

# Whole-body cryotherapy multi exposures speed up performance supercompensation during the taper in functionally overreached endurance athletes

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## Headline

In many endurance sports, the competitive season involves a series of events that can stretch over several weeks or months (e.g. cycling, triathlon, biathlon). The resulting combination of frequent competitions with short tapers largely increases the risk of functional overreaching (F-OR) resulting in a decline in performance. Even though the F-OR state is generally reversed when an appropriate period of recovery is provided (~1-2 weeks), it can compromise the competition outcome in the short term. A recent study suggested that daily whole-body cryotherapy (WBC) exposures may mitigate the signs of F-OR during intensified training blocks (i.e. reduced sleep quantity, increased fatigue, and impaired exercise capacity) (1) but more research remains required to confirm this finding.

**Aim.** This aim of the present study was to investigate whether multiple WBC exposures would represent a convenient tool for recovering from F-OR by speeding up the performance supercompensation during a 1-week taper programmed after a heavy load training period in well-trained endurance athletes.

## Methods

**Athletes.** Sixteen triathletes volunteered to participate in this study ( $32 \pm 4$  y,  $VO_{2max}$   $63 \pm 6$  mL $O_2$ .min<sup>-1</sup>.kg<sup>-1</sup>). All subjects had competed regularly for the past 2 years and were training a minimum of 6 times.wk<sup>-1</sup>. Their typical performance level over the Olympic distance triathlon ranged between 2h00 and 2h20. The experimental design of the study was approved by the Ethical Committee of Saint-Germain-en-Laye (acceptance no. 10054) and was carried out in accordance with the Declaration of Helsinki. Prior to participation in the investigation, subjects underwent a medical assessment. After comprehensive verbal and written explanations of the study, all subjects gave their written informed consent.

**Design.** The protocol is illustrated in Figure 1. During the taper (phase IV), the subjects were assigned to either a 1) WBC F-OR group or a 2) control F-OR group depending on their performance response at Mid and on their availability to perform one WBC session per day during the taper phase. The WBC F-OR group had one exposure (-110°C) per day during one week between 5 pm and 8 pm. WBC sessions were administered in a specially built, temperature-controlled unit (Zimmer MedizinSysteme GmbH, Ulm, Germany). During each WBC session, subjects remained in the therapy room for 3 min. The subject of the control F-OR group performed the same training program than the WBC F-OR group but they were not exposed to WBC. During the 48 h prior to each

maximal oxygen uptake (VO<sub>2</sub>max) test, the participants were required to follow a nutritional plan in order to ensure adequate muscle glycogen stores for the performance tests.

**Methodology.** At the end of phases II (Pre), III (Mid) and IV (Post), the athletes performed a performance test consisting in a maximal incremental running test on a 340-m indoor running track. To ensure that performance variations during the maximal incremental runs were due to the global training regimen and not to the training session(s) performed the day before each test, the subjects were required to respect a 24 h rest period before each maximal incremental run session. The maximal incremental running tests allowed to determine a running performance through the total distance covered during the test by each triathlete. The test began at 11 km.h-1

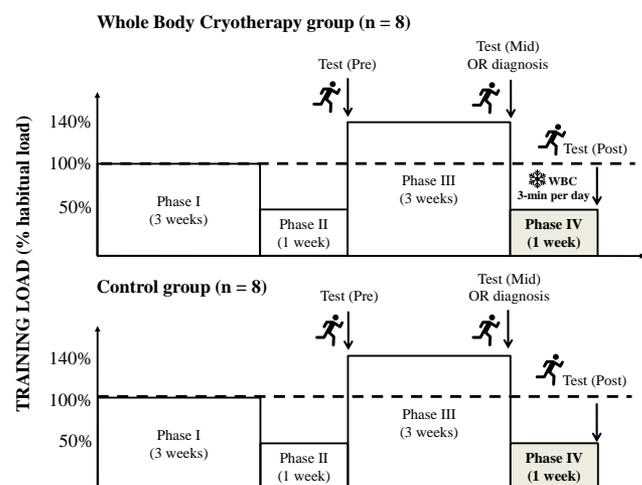
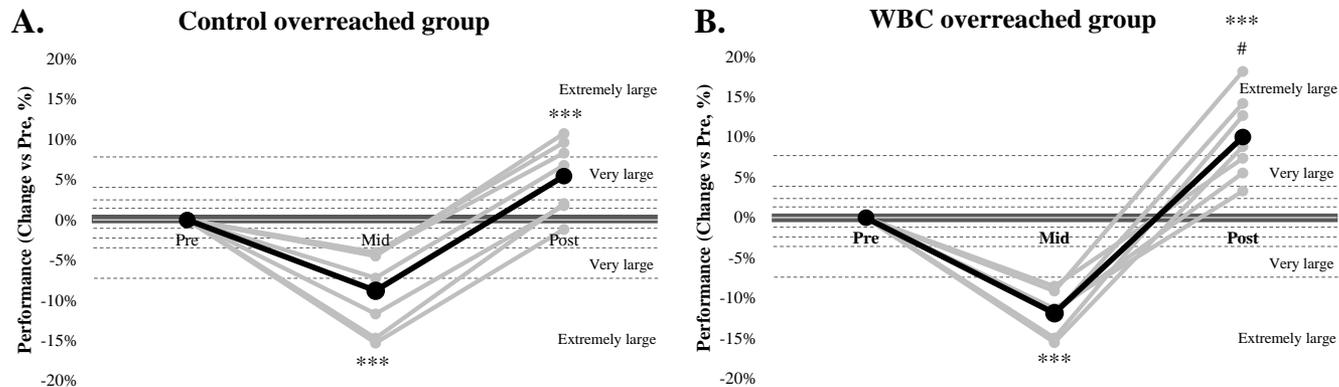


Fig. 1. Schematic representation of the experimental protocol. WBC: whole-body cryotherapy.

Table 1. Mean (90% CI) values for perceived fatigue at rest before (Pre), after the overload training period (Mid) and at the end of the taper (Post) in both groups.

	Intra-day reliability			Inter-day reliability		
	Pre	Mid	Post	Pre	Mid	Post
Perceived Fatigue (/100)	36 ± 21	83 ± 11***	37 ± 29	22 ± 21	85 ± 13***	38 ± 23

F-OR: functional overreaching, WBC: whole-body cryotherapy. Within-group difference vs. Pre: \*likely; \*\*very likely; \*\*\*almost certain. No between-group or between-group difference in change were reported.



**Fig. 2.** Changes in performance from baseline during the maximal incremental running test before (Pre) and after the overload period (Mid) and at the end of the 1-week taper (Post) for the control F-OR group (A) and the WBC F-OR group (B). Within-group difference in change vs. Pre: \*likely, \*\*very likely, \*\*\*almost certain. Between-group difference in change vs. overreached control: #likely, ##very likely, ###almost certain. The shaded area represents the smallest worthwhile change (see Methods). WBC: whole-body cryotherapy; F-OR: functional overreaching.

and the speed was increased by 1 km.h<sup>-1</sup> every 3 minutes until volitional exhaustion. The effect of the training regimen was also recorded through the assessment of the perceived fatigue of subjects before each test at rest.

## Analyses

**Assessment of overreaching.** The triathletes who demonstrated decreased performance (vs. Pre) and high perceived fatigue ("very tired" to "extremely tired" on the fatigue scale) at Mid with subsequent performance supercompensation were diagnosed as F-OR (2).

**Statistical analysis.** The data were analyzed using the magnitude-based inference approach (3). The magnitude of the within-group changes, or between-group differences in the changes, were interpreted by using values of 0.2, 0.6, 1.2, 2.0 and 4.0 of the within-athlete variation (CV) as thresholds for small, moderate, large, very large and extremely large differences in the change between the trials or between the two groups. The mean typical within-athlete variation of each measured parameter was determined in a parallel group of eight control triathletes tested before and after a 3-week period of habitual training (data not presented here). To be diagnosed as overreached, the participants had to reveal a performance decrement higher than the largest variation reported in this control group (i.e. overreaching threshold, 3.3%). Quantitative chances of higher or lower differences were evaluated qualitatively as follows: <math>\leq 1\%</math>, almost certainly not; 1-5%, very unlikely; 5-25%, unlikely; 25-75%, possible; 75-95%, likely; 95-99%, very likely; >99%, almost certain. If the chance of higher or lower differences was <math>\leq 5\%</math>, the true difference was assessed as unclear.

## Results

For two subjects, the performance drop during the overload period did not reach the overreaching threshold despite a high perceived fatigue score. They were diagnosed as 'acutely fatigued' (2) and were excluded from subsequent analyses. Thus, the subsequent results are presented for 14 F-OR subjects distributed in a control F-OR group (n = 7) and a WBC F-OR group (n = 7). The evolution of performance and perceived

fatigue in both group are presented in Figure 2 and Table 1, respectively. An almost certain extremely large decrease in running performance was observed in both groups during the overload training period ( $-8.8\% \pm 5.0\%$  and  $-11.9\% \pm 2.6\%$  in the F-OR control group and in the F-OR WBC group, respectively). The difference in change between both groups during this period was unclear ( $-3.0 \pm 4.2\%$ ). At Post, both group demonstrated an almost certain higher performance than at Pre ( $+5.4 \pm 4.6\%$  and  $+10.0 \pm 5.2\%$  in the F-OR control group and in the F-OR WBC group, respectively), with a likely larger improvement in the F-OR WBC group ( $+4.2 \pm 4.5\%$ , very large).

## Discussion

Results showed that completing multi exposures to WBC induced a larger performance supercompensation after a simulated one-week taper in functionally overreached endurance athletes ( $+4.2 \pm 4.5\%$ ). No between-group difference were reported while considering the changes in perceived fatigue level at rest but both groups returned to baseline values at the end of the taper phase. While previous studies have already demonstrated that peak performance can be optimized by modifying training parameters (i.e., volume, intensity, frequency, taper pattern) (4) or using nutritional strategies (5), this study shows that daily cold exposure during a simulated 7-day taper is likely to help endurance athletes to improve the magnitude of performance supercompensation. More research is needed to understand the mechanisms underlying this result but preliminary findings showed that multiple exposures to WBC after a period of heavy training may mitigate the signs of accumulated fatigue during intensified training blocks (e.g. reduced sleep quantity and increased perceived fatigue) (1). We cannot exclude that a placebo effect may also have played a substantial role in the present study. WBC multi-exposures could potentially have motivated participants to sustain higher exercise intensity during the performance test at the end of the taper phase than their control counterparts. Lastly, further research is required to determine if such finding may also be observed while using cold water immersion, which represents a more convenient and less expensive cold exposure recovery therapy.

### Practical Applications

- Multi exposures to WBC may likely influence positively recovery in F-OR endurance athletes.
- The present results specifically support the use of WBC multi-exposure – and more generally the importance of optimizing recovery – for endurance athletes in the context of short tapers.

### Limitations

- The decrease in performance during the intensified training period was slightly larger in the WBC F-OR group ( $-11.9 \pm 2.6\%$  vs  $-8.8 \pm 5.0\%$  in the WBC F-OR group and in the control F-OR group, respectively). This point may potentially have influenced the performance rebound during the taper phase. Nevertheless, maximizing the fatigue level during the pre-taper phase does not necessarily contribute to an improved subsequent performance response. In fact, we recently reported that maximizing a state of overreaching during a pre-taper phase may even be harmful and that it could reduce the subsequent performance supercompensation (6).

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### Dataset

Dataset available on SportPerfSci.com

**Twitter:** Follow Y. Le Meur @YLMsportScience, J. Louis @Jlnlouis, K. Schaal, @KarineSchaal; F. Bieuzen, @FrancoisBieuzen ; J. Brisswalter, @brisswalter; C. Hausswirth, @HausswirthC.

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