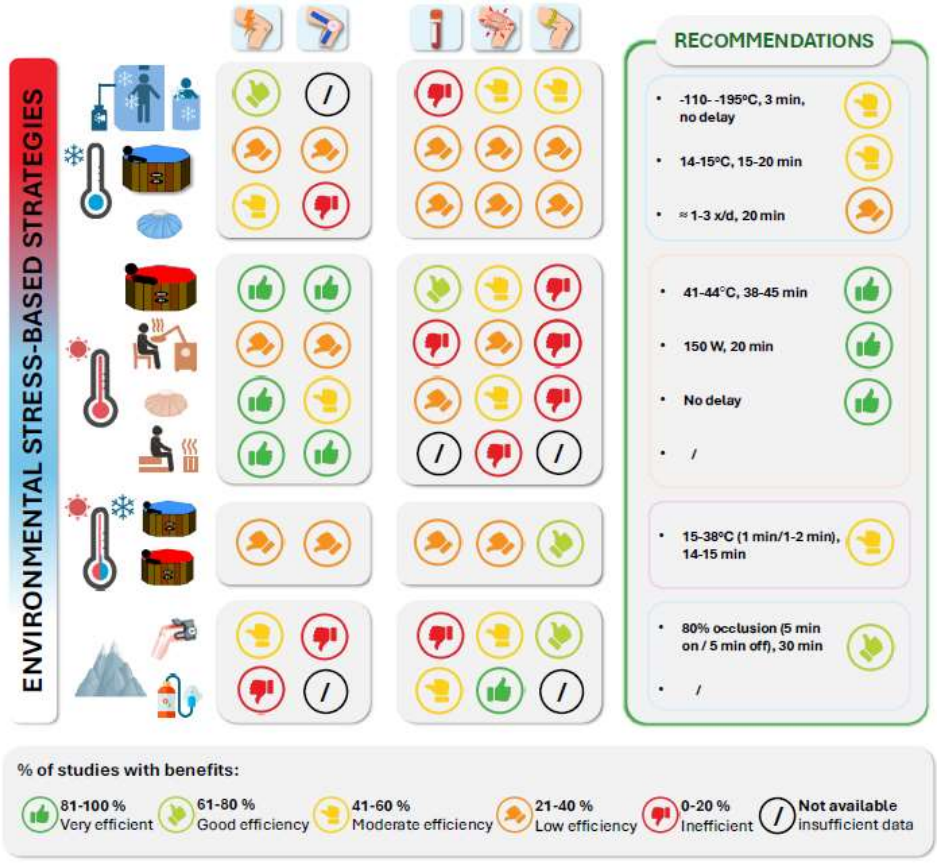
Brocherie et al. (2017); @Nbourrel (2020).

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.

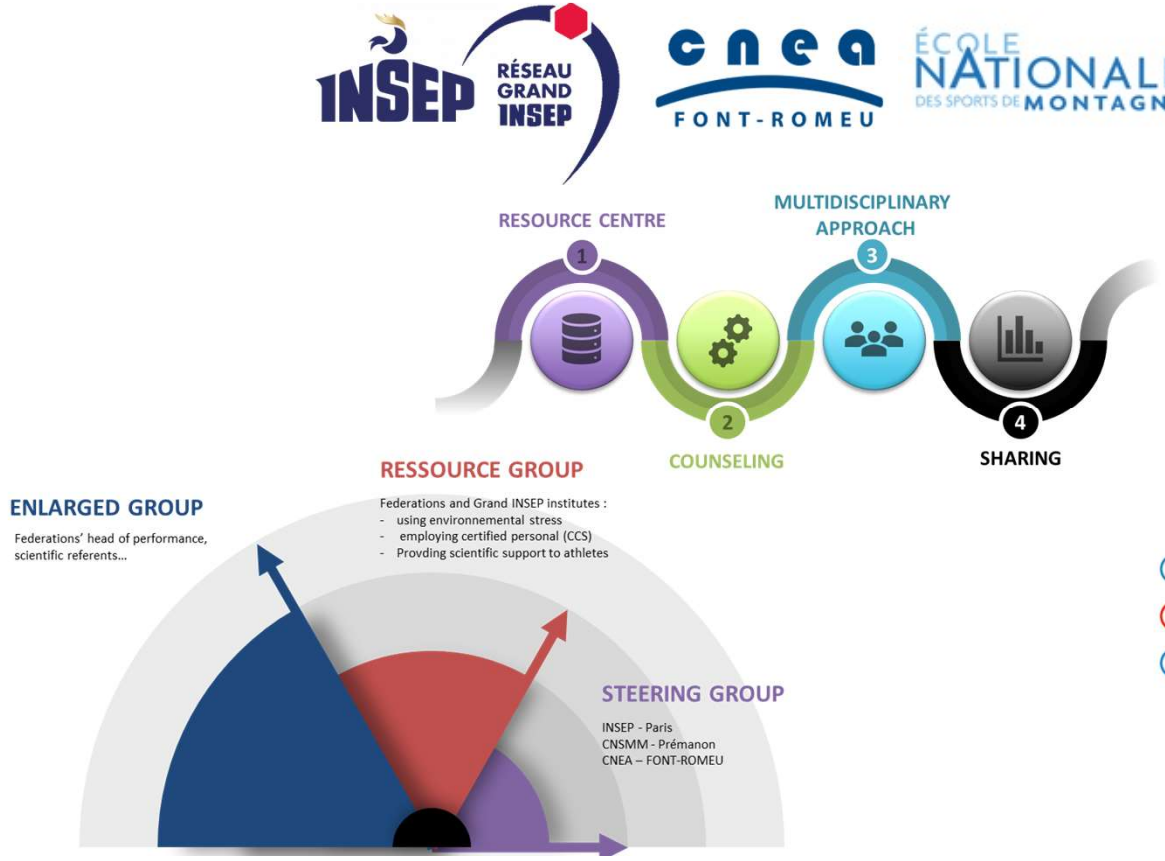
Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?





Rousse et al., *Sports Med* (in press).

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



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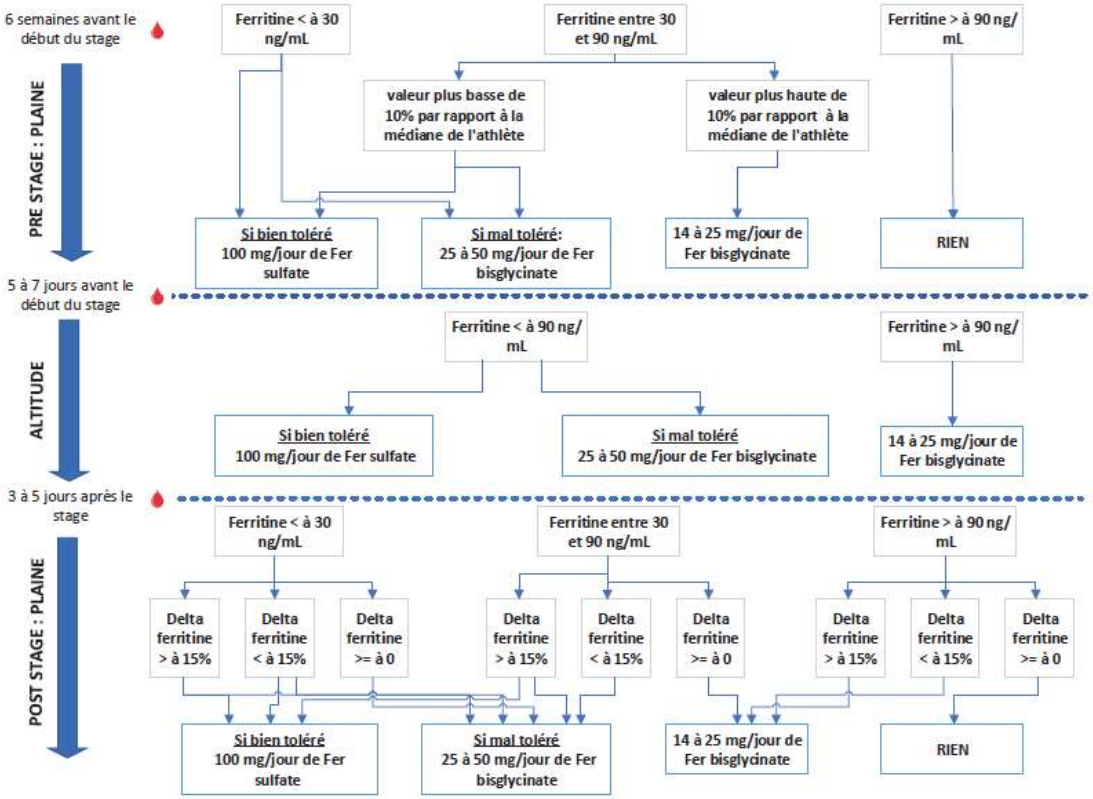

Current Practice of Heat and Altitude Training at INSEP – Risks or Opportunities?

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CCS INSEP
« entraînement sous stress environnemental »

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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,[1,2] R Bahr,[3] P Bartsch,[4] L Bourdon,[5] JAL Calbet,[6] KH Carlsen, O Castagna,[7-9] J Gonzalez-Alonso,[10] C Lundby,[11] RJ Maughan,[12] G Millet,[13] M Mountjoy,[14,15] S Racinais,[17] P Rasmussen,[11,18] DG Singh,[19,21] AW Subudhi,[22] AJ Young,[23] T Soligard,[24] L Engebretsen[24]

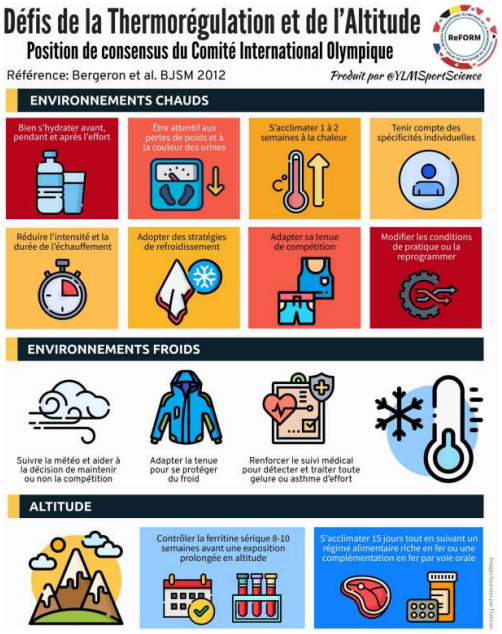


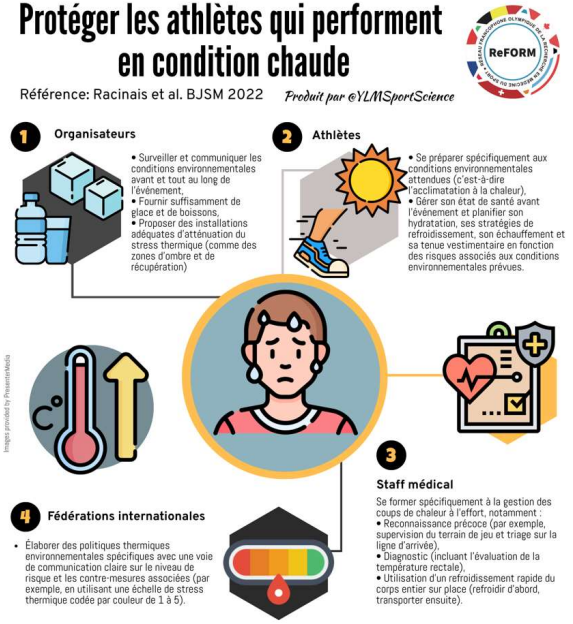
Figure 1 Synthèse graphique des recommandations face aux défis liés à la thermorégulation et à l'altitude.

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



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

Symposiums

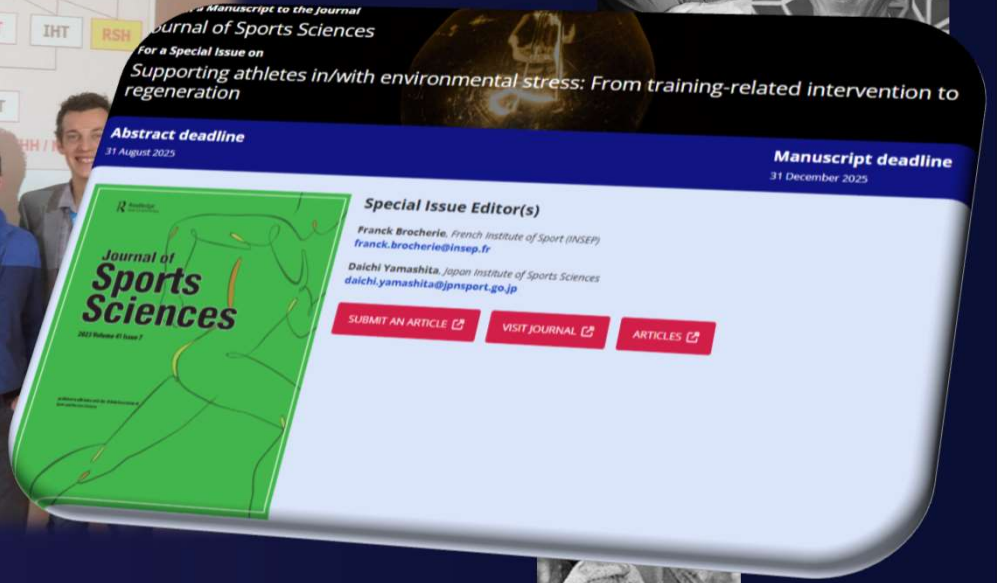
March 26 – 27. 2025
USING ENVIRONMENTAL STRESSORS TO ACHIEVE PEAK PERFORMANCE
From evidence to avenues to explore

HONG KONG SPORTS INSTITUTE
香港體育學院

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…

INSEP



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