Competition Preparation: From Research to the Start Line

AUT SPORTS PERFORMANCE RESEARCH INSTITUTE NEW ZEALAND

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Start Line

6 hours → Priming

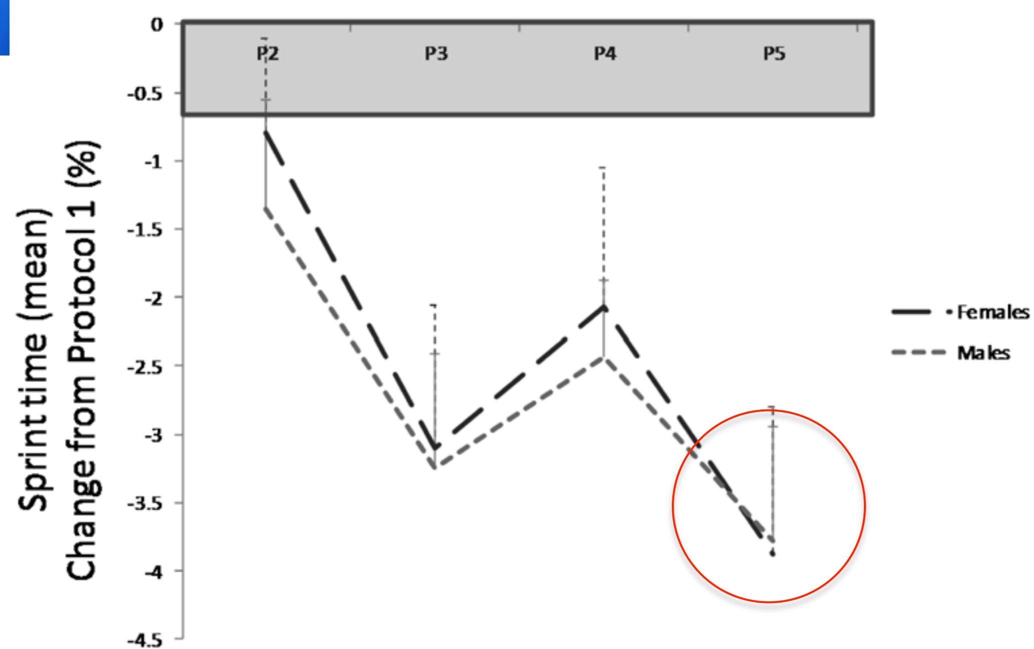
45-20 mins → Active WU

15 mins → Video + feedback

12-8 mins → PAP stimulus

Competition Start

Passive heat maintenance



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Where to start?

Quick Brain Storming Session

- Identify a power or team based sport were you have significant experience
- Develop a pre-competition timeline: Work back from the competition start time?
- Add any Sport Rules and Regulations that may impact the timeline/ pre-competition strategies
- As we progress add in the pre-competition strategies that might fit with your chosen sport
- **What to Observe**
  - Timings (+ heat loss windows)
  - Duration
  - Content
  - Competition start time
  - Competition structure (e.g. multiple events)
- **What to measure**
  - Responses to the WU (e.g. intensity)
  - Performance change (e.g. sensitive and known response)

Bobsleigh Example Warm-up

P1 Control

Competition Start time 2pm

Warm-up procedure

Duration		Distances
	Baseline Measurements	
Duration	**T-60**	**Distances**
2 mins	light jogging	3-400m
3 mins	Increased intensity jogging	3-400m
10 mins	static stretching	-
2 mins	High Knees	40m
3 mins	running high knees	60m
10 mins	Intense stretching (static)	-
10 mins	high intensity runs & jumps/bounds	30m
	Post-Warm-up Measurements	
	T-20	
5 mins	Changing	
	Competition Start (Measurements)	

	P1 (control)
Max HR (bpm)	126
Average HR (bpm)	106
Tc change (°C) (Pre to Post WU)	0.35
Tc change (°C) (Pre to Start line)	0.05
Blood Lactate Change (mmol/L) (Pre to Post WU)	1.1

OBSERVATIONS

- Heat Loss Window
  - Recovery between end of WU and Start of competition
    - Passive
- Structure and Content
  - Intensity & Restructure
- Type of Sport (e.g. Power based)
  - Potential Additions
    - PAP
    - Morning Priming

The end point

Team Build-up in the Rugby World Cup

- 7:00- 7:30 WAKE UP
- 8:30: BREAKFAST
- 10:15: LIGHT MASSAGE
- 11:30: JOG/SWIM/CYCLE
- 12:30: WALK-THROUGH
- 1:30: LUNCH
- 2:15: REST
- 4:00: BOXING/WEIGHTS
- 5:15: TEAM MEETING
- 5:45: LIGHT SNACK
- 6:00: DEPARTURE
- 6:30: ARRIVE AT THE STADIUM
- 7:00: WARM-UP ON THE PITCH
- 7:40: RETURN TO THE DRESSING ROOM
- 7:52: LEAVE THE DRESSING ROOM
- 7:55: ANTHEMS
- 8:00: KICK-OFF

Close the Window (s)

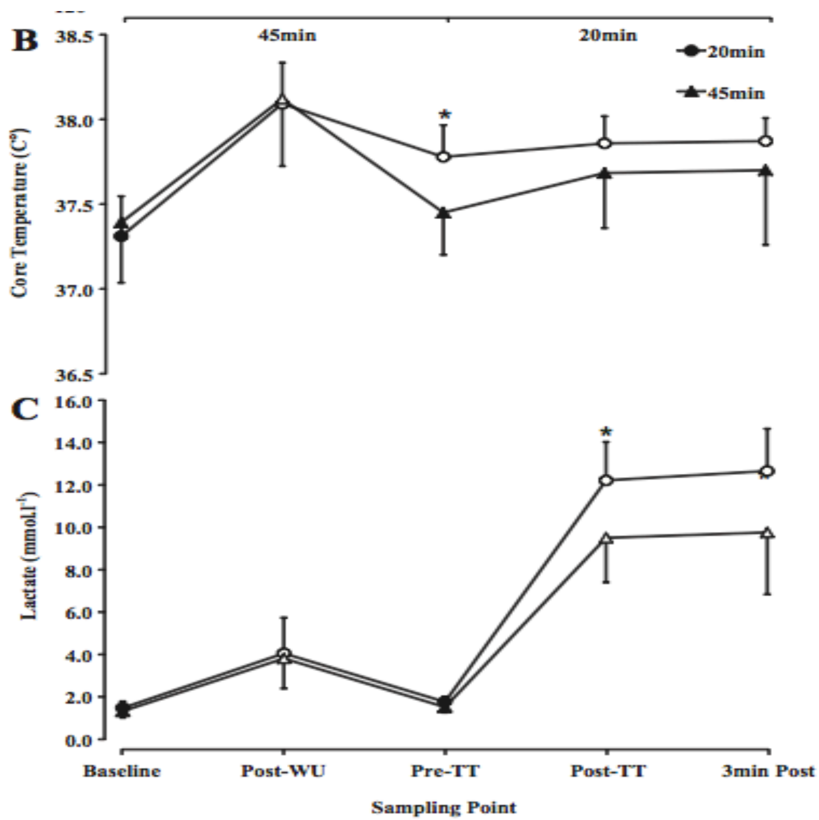

Fig. 1. Individual 200 m swim time changes (A), T_{core} (B) and blood lactate (C) responses to the trials. In Figure B and C, hollow sample points indicate different to baseline ($P < 0.05$). * indicates between trial difference at the respective time point ($P < 0.05$). Data presented as mean ± SD ($n = 8$).

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Original research

Influence of post-warm-up recovery time on swim performance in international swimmers

Daniel J. West[d], Bernie M. Dietzig[b], Richard M. Bracken[a], Daniel J. Cunningham[a], Blair T. Crewther[e], Christian J. Cook[a,c], Liam P. Kilduff[a,*]

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ABSTRACT

Objectives: Swimmers must enter a marshalling call-room 20 min prior to racing, which results in some swimmers completing their warm-up 45 min pre-race. Since a recovery period longer than 15–20 min may prove problematic, this study examined 200 m freestyle performance after a 20 and 45 min post-warm-up recovery period.
Design: Eight international swimmers completed this randomised and counter-balanced study.
Methods: After a standardised warm-up, swimmers rested for either 20 (20 min) or 45 min (45 min) prior to completing a 200 m freestyle time-trial (TT). Core temperature (T_{core}), blood lactate (BL), heart rate and rate of perceived exertion (RPE) were recorded at baseline, post-warm-up, pre-TT, immediately post-TT and at 3 min post-TT.
Results: T_{core} was similar after the warm-up under both conditions, however, at pre-TT T_{core} was greater under 20 min (mean ± SD; 20 min 37.8 ± 0.2 vs. 45 min 37.5 ± 0.2 °C; $P = 0.002$). BL was similar between conditions at all-time points before the TT ($P > 0.05$). Swimmers demonstrated a 1.5 ± 1.1% improvement in performance under 20 min (20 min 125.74 ± 3.64 vs. 45 min 127.60 ± 3.55 s; $P = 0.01$). T_{core} was similar between conditions at immediately post-TT and 3 min post-TT ($P > 0.05$), however, BL was higher at these time points under 20 min ($P < 0.05$). Heart rate and RPE were similar between conditions at all-time points ($P > 0.05$).
Conclusions: 200 m freestyle performance is faster 20 min post-warm-up when compared to 45 min probably due to better T_{core} maintenance. This has implications for swim race preparation as warm-up procedures should be completed close to entering the pre-race call room, in order to maintain elevated core temperature.

1. Introduction

It has been well documented that a warm-up is important for subsequent exercise performance, e.g.1–3. Moreover, data from a recent meta-analysis suggest that 79% of research has demonstrated an improvement in performance following a warm-up procedure.[4] The effectiveness of the warm-up on subsequent performance is influenced by warm-up intensity, duration and the recovery time between the warm-up and event.[5,6] Primarily, the improvement in performance is related to an increase in muscle temperature. A rise in muscle temperature results in multiple physiological and metabolic changes, such as increases in anaerobic metabolism,[7] increased oxygen delivery to the active muscle,[8] and increased nerve conduction rate.[9] Although prior exercise/activation may induce psychological[10] and muscle-neural changes (post-activation potentiation[11,12]) which have been shown to improve performance, it has been suggested that the rise in muscle temperature is the major contributing factor.[11]

Muscle temperature rises rapidly within the first 3–5 min of exercise and reaches a plateau after 10–20 min.[13] On the other hand, it has been demonstrated that muscle temperature is likely to drop significantly following ~15–20 min of the cessation of exercise.[13,14] For example, Mohr et al.,[14] demonstrated that muscle temperature may drop by ~2 °C during the 15 min half time break in soccer. The importance of changes in muscle temperature on subsequent performance has been established by Sargeant,[15] who demonstrated that for every 1 °C rise in muscle temperature there is a concomitant 4% improvement in leg muscle power and,

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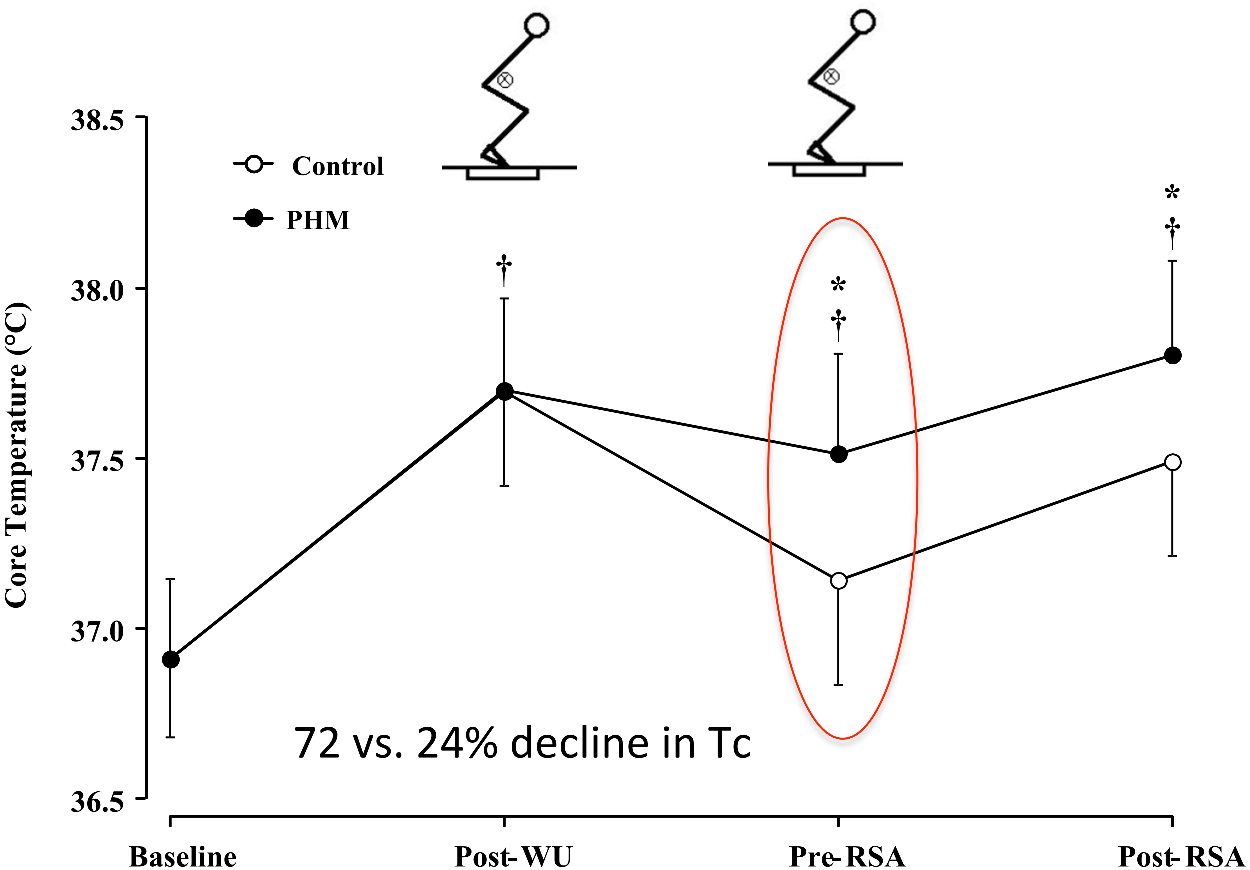
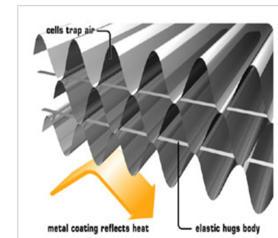
Original research

The influence of passive heat maintenance on lower body power output and repeated sprint performance in professional rugby league players

Liam P. Kilduff[a,*], Daniel J. West[c], Natalie Williams[a], Christian J. Cook[a,b]

Journal of Science and Medicine in Sport, Volume 16, Issue 5, 2013, 482–486





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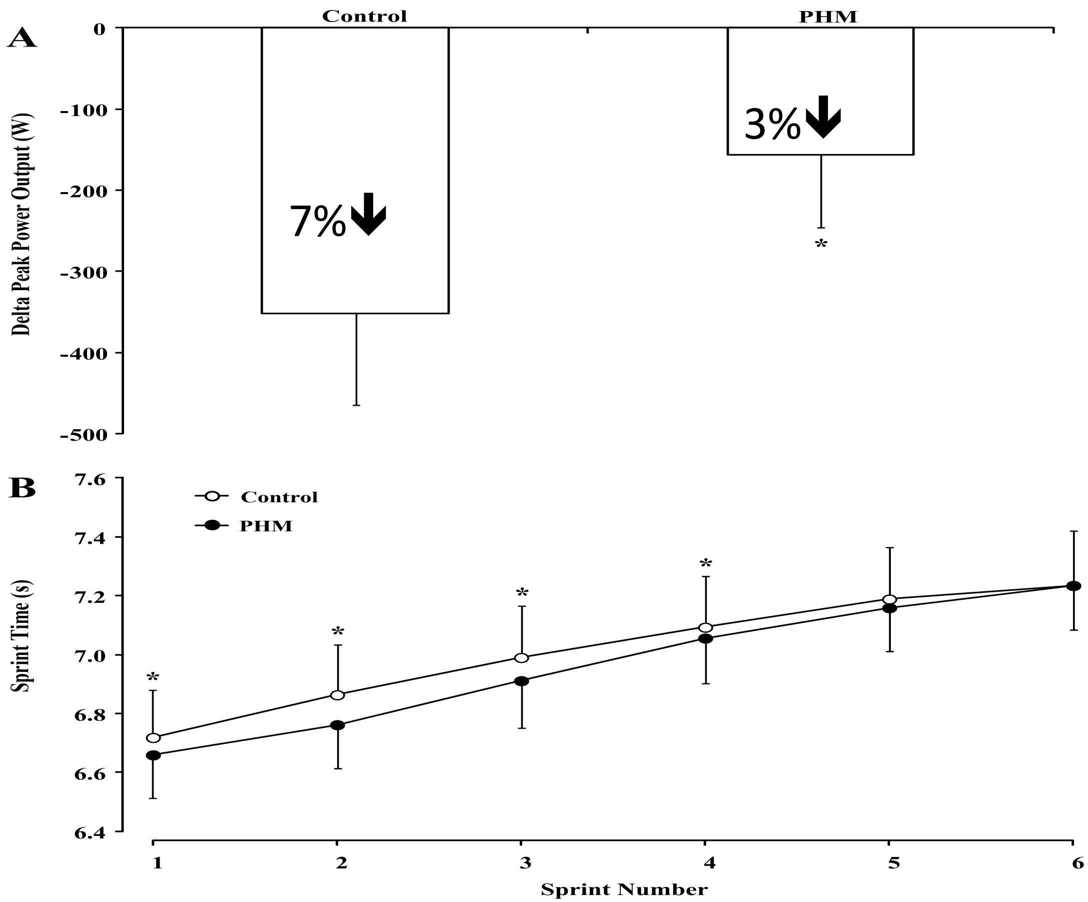

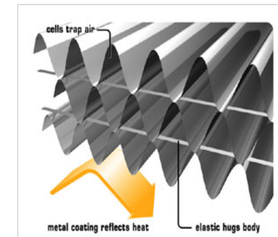

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Postactivation Potentition (PAP)

PAP

Acute enhancement of muscle function following intense muscle activity

Performing a strength based activity eg squat results in both a potentially enhancing PAP effect but also a fatiguing effect on skeletal muscle (Chiu *et al*., 2004).

- Coexistence of PAP & Fatigue
- Baker (2003) reported 4.5% ↑ in upper body power
- Brandenburg (2005) failed to demonstrate any change in upper body power

Typical example of PAP performed as a ‘complex’ set

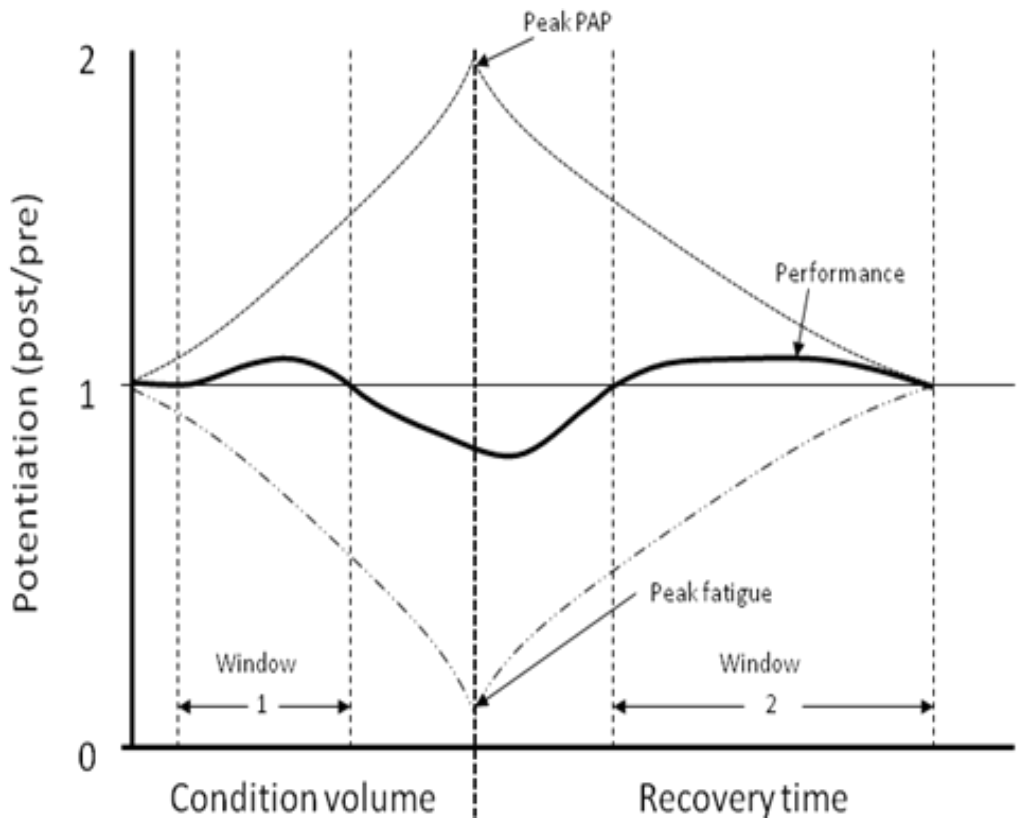
Priming or Conditioning Contraction

Heavy set of back squats: 3 reps @ 90% 1RM

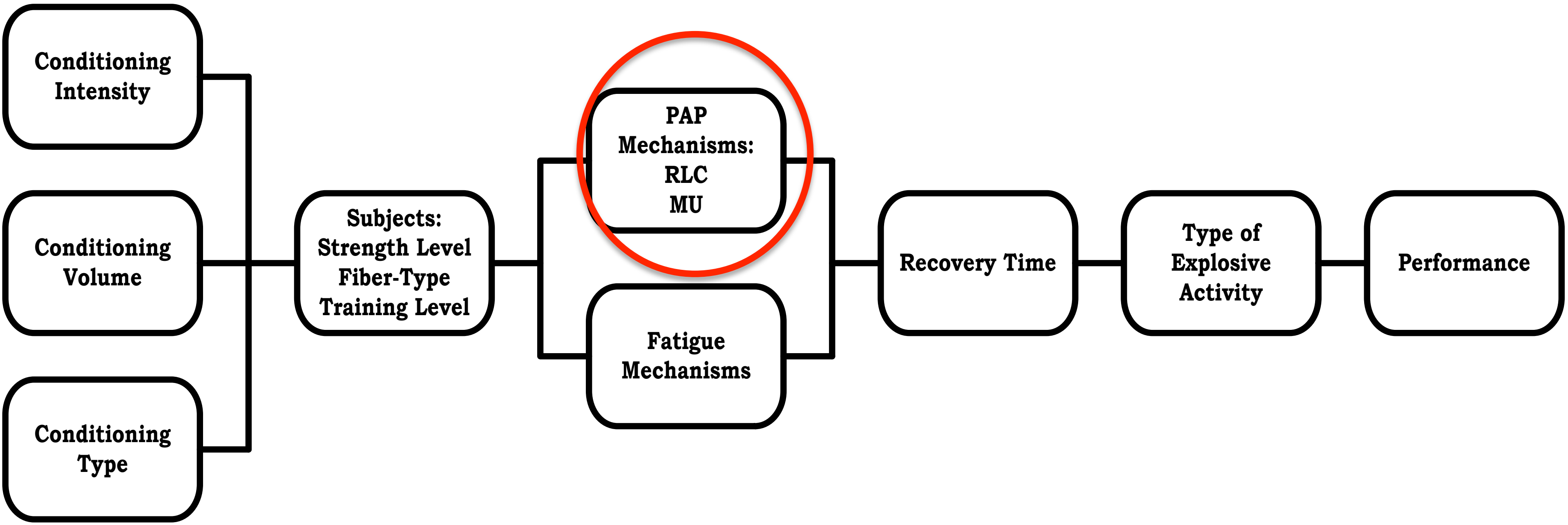
Brief rest period

Functional power performance

Perform explosive box jump

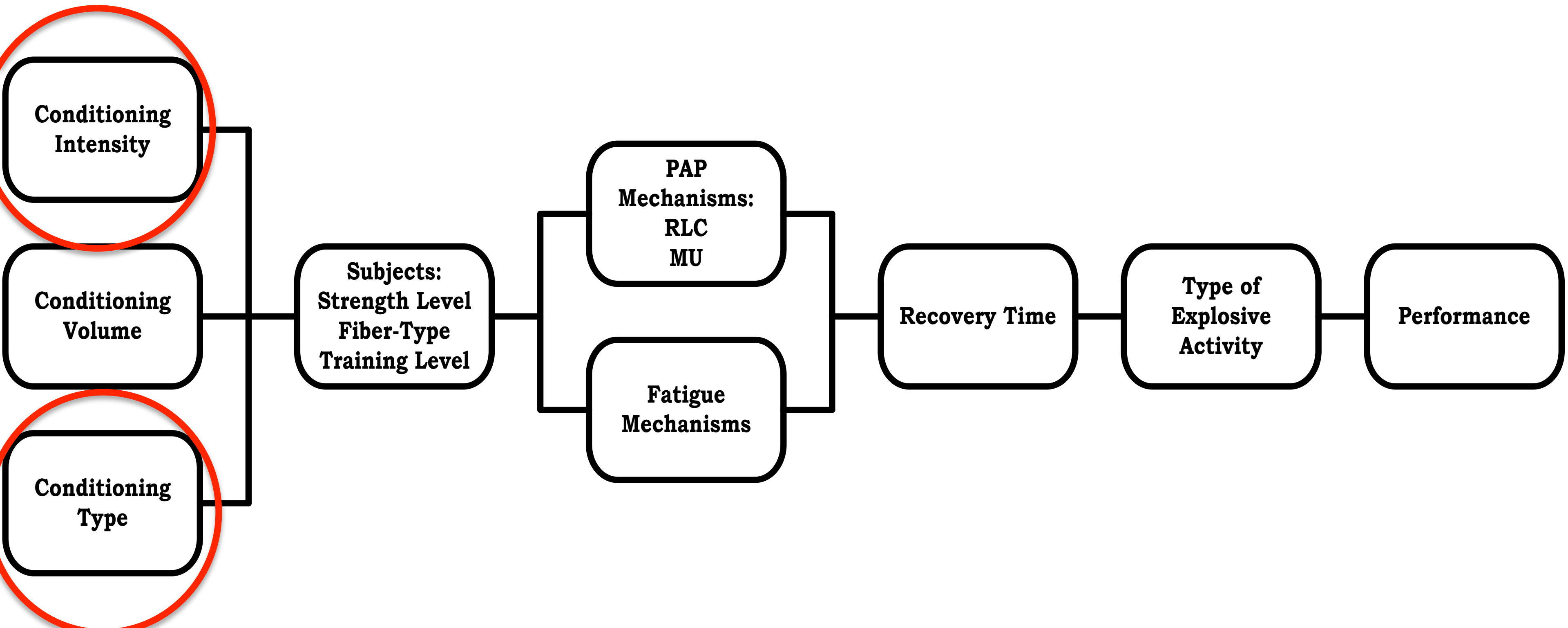

Peak PAP
Performance
Peak fatigue
Window
1
Window
2
2
1
0
Potentiation (post/pre)
Condition volume
Recovery time

Factors Modulating PAP



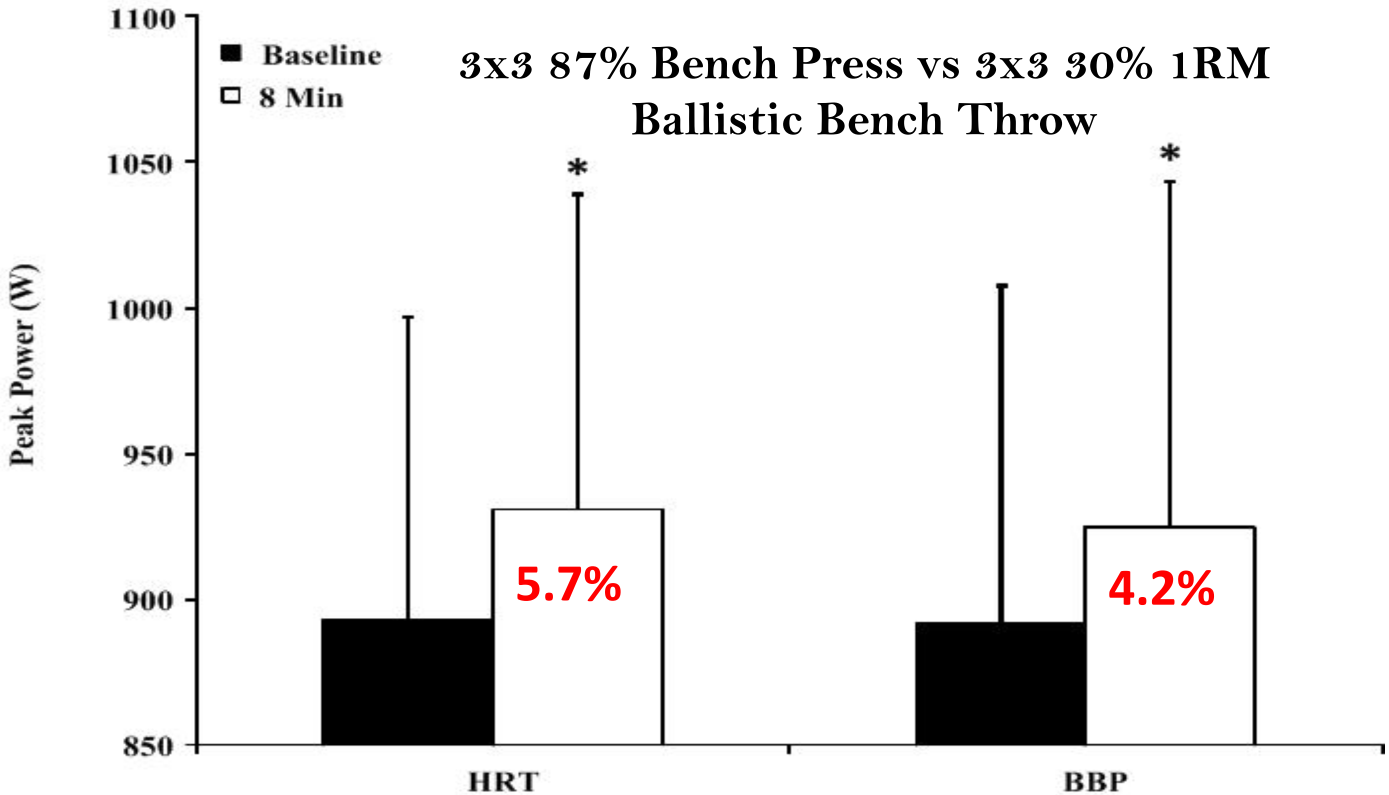
Adapted from: Tillin & Bishop, 2009, Sports Medicine; 39: 147-166.

Factors Modulating PAP



Adapted from: Tillin & Bishop, 2009, Sports Medicine; 39: 147-166.

PAP: Conditioning Type & Intensity



West et al. JSCR, 2013, 27, 2282-2287

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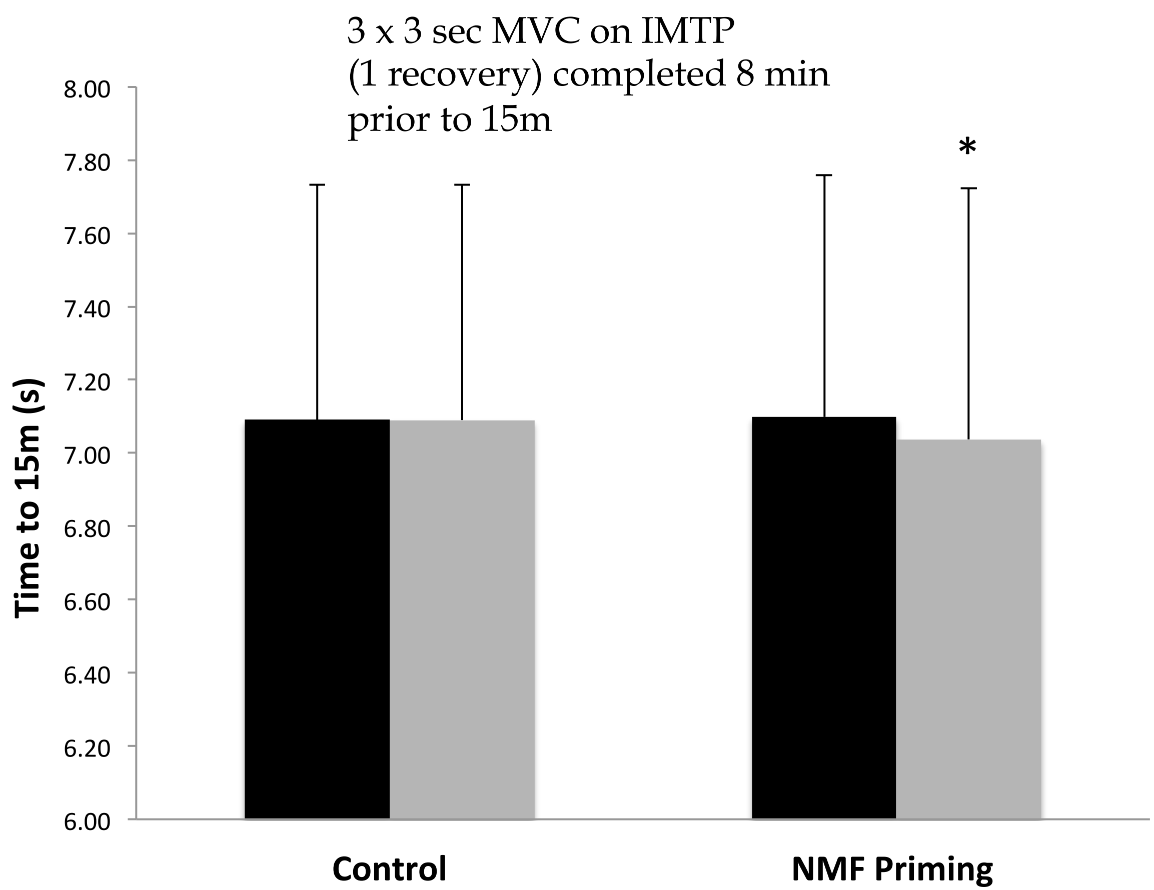
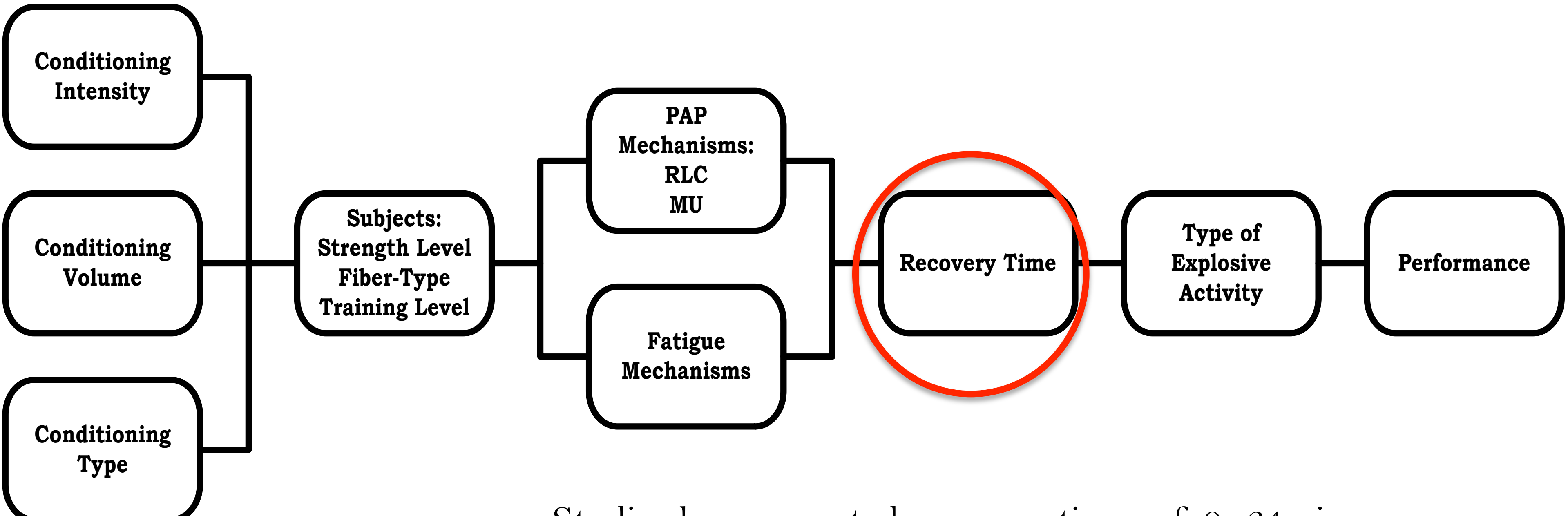


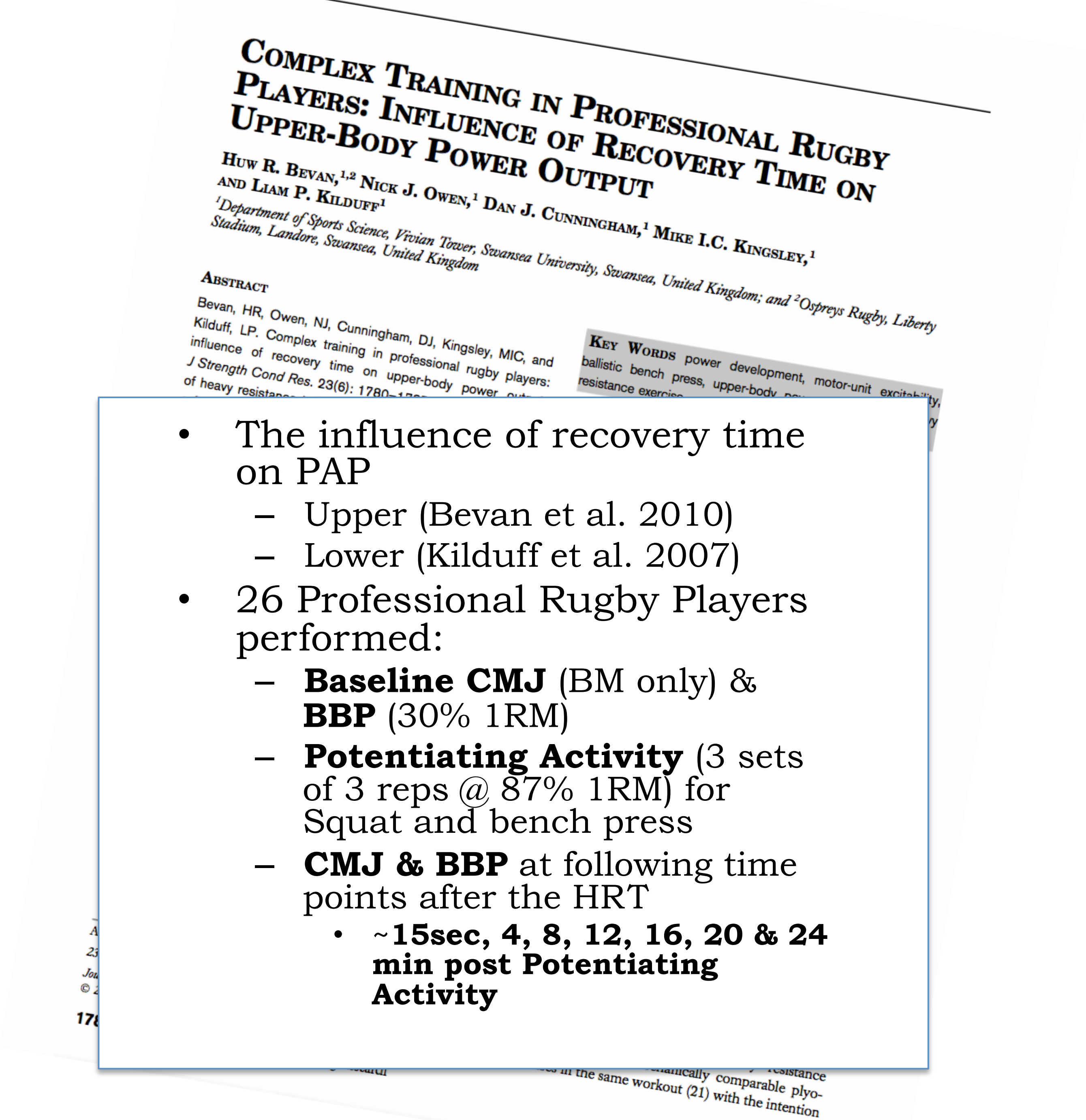
West et al., Unpublished

Factors Modulating PAP



Studies have reported recovery times of 0 -24min

Adapted from: Tillin & Bishop, 2009, Sports Medicine; 39: 147-166.


COMPLEX TRAINING IN PROFESSIONAL RUGBY PLAYERS: INFLUENCE OF RECOVERY TIME ON UPPER-BODY POWER OUTPUT

HUW R. BEVAN,[1,2] NICK J. OWEN,[1] DAN J. CUNNINGHAM,[1] MIKE I.C. KINGSLEY,[1] AND LIAM P. KILDUFF[1]

[1]Department of Sports Science, Vivian Tower, Swansea University, Swansea, United Kingdom; and [2]Ospreys Rugby, Liberty Stadium, Landore, Swansea, United Kingdom

ABSTRACT

Bevan, HR, Owen, NJ, Cunningham, DJ, Kingsley, MIC, and Kilduff, LP. Complex training in professional rugby players: influence of recovery time on upper-body power output. J Strength Cond Res. 23(6): 1780–17...

KEY WORDS power development, motor-unit excitability, ballistic bench press, upper-body ...

- The influence of recovery time on PAP
  - Upper (Bevan et al. 2010)
  - Lower (Kilduff et al. 2007)
- 26 Professional Rugby Players performed:
  - **Baseline CMJ** (BM only) & **BBP** (30% 1RM)
  - **Potentiating Activity** (3 sets of 3 reps @ 87% 1RM) for Squat and bench press
  - **CMJ & BBP** at following time points after the HRT
    - **~15sec, 4, 8, 12, 16, 20 & 24 min post Potentiating Activity**

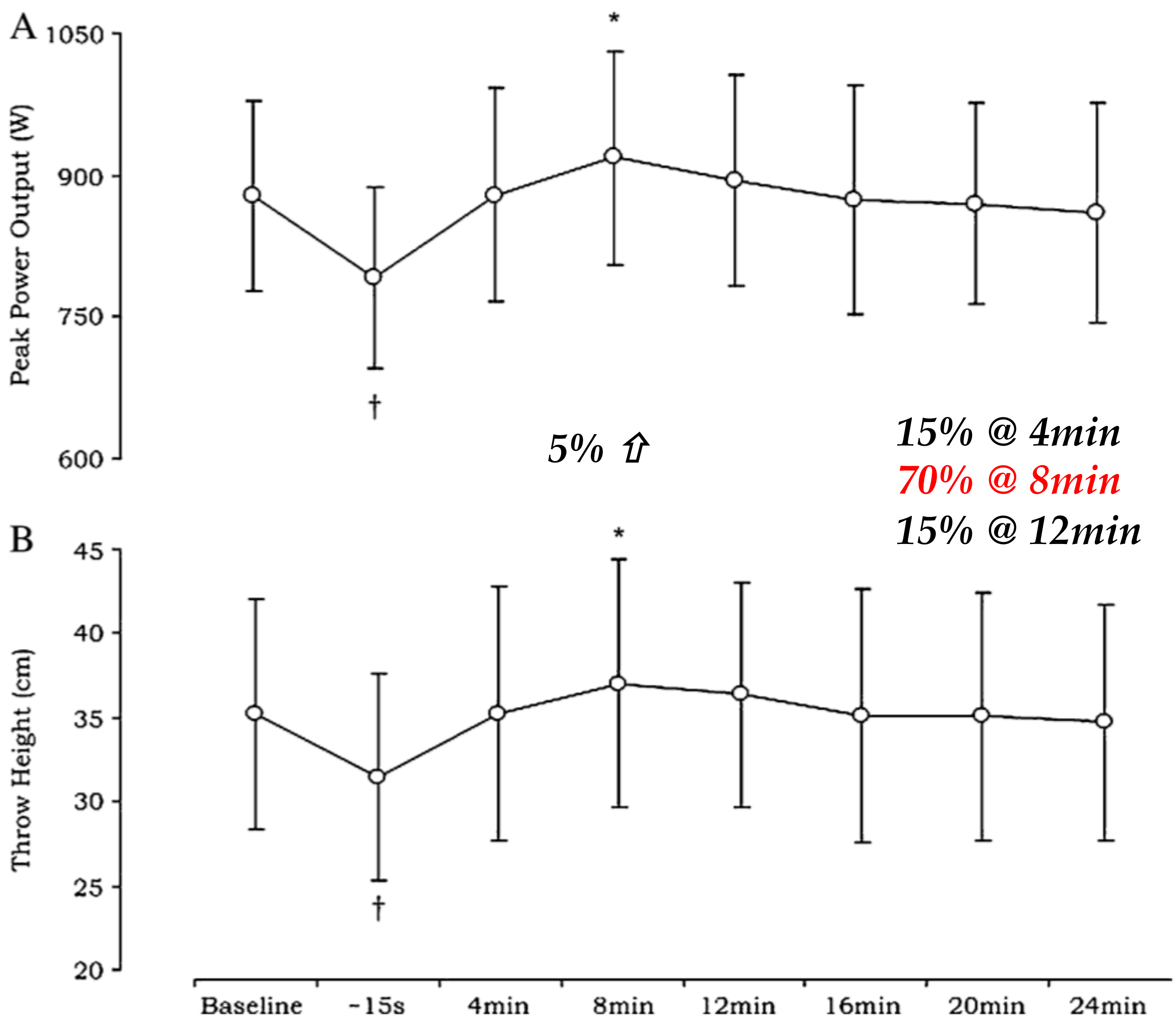
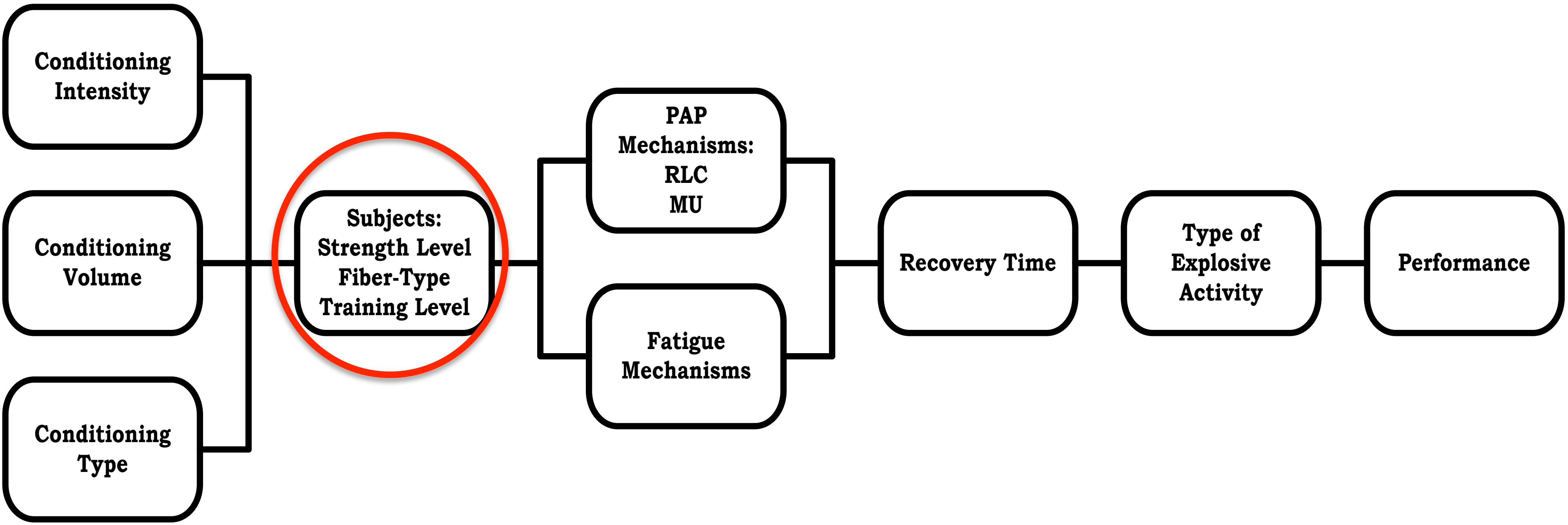


Figure 1. A) Peak power output B) and throw height during ballistic bench throws before and after heavy resistance training. *Indicates significant increase compared with all other time points. †Indicates significant decrease compared with baseline.

Factors Modulating PAP



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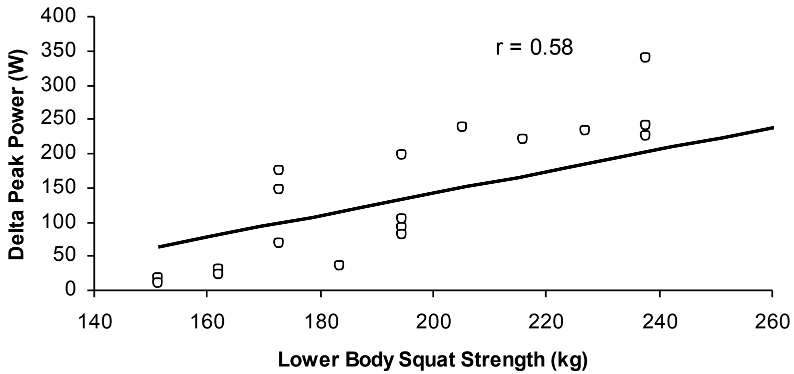
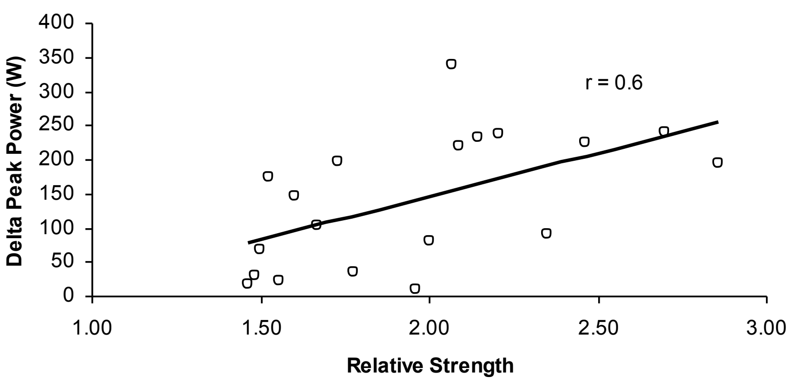
Subject : Strength Levels

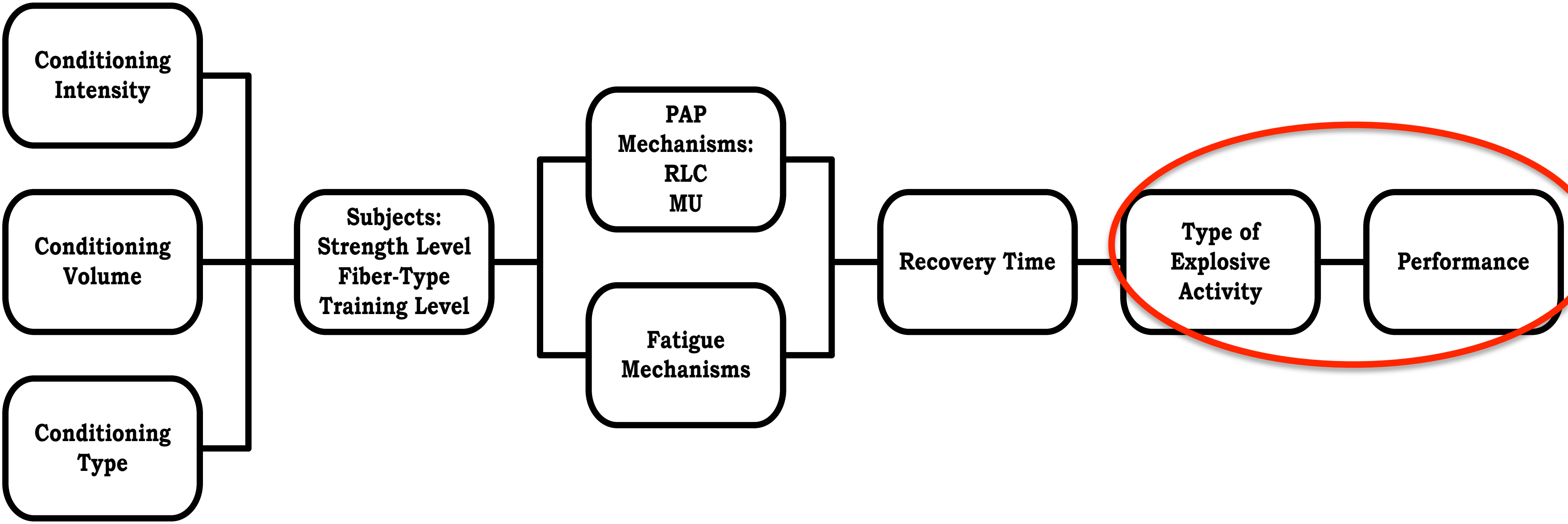




Strength Level
Fibre Type: Greatest Increase RLC phosphorylation post conditioning contraction
Training Level: Fatigue resistance

Mechanism?

Factors Modulating PAP



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Postactivation Potentiation of Sprint Acceleration Performance Using Plyometric Exercise

Anthony P. Turner, Sam Bellhouse, Liam P. Kilduff, and Mark Russell

The Acute Potentiating Effects of Back Squats on Athlete Performance

Blair T. Crewther, Liam P. Kilduff, Christian J. Cook, Matt K. Middleton, Paul J. Bunce, and Guang-Zhong Yang

...ce of Postactivation Potentiation on ...ng Performance in Professional Players

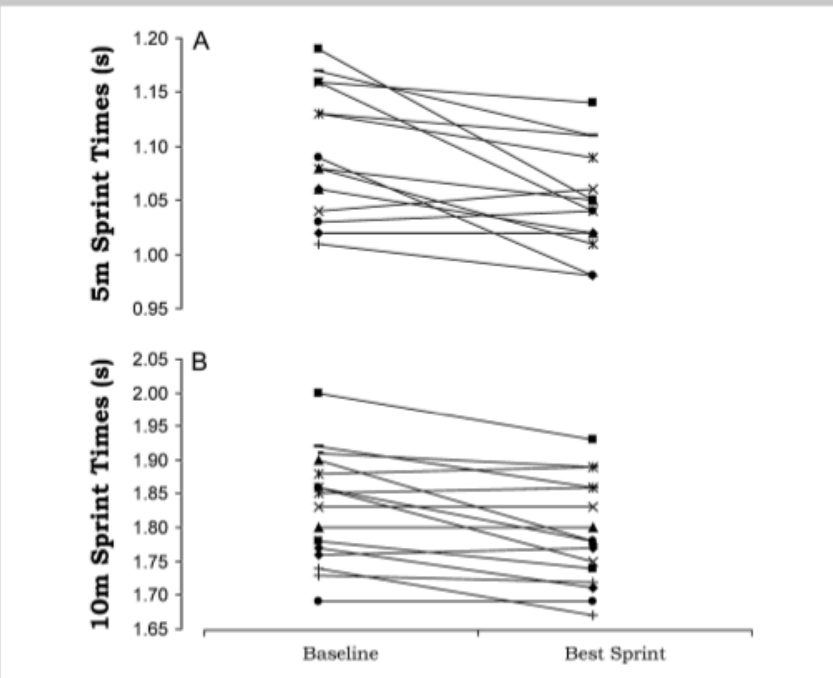

Figure 2. Five meters (A) and 10 m (B) sprint times at baseline and best sprint postpotentiation ($n = 16$).

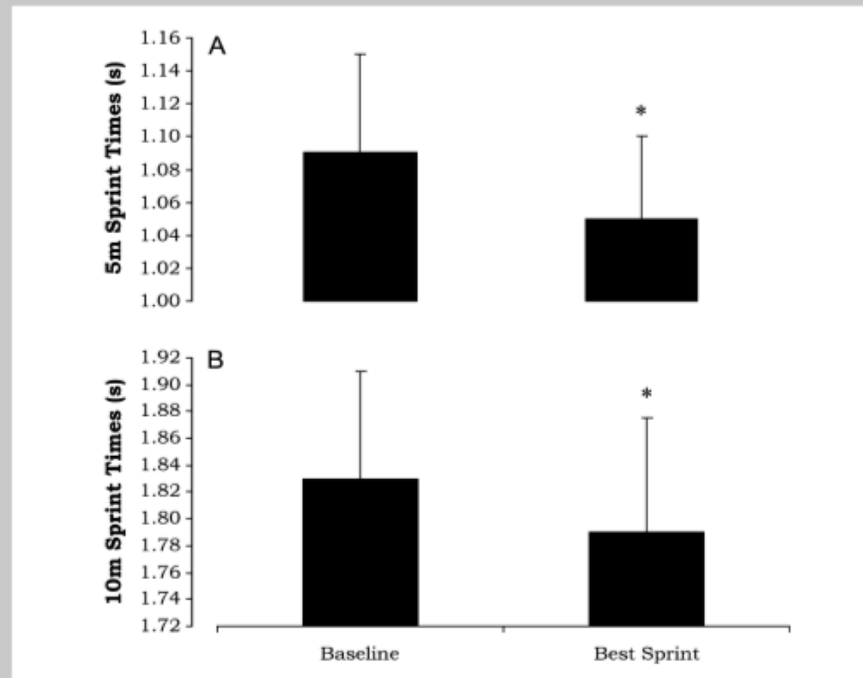

Figure 1. Five meters (A) and 10 m (B) sprint times at baseline and best sprint postpotentiation ($n = 16$).

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Key Messages

- PAP can be harnessed to improve performance in a range of athletic events
- Individual determination of optimal recovery for enhanced effects (8 min)
- Initial Strength levels influences ability to utilize PAP
- PAP can be induced with heavy dynamic, Isometric Ballistic Activities

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Morning Priming

http://dx.doi.org/10.1123/ijspp.2015-0508

A Comparison of Different Modes of Morning Priming Exercise on Afternoon Performance

Mark Russell, Aden King, Richard. M. Bracken, Christian. J. Cook, Thibault Giroud, Liam. P. Kilduff

Purpose: To assess the effects of different modes of morning (AM) exercise on afternoon (PM) performance and salivary hormone responses in professional rugby union players. ***Methods:*** On 4 occasions (randomized, crossover design), 15 professional rugby players provided AM (~8 AM) and PM (~2 PM) saliva samples before PM assessments of countermovement-jump height, reaction time, and repeated-sprint ability. Control (passive rest), weights (bench press: 5 × 10 repetitions, 75% 1-repetition maximum, 90-s intraset recovery), cycling (6 × 6-s maximal sprint cycling, 7.5% body mass load, 54-s intraset recovery), and running (6 × 40-m maximal sprints, 20-s intraset recovery) interventions preceded (~5 h) PM testing. ***Results:*** PM sprint performance improved (P < .05) after weights (>0.15 ± 0.19 s, >2.04% ± 2.46%) and running (>0.15 ± 0.17 s, >2.12% ± 2.22%) but not cycling (P > .05). PM jump height increased after cycling (0.012 ± 0.009 m, 2.31% ± 1.76%, P < .001) and running (0.020 ± 0.009 m, 3.90% ± 1.79%, P < .001) but not weights (P = .936). Reaction time remained unchanged between trials (P = .379). Relative to control (131 ± 21 pg/mL), PM testosterone was greater in weights (21 ± 23 pg/mL, 17% ± 18%, P = .002) and running (28 ± 26 pg/mL, 22% ± 20%, P = .001) but not cycling (P = .072). Salivary cortisol was unaffected by AM exercise (P = .540). ***Conclusions:*** All modes of AM exercise improved at least 1 marker of PM performance, but running appeared the most beneficial to professional rugby union players. A rationale therefore exists for preceding PM competition with AM exercise.

Keywords: ergogenic, potentiation, hormone, rugby

Match play in elite team sports commences at varying times throughout the waking day, with kickoffs typically ranging from 11 AM to 8 PM. Although optimized sporting performance is subject to a range of intrinsic and extrinsic factors, the influence of circadian rhythm is acknowledged (for review see Atkinson and Reilly, Chtourou and Souissi, and Teo et al[1–3]), with changes in anaerobic physical performance (eg, force and power expression) occurring at different times of the day.[2,4] While kickoff times are likely determined by extraneous factors (including the demands of television[5]), opportunities exist on the day of competition to influence subsequent performance, as athletes may be susceptible to changes in their physical performance as a function of time.[6]

Testosterone and cortisol concentrations exhibit circadian rhythmicity and are known to correlate with indices of athletic performance,[7–9] particularly in elite athletic populations.[7,10,11] For example, salivary testosterone appears highly correlated with both squat strength (r = .92) and sprint times (r = –.87) in elite strength-trained athletes.[11] Moreover, improved 3-repetition-maximum strength was correlated to the acute increase in testosterone concentrations elicited via visual stimulation,[7] and pregame testosterone concentrations have been implicated in match outcomes in professional rugby players.[12] However, testosterone and cortisol typically display an early-morning (AM) peak before slowly declining across the waking day.[4,13] Considering the potential role of testosterone in mediating athletic performance, offsetting the circadian decline could be of benefit to sporting activities performed at times when testosterone concentrations have experienced a circadian decline, such as in the afternoon (PM). Acutely, a strength/hypertrophy-training stimulus can raise postexercise testosterone concentrations[14] and thus may be beneficial when preceding subsequent training or competition. However, the effects of other modes of activity (eg, running and cycling protocols) on postexercise testosterone responses remain unclear.

Ekstrand et al[15] have demonstrated that an AM resistance session that included back squats performed to failure and power-clean exercises improved throwing distance in well-trained shot-putters when performed 6 hours before subsequent exercise. Similarly, improved PM performance has been observed in rugby union players who preceded PM physical-performance assessments (ie, countermovement jumps, 40-m sprints, bench press, and back squats) with sprints (5 × 40 m) and whole-body resistance (bench-press and back-squat routines up to 100% of 3-repetition-maximum values) exercises 6 hours earlier.[6] Notably, the AM sprint and resistance exercise attenuated a circadian decline in testosterone concentrations compared with a rested control trial.[6] Such findings highlight a potential role for specific modes of AM exercise to improve PM performance and that such findings may be modulated by changes in hormone status.

Unfortunately, acknowledging the practical considerations associated with the precompetition practices of professional athletes, the methods of AM exercise examined previously[6,15] may preclude their use on the day of competition and/or have limited transfer to match-specific performance indicators. Whole-body resistance exercises performed to maximal intensity and/or failure, while beneficial to linear sprinting and force expression, are unlikely to be routinely adopted in the precompetition setting. Therefore, methods of "priming" PM performances that may be better accepted by players and coaches on the day of competition while demonstrating transfer to

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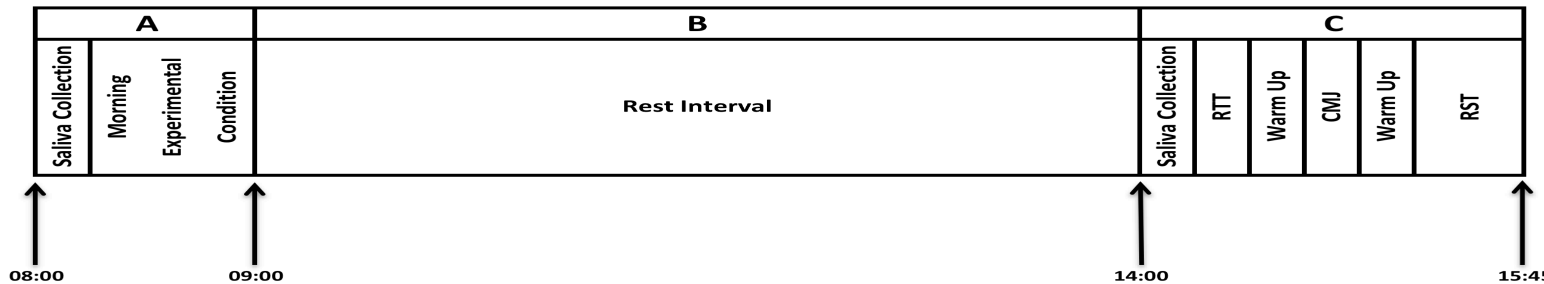

5 x 10 reps @ 75% 1RM Bench Press (90sec recovery between sets)

6 x 6 sec (54 sec recovery between sprints) (7.5% BM resistance)

6 x 40m sprints (20 sec recovery between sprints)

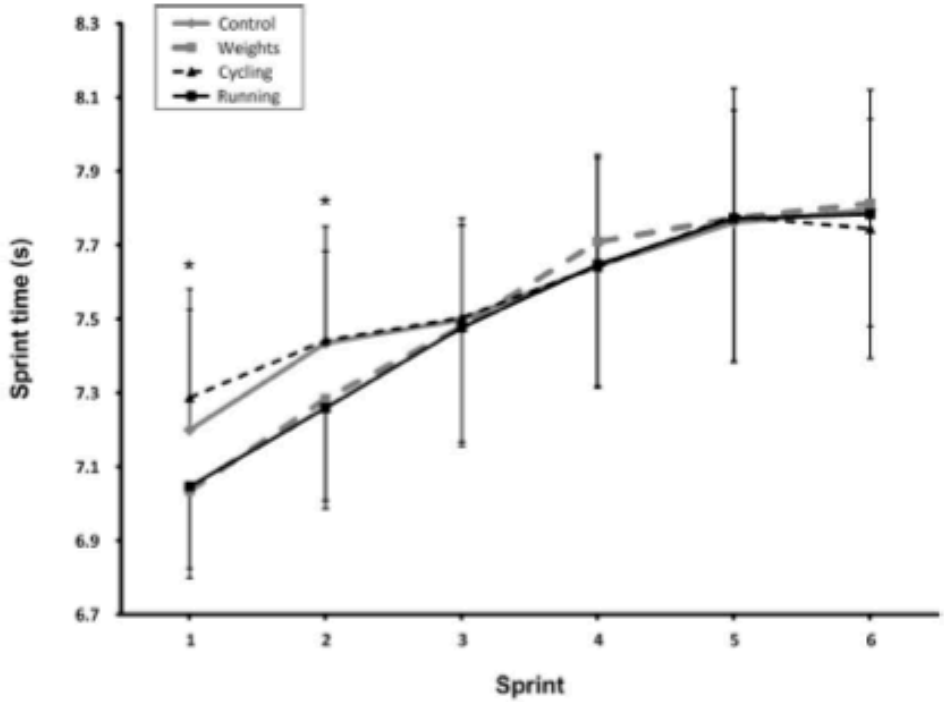

Figure 1 — Sprint times throughout the control, weights, cycling, and running trials, mean ± SD. *Significant main effect of trial ($P < .05$) at the corresponding time point.

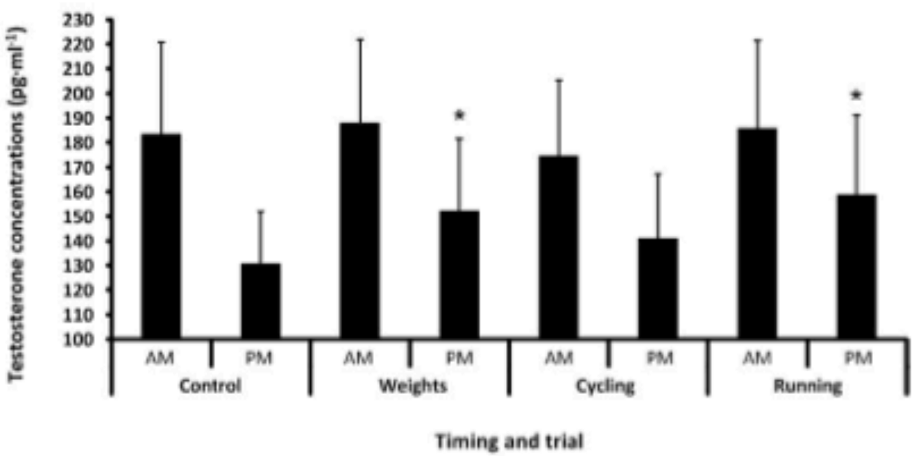

Figure 2 — Testosterone concentrations throughout the control, weights, cycling, and running trials, mean ± SD. Abbreviations: AM, morning; PM, afternoon. *Significant difference ($P < .05$) compared with corresponding time point in control.

ORIGINAL INVESTIGATION

http://dx.doi.org/10.1123/ijspp.2015-0508

A Comparison of Different Modes of Morning Priming Exercise on Afternoon Performance

Mark Russell, Aden King, Richard. M. Bracken, Christian. J. Cook, Thibault Giroud, Liam. P. Kilduff

Purpose: To assess the effects of different modes of morning (AM) exercise on afternoon (PM) performance and salivary hormone responses in professional rugby union players. ***Methods:*** On 4 occasions (randomized, crossover design), 15 professional rugby players provided AM (~8 AM) and PM (~2 PM) saliva samples before PM assessments of countermovement-jump height, reaction time, and repeated-sprint ability. Control (passive rest), weights (bench press: 5 × 10 repetitions, 75% 1-repetition maximum, 90-s intraset recovery), cycling (6 × 6-s maximal sprint cycling, 7.5% body mass load, 54-s intraset recovery), and running (6 × 40-m maximal sprints, 20-s intraset recovery) interventions preceded (~5 h) PM testing. ***Results:*** PM sprint performance improved ($P < .05$) after weights (>0.15 ± 0.19 s, >2.04% ± 2.46%) and running (>0.15 ± 0.17 s, >2.12% ± 2.22%) but not cycling ($P > .05$). PM jump height increased after cycling (0.012 ± 0.009 m, 2.31% ± 1.76%, $P < .001$) and running (0.020 ± 0.009 m, 3.90% ± 1.79%, $P < .001$) but not weights ($P = .936$). Reaction time remained unchanged between trials ($P = .379$). Relative to control (131 ± 21 pg/mL), PM testosterone was greater in weights (21 ± 23 pg/mL, 17% ± 18%, $P = .002$) and running (28 ± 26 pg/mL, 22% ± 20%, $P = .001$) but not cycling ($P = .072$). Salivary cortisol was unaffected by AM exercise ($P = .540$). ***Conclusions:*** All modes of AM exercise improved at least 1 marker of PM performance, but running appeared the most beneficial to professional rugby union players. A rationale therefore exists for preceding PM competition with AM exercise.

Keywords: ergogenic, potentiation, hormone, rugby

Match play in elite team sports commences at varying times throughout the waking day, with kickoffs typically ranging from 11 AM to 8 PM. Although optimized sporting performance is subject to a range of intrinsic and extrinsic factors, the influence of circadian rhythm is acknowledged (for review see Atkinson and Reilly, Chtourou and Souissi, and Teo et al[1–3]), with changes in anaerobic physical performance (eg, force and power expression) occurring at different times of the day.[2,4] While kickoff times are likely determined by extraneous factors (including the demands of television[5]), opportunities exist on the day of competition to influence subsequent performance, as athletes may be susceptible to changes in their physical performance as a function of time.[6]

Testosterone and cortisol concentrations exhibit circadian rhythmicity and are known to correlate with indices of athletic performance,[7–9] particularly in elite athletic populations.[7,10,11] For example, salivary testosterone appears highly correlated with both squat strength ($r = .92$) and sprint times ($r = -.87$) in elite strength-trained athletes.[11] Moreover, improved 3-repetition-maximum strength was correlated to the acute increase in testosterone concentrations elicited via visual stimulation,[7] and pregame testosterone concentrations have been implicated in match outcomes in professional rugby players.[12] However, testosterone and cortisol typically display an early-morning (AM) peak before slowly declining across the waking day.[4,13] Considering the potential role of testosterone in mediating athletic performance, offsetting the circadian decline could be of benefit to sporting activities performed at times when testosterone concentrations have experienced a circadian decline, such as in the afternoon (PM). Acutely, a strength/hypertrophy-training stimulus can raise postexercise testosterone concentrations[14] and thus may be beneficial when preceding subsequent training or competition. However, the effects of other modes of activity (eg, running and cycling protocols) on postexercise testosterone responses remain unclear.

Ekstrand et al[15] have demonstrated that an AM resistance session that included back squats performed to failure and power-clean exercises improved throwing distance in well-trained shot-putters when performed 6 hours before subsequent exercise. Similarly, improved PM performance has been observed in rugby union players who preceded PM physical-performance assessments (ie, countermovement jumps, 40-m sprints, bench press, and back squats) with sprints (5 × 40 m) and whole-body resistance (bench-press and back-squat routines up to 100% of 3-repetition-maximum values) exercises 6 hours earlier.[6] Notably, the AM sprint and resistance exercise attenuated a circadian decline in testosterone concentrations compared with a rested control trial.[6] Such findings highlight a potential role for specific modes of AM exercise to improve PM performance and that such findings may be modulated by changes in hormone status.

Unfortunately, acknowledging the practical considerations associated with the precompetition practices of professional athletes, the methods of AM exercise examined previously[6,15] may preclude their use on the day of competition and/or have limited transfer to match-specific performance indicators. Whole-body resistance exercises performed to maximal intensity and/or failure, while beneficial to linear sprinting and force expression, are unlikely to be routinely adopted in the precompetition setting. Therefore, methods of "priming" PM performances that may be better accepted by players and coaches on the day of competition while demonstrating transfer to

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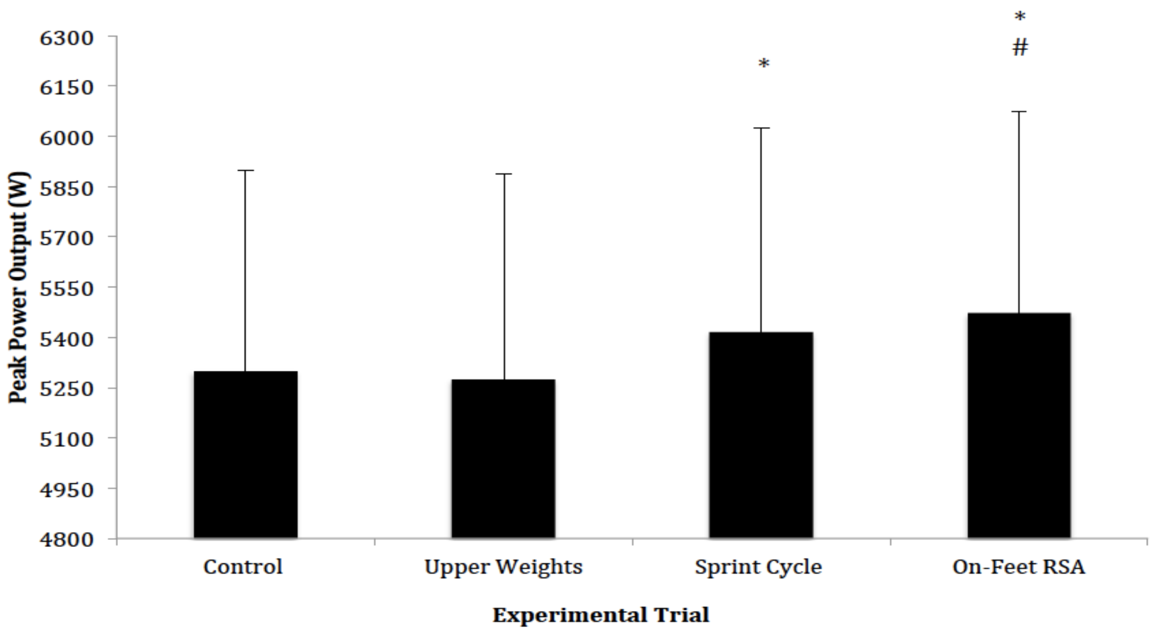
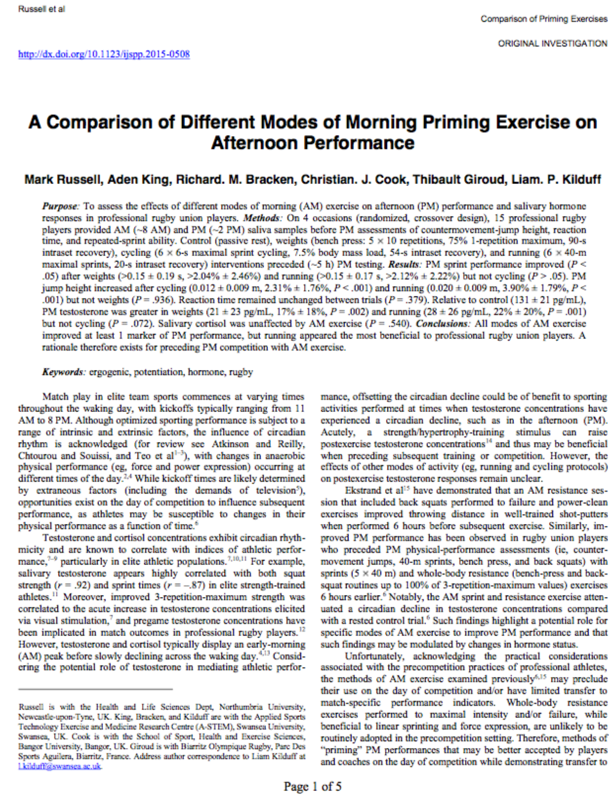


Figure 4.5 – Countermovement jump power output response to trials. * Indicates significantly greater than Control (p<0.01). # Indicates significantly greater than Upper Weights (p<0.05).



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The effects of different pre-game motivational interventions on athlete free hormonal state and subsequent performance in professional rugby union matches

Christian J. Cook [a,b,c,d], Blair T. Crewther [b,d,*]

Self Motivate　　*Positive Coach Feedback*　　*Negative Coach Feedback*

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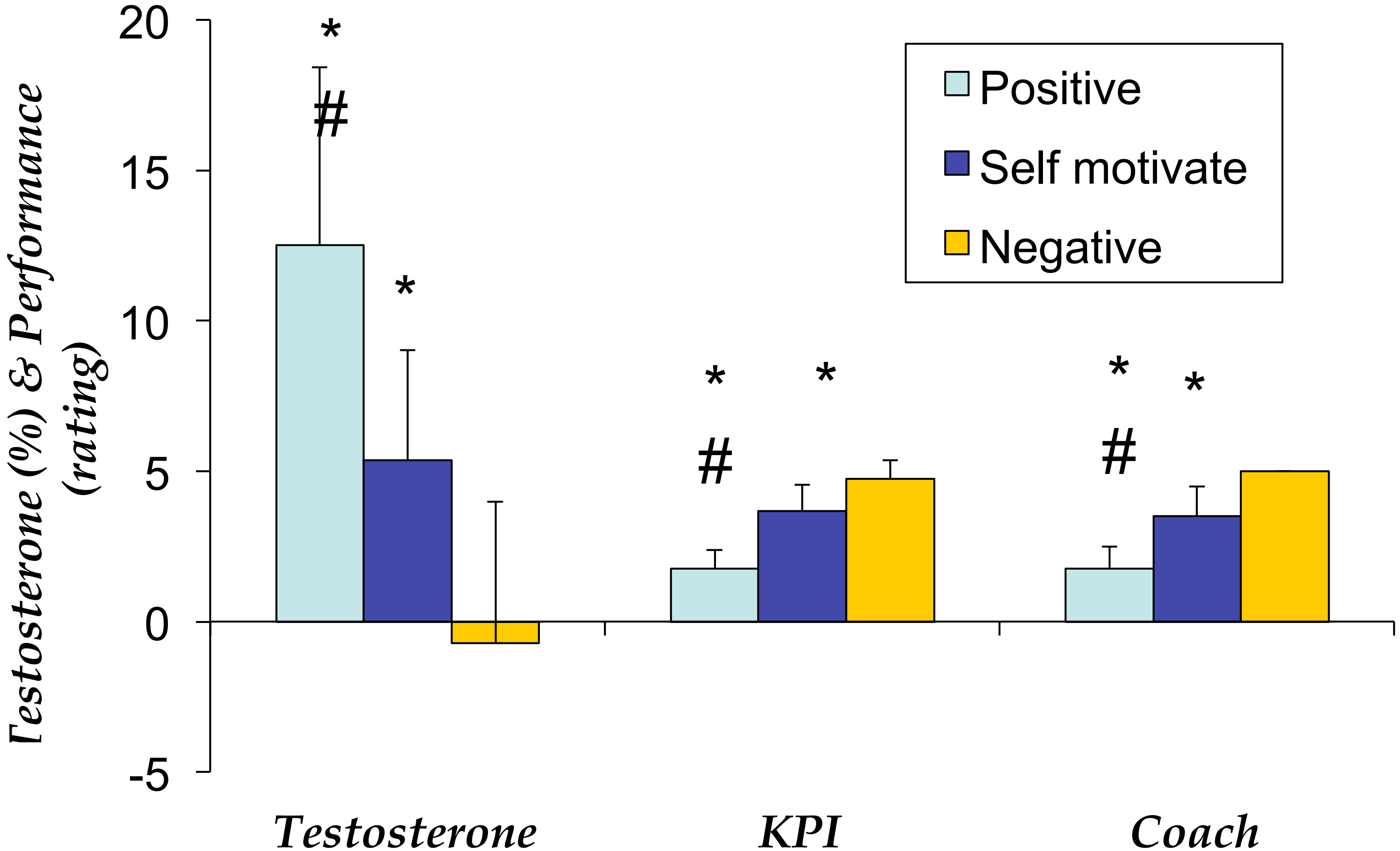

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Early Morning Starts
(Competition and Sleep)

Cook et al. Journal of the International Society of Sports Nutrition 2011, 8:2
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RESEARCH ARTICLE Open Access

Skill execution and sleep deprivation: effects of acute caffeine or creatine supplementation - a randomized placebo-controlled trial

Christian J Cook[1,3,4*†], Blair T Crewther[3†], Liam P Kilduff[2†], Scott Drawer[1†], Chris M Gaviglio[5†]

Abstract

Background: We investigated the effects of sleep deprivation with or without acute supplementation of caffeine or creatine on the execution of a repeated rugby passing skill.

Method: Ten elite rugby players completed 10 trials on a simple rugby passing skill test (20 repeats per trial), following a period of familiarisation. The players had between 7-9 h sleep on 5 of these trials and between 3-5 h sleep (deprivation) on the other 5. At a time of 1.5 h before each trial, they undertook administration of either: placebo tablets, 50 or 100 mg/kg creatine, 1 or 5 mg/kg caffeine. Saliva was collected before each trial and assayed for salivary free cortisol and testosterone.

Results: Sleep deprivation with placebo application resulted in a significant fall in skill performance accuracy on both the dominant and non-dominant passing sides ($p < 0.001$). No fall in skill performance was seen with caffeine doses of 1 or 5 mg/kg, and the two doses were not significantly different in effect. Similarly, no deficit was seen with creatine administration at 50 or 100 mg/kg and the performance effects were not significantly different. Salivary testosterone was not affected by sleep deprivation, but trended higher with the 100 mg/kg creatine dose, compared to the placebo treatment ($p = 0.067$). Salivary cortisol was elevated ($p = 0.001$) with the 5 mg/kg dose of caffeine (vs. placebo).

Conclusion: Acute sleep deprivation affects performance of a simple repeat skill in elite athletes and this was ameliorated by a single dose of either caffeine or creatine. Acute creatine use may help to alleviate decrements in skill performance in situations of sleep deprivation, such as transmeridian travel, and caffeine at low doses appears as efficacious as higher doses, at alleviating sleep deprivation deficits in athletes with a history of low caffeine use. Both options are without the side effects of higher dose caffeine use.

Background

Both creatine and caffeine have found common use in sport [1-4] for a variety of training and competitive aims. Popular use of caffeine is often at high concentrations (4-9 mg/kg) on the basis that these are more efficacious, but the proof of this is low with individual variability and consumption habits being the more dominant factors [5,6]. In contrast, popular creatine supplementation dosages appear to have fallen as literature supports the contention that lower doses can be as effective as higher loading schemes, again individual variability and responsiveness being major determinants [4].

While the ability of acute caffeine to address cognitive related sleep deficits is reasonably established [7], it is only recently that creatine has demonstrated similar properties [8,9]. It has been suggested that sleep deprivation is associated with an acute reduction in high energy phosphates that in turn produces some degree of cognitive processing deficit [8-14]. Creatine supplementation has been shown to improve certain aspects of cognitive performance with sleep deprivation and to have some positive benefits in deficits associated with certain pathophysiologies [13,14]. If sleep deprivation is associated with an energy deficit then errors in performance are perhaps more likely to occur when concentration demands are high and/or for prolonged periods of repeated task execution. Some evidence suggests that it is tasks of this nature that are most affected by acute sleep deprivation [15].

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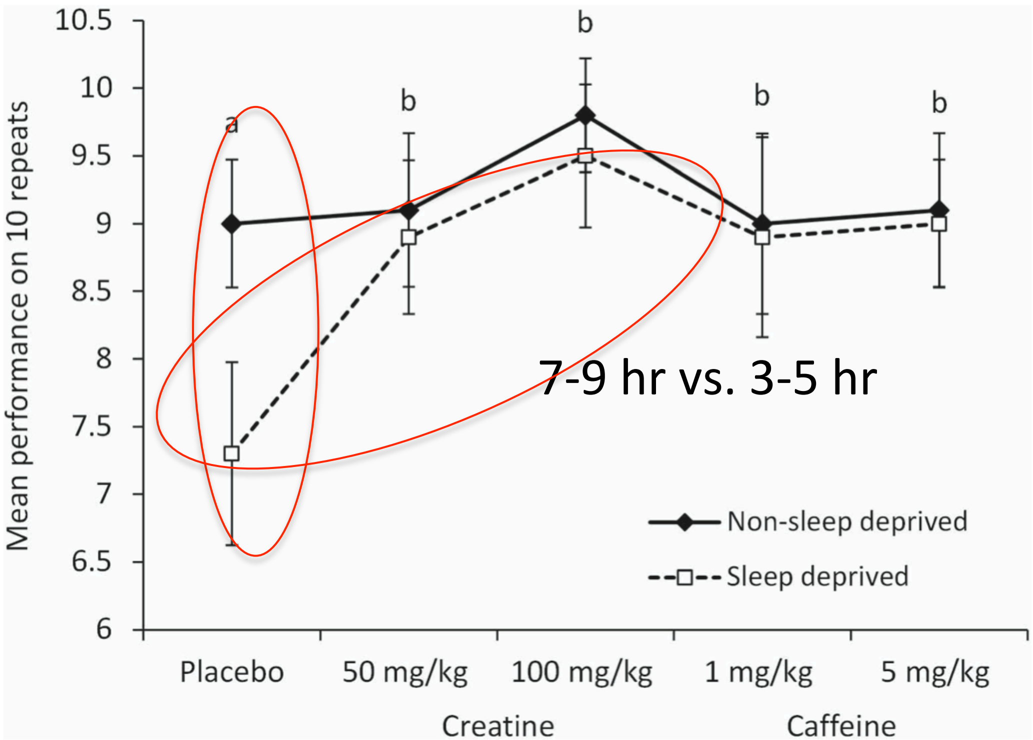

Figure 1 Effects of sleep deprivation and acute supplementations on passing accuracy (dominant side). The mean ± SD is displayed for accuracy out of 10 passes on the dominant side (20 passes total per trial) for the 10 subjects under different treatment conditions (placebo; 1 or 5 mg/kg caffeine, 50 or 100 mg/kg creatine) either in non-sleep deprived or sleep deprived states. Dominant was chosen by the subjects as the side they believed showed better passing accuracy. All subjects completed 20 repetitions of the passing skill per trial, alternating passing sides (10 on dominant side). With placebo treatment sleep deprivation was associated with a significant fall in performance (a) ($p < 0.001$) compared to non-sleep deprivation. The 50 and 100 mg/kg creatine and 1 and 5 mg/kg caffeine doses were all associated with a significantly better performance (b) ($p < 0.001$) than the placebo conditions.

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Update your Timeline

Skeleton Bobsleigh Example


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CASE STUDY

Designing a Warm-Up Protocol for Elite Bob-Skeleton Athletes

Christian Cook, Danny Holdcroft, Scott Drawer, and Liam P. Kilduff

Purpose: To investigate how different warm-ups influenced subsequent sled-pull sprint performance in Olympic-level bob-skeleton athletes as part of their preparation for the 2010 Winter Olympics. ***Methods:*** Three female and 3 male athletes performed 5 different randomized warm-ups of differing intensities, durations, and timing relative to subsequent testing, each 2 days apart, all repeated twice. After warm-ups, testing on a sled-pull sprint over 20 m, 3 repeats 3 min apart, took place. ***Results:*** Performance testing showed improvement ($P < .001$, ES > 1.2) with both increasing intensity of warm-up and closeness of completion to testing, with 20-m sled sprinting being 0.1–0.25 s faster in higher-intensity protocols performed near testing In addition, supplementing the warm-ups by wearing of a light survival coat resulted in further performance improvement ($P = .000$, ES 1.8). ***Conclusions:*** Changing timing and intensity of warm-up and using an ancillary passive heat-retention device improved sprint performance in Olympic-level bob-skeleton athletes. Subsequent adoption of these on the competitive circuit was associated with a seasonal improvement in push times and was ultimately implemented in the 2010 Winter Olympics.

Keywords: sprint performance, body temperature, passive heat maintenance, winter sports

A warm-up is important for subsequent performance,[1,2] and a recent meta-analysis suggests that 79% of research demonstrated improvement in performance with warm-up.[3] Bob-skeleton (skeleton) is a winter Olympic Sport in which participants push a sled for 20–30 m before launching their upper torso onto the sled and then "driving" down an ice course. The initial push demands great speed and power,[4] which can be influenced by warm-up.[1,2] The event is in cold environments, ranging anywhere from approximately +5°C to −40°C, and athletes spend considerable time prior to the race outside. Observing British international competing athletes, a typical pattern emerged: They perform warm-ups outside 30 to 40 min before race start. They come outside several minutes in advance of their race, stripping down to a light Lycra race suit. Similar observations have been recently reported by Sporer et al.[5] Our purpose was to adjust warm-ups and examine subsequent performance outcomes. Athletes used their current warm-up protocol as the control basis against which we changed intensity, duration, and timing relative to performance testing.

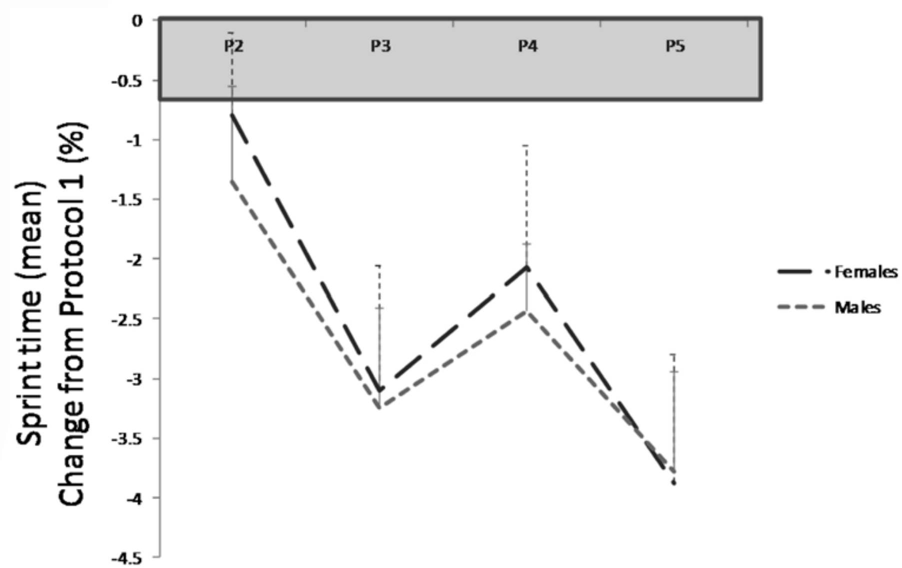
Methods

Three female and 3 male British skeleton athletes competing for selection to the Olympic team participated. Male athletes at time of study were (mean ± SD) height 1.74 ± 0.08 m, weight 78.7 ± 10.2 kg, and age 28.3 ± 3.1 years, while female athletes were height 1.72 ± 0.02 m, weight 62.0 ± 1.6 kg, and age 27.3 ± 0.5 years. Warm-ups were performed at 9 AM on alternate days in a randomized counterbalanced manner. Protocol 1 (P1) consisted of a standardized version of the athletes' own existing competition warm-ups. This warm-up took 20 minutes and was completed 35 minutes before testing. It consisted of 3 × 20-m jogging and skipping with walking back; 3 × 20-m of submaximal sprinting; 3 × 20-m sprint form drills; 2 × 20-m leg swings, fast feet and high knees; 3 × 10-m maximal sprints; 30 seconds of mixed calisthenics (press-ups, dead bugs, planks); and 2 minutes of dynamic stretching. Protocol 2 (P2) consisted of the same timing and durations but with increased intensity due to including more sprint drills and sprints and reducing rest intervals. The load increase per time (meters covered) was approximately 30%.

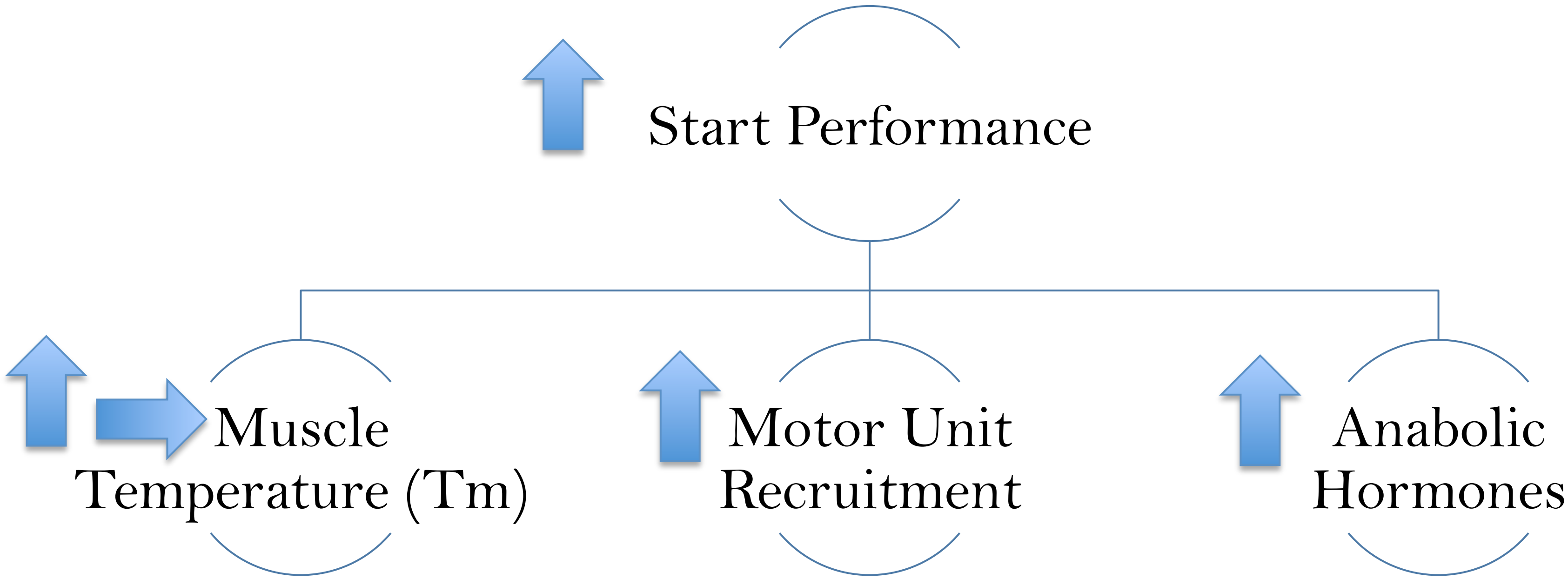
Protocol 3 (P3) consisted of the same high intensity but was completed 15 minutes before testing. Protocol 4 (P4) was the same high-intensity warm-up but split into 2 × 10-minute warm-ups, one completed 40 minutes before testing and the second completed 15 minutes before testing. In all protocols, athletes undertook 3 further short bursts (20- to 30-s duration) of activities such as press-ups or knee-ups at 12, 8, and 4 minutes before testing.

After completion of the warm-up trials, a further protocol 5 (P5) was undertaken in which a survival garment (Blizzard Survival Garments, UK) was worn, for passive heat retention, between warm-up activities and until testing while undertaking P4.

Cook and Drawer are with UK Sport, London, UK. Holdcroft is with British Skeleton, Bath, UK. Kilduff is with the College of Engineering, Swansea University, UK.



Skeleton Bobsleigh Start Performance



P1: Characterize

Table 1 Warm-Up Protocol-Related Changes (Post – Pre)

	P1
Maximum heart rate (beats/min)	138.0 ± 8.9
Rating of perceived exertion	2.5 ± 0.4
Tympanic change (°C) at room temperature	0.1 ± 0.2

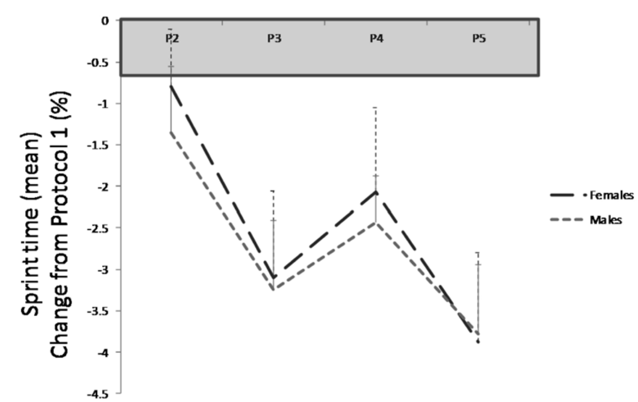
Note. Group mean ± SD is presented pooled across all protocol repeats combined for both women and men.

°Significant difference (*P* < .001) compared with P1. *Significant difference (*P* < .001) compared with P2. †Significant difference (*P* < .001) compared with P4. ‡Significant difference (*P* < .01) compared with P5.

Key Points noted:

- Warm-up duration 20min completed 35min prior to race
- Minimal change in Temperature
- RPE
- HR (~70% of Max HR)

Next Step: Increase Intensity



P2: Increase Intensity

Table 1 Warm-Up Protocol-Related Changes (Post – Pre)

	P1	P2
Maximum heart rate (beats/min)	138.0 ± 8.9	145.8 ± 7.1°
Rating of perceived exertion	2.5 ± 0.4	3.7 ± 0.5
Tympanic change (°C) at room temperature	0.1 ± 0.2	0.5 ± 0.2°

Note. Group mean ± SD is presented pooled across all protocol repeats combined for both women and men.

°Significant difference ($P < .001$) compared with P1. *Significant difference ($P < .001$) compared with P2. †Significant difference ($P < .001$) compared with P4. ‡Significant difference ($P < .01$) compared with P5.

Manipulation:

Increase intensity (Increase Sprint volume by 30%)

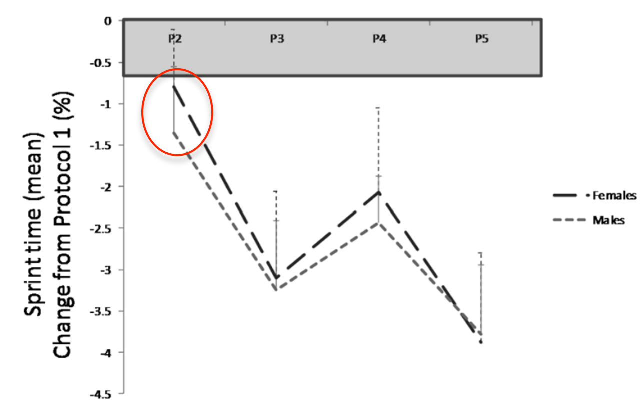
Key Reponses:

Increase in HR, Δ Temp

Increase in KPI

Next Steps

Change timing of Warm-up completion



P3: Timing

Table 1 Warm-Up Protocol-Related Changes (Post – Pre)

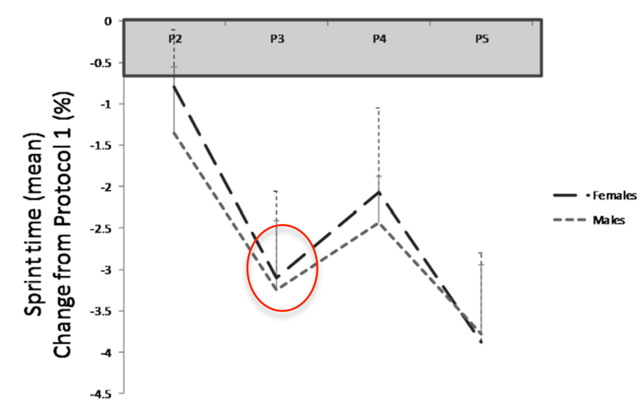
	P1	P2	P3
Maximum heart rate (beats/min)	138.0 ± 8.9	145.8 ± 7.1°	159.3 ± 9.8°*
Rating of perceived exertion	2.5 ± 0.4	3.7 ± 0.5	4.5 ± 0.4
Tympanic change (°C) at room temperature	0.1 ± 0.2	0.5 ± 0.2°	0.9 ± 0.2°*†

Note. Group mean ± SD is presented pooled across all protocol repeats combined for both women and men.
°Significant difference ($P < .001$) compared with P1. *Significant difference ($P < .001$) compared with P2. †Significant difference ($P < .001$) compared with P4. ‡Significant difference ($P < .01$) compared with P5.

Manipulation:
- WU (P2) moved to finish 15min prior to competition start time

Key Reponses:
- Better Temp maintenance
- Improved KPI

Next Step: **Athlete Feedback**



P4: Split Warm- Up

Table 1 Warm-Up Protocol-Related Changes (Post – Pre)

	P1	P2	P3	P4
Maximum heart rate (beats/min)	138.0 ± 8.9	145.8 ± 7.1°	159.3 ± 9.8°*	157.2 ± 13.8°*
Rating of perceived exertion	2.5 ± 0.4	3.7 ± 0.5	4.5 ± 0.4	3.4 ± 0.6
Tympanic change (°C) at room temperature	0.1 ± 0.2	0.5 ± 0.2°	0.9 ± 0.2°*†	0.6 ± 0.1°*

Note. Group mean ± SD is presented pooled across all protocol repeats combined for both women and men.

°Significant difference ($P < .001$) compared with P1. *Significant difference ($P < .001$) compared with P2. †Significant difference ($P < .001$) compared with P4. ‡Significant difference ($P < .01$) compared with P5.

Manipulation:

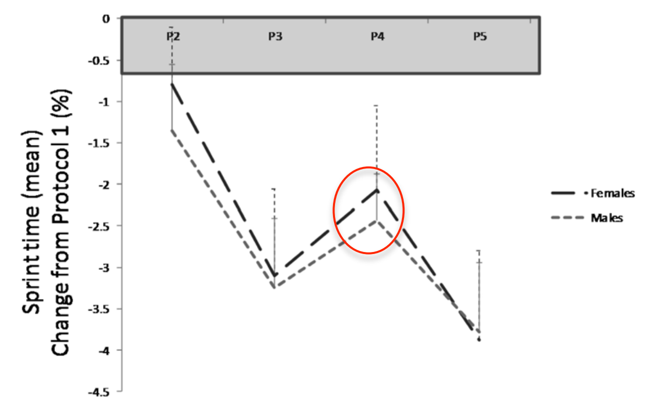
Warm-up Split into 2x 10min Blocks (Completed 40min and 15min prior to start of competition)

Key Reponses:

Reduction in Δ Temp

Decrease in KPI

Next Step: Passive Heat Maintenance



P5: Passive Heat Maintenance Strategy

Table 1 Warm-Up Protocol-Related Changes (Post – Pre)

	P1	P2	P3	P4	P5
Maximum heart rate (beats/min)	138.0 ± 8.9	145.8 ± 7.1°	159.3 ± 9.8°*	157.2 ± 13.8°*	160.1 ± 14.2°*†
Rating of perceived exertion	2.5 ± 0.4	3.7 ± 0.5	4.5 ± 0.4	3.4 ± 0.6	3.3 ± 0.4
Tympanic change (°C) at room temperature	0.1 ± 0.2	0.5 ± 0.2°	0.9 ± 0.2°*†	0.6 ± 0.1°*	1.0 ± 0.3°*†‡

Note. Group mean ± SD is presented pooled across all protocol repeats combined for both women and men.

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Manipulation:

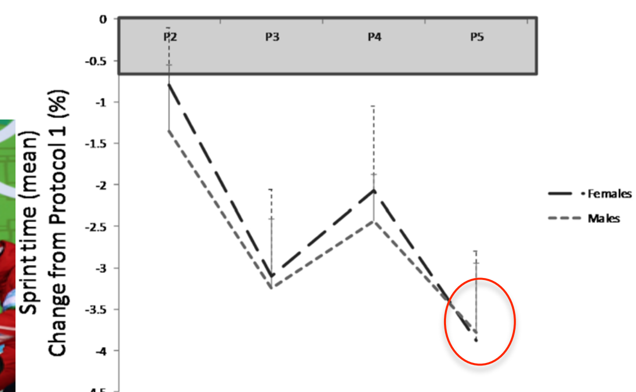
P4 plus Passive Heat Retention strategy

Key Reponses:

Increase Δ Temp

Best KPI improvement

Next Step: Apply in competition



End Point

6 hours → Priming

45-15 mins → Active WU

15 mins → Video + feedback

12-8 mins → PAP stimulus

→ **Competition Start**

Passive heat maintenance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Conclusion

- **Changing timing** and **intensity of warm-up**, using an **ancillary passive heat-retention device** and the addition of **PAP** improved sprint performance in Olympic-level bob-skeleton athletes.
- Subsequent **adoption** of this new pre-competition routine on the competitive circuit was associated with a **seasonal improvement in push times and was ultimately implemented in the 2010 Winter Olympics.**

Finish