SEMIPRO CYCLING

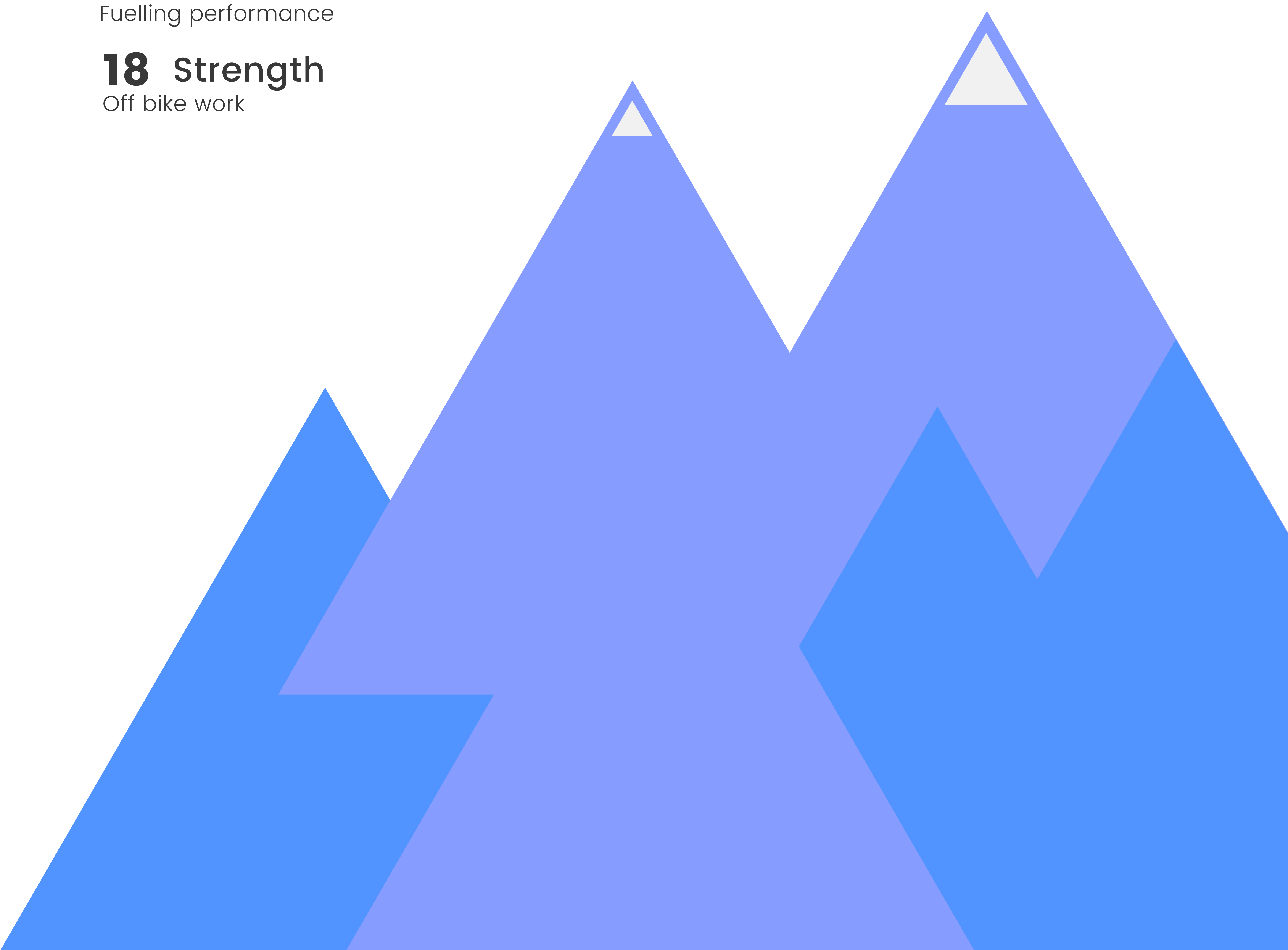
JULY 2021 | ISSUE #07

CYCLING SCIENCE

DIGEST

A MONTHLY SUMMARY OF THE LATEST ENDURANCE & CYCLING PERFORMANCE RESEARCH

Contents



How to read the digest

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Abstract

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Title

The role of resistance exercise intensity on muscle fibre adaptations

Study details

OBJECTIVE

Although many training variables contribute to the performance, cellular and molecular adaptations to resistance exercise, relative intensity (% 1 repetition maximum [%1RM]) appears to be an important factor.

This review aimed to provide an examination of the role of resistance training load on adaption of human skeletal muscle.

As Fry says "Only when knowledge of muscle physiology and the appropriate application of training stimuli are combined can we hope to optimise the adaption process".

WHAT THEY DID

This review examines the scientific literature concerning the role of resistance exercise intensity on cellular and molecular adaptions of human skeletal muscle.

The author summarises and analyses data from numerous resistance exercise training studies that have monitored percentage fibre type, fibre type cross-sectional areas, percentage cross-sectional areas, and myosin heavy chain (MHC) isoform expression.

The review was limited to studies analysing the vastus laterlais muscle using muscle biopsies.

WHAT THEY FOUND

- Muscular hypertrophy responses to different relative training intensities follows a dose-response curve.
- There may be a threshold for optimal growth responses once intensity reaches 80% of 1RM. And maximal growth occurs with loads between 80% and 95% of 1RM.
- The optimal relative intensity range for muscular hypertrophy is 40% to 80% of 1RM.
- For endurance cyclists not wanting large levels of muscular hypertrophy, it is important to also include work at ≥80% 1RM because there are other physiological and performance reasons to train e.g. muscular strength or power.

Practical takeaways from study

Practical Takeaways

Fry found that Fast Twitch recruitment begins at approximately 40% of maximum voluntary contraction (MVC) and peaks at ~ 80-85% MVC. Reminder: MVC is a measure of strength.

- These numbers were intended to be transferred across percentages of maximum repetitions when doing strength work. But it's also possible to use them for on the bike strength workouts using power prescriptions.

To understand how this works, we need to find an athlete's peak torque. We can calculate this using peak power and cadence. For example for an athlete that has a peak power output of 1300W (snd peak cadence of 130rpm) has a peak torque of 95 Newton meters. To prescribe strength intervals use the power that corresponds to 40-80% of peak torque. In this case 38-76 Newton meters. At 50rpm that's a power range of 200-400w.

- Once you have that information you can create interval durations that fit the athlete's ability and specificity requirements. For example, long strength endurance intervals at 40-50% of max torque might be 30-minute blocks (max 3 x 30 minutes total) at 200-250w @ 50rpm. Or shorter intervals hill reps at 80-85% of max torque might be 6 x 4-minute blocks at 400-425w @ 50rpm.

Damian's Comments

"I have used this study for many years to quantify my power prescriptions for on bike strength and strength endurance work. A quick calculation can keep an athlete in their personal hypertrophy range - and not waste their training time on guesses.

Also, having a personal range helps to measure progress (see below) and helps with motivation. Give this a try the next time you are prescribing strength endurance intervals."

Session 1

Torque Nm/kg Nm/kg	Torque Nm	% of Peak Torque %
0.81	60	48
0.83	62	50
0.84	63	50
0.85	63	51
0.85	63	50
0.85	63	50
0.85	63	51
0.85	63	51

Session 2

Torque Nm/kg Nm/kg	Torque Nm	% of Peak Torque %
1.01	75	60
1.11	82	65
1.11	82	65
1.10	81	65
1.10	81	65
1.10	81	65
1.08	80	64
1.10	81	65

Reviewers comments on the study

Related links to learn more about the topic

Want to learn more?
Check these out...

Welcome

If you're reading this right now, then I am seriously honoured you decided to invest in yourself and join Cycling Science Digest. I am extremely thankful for every single member who chooses to join us on our relentless quest to get cyclists the right advice at the right time. Without you, this would simply not be possible; so thank you.

So, what's special in this month's issue?

1. Lots of interesting papers in this issue. A bit more of a performance focus but overall a good balance of topics. I think you'll enjoy this one ;)

2. As this was a big month for publishing, I've added a list of links to the papers (27!) that didn't make it to this month's edition.

Thanks for reading, and for being a member :)

Damian

Damian Ruse

Founder and Head Coach of SEMIPRO Cycling

Damian is an elite cycling coach and cycling science educator and has worked in the field of sports performance for over 8 years, helping athletes get the best out of themselves. Damian coaches professional, elite, and amateur athletes and has been the Performance Director of a top Australian road cycling team. Damian is also a lifelong cyclist, riding and racing bikes for over 28 years.

Performance

This month's top research on cycling performance

Programming Interval Training to Optimize Time-Trial Performance: A Systematic Review and Meta-Analysis

Rosenblat, M., et al. Sports Medicine. 2021.

Heat Reacclimation Using Exercise or Hot Water Immersion

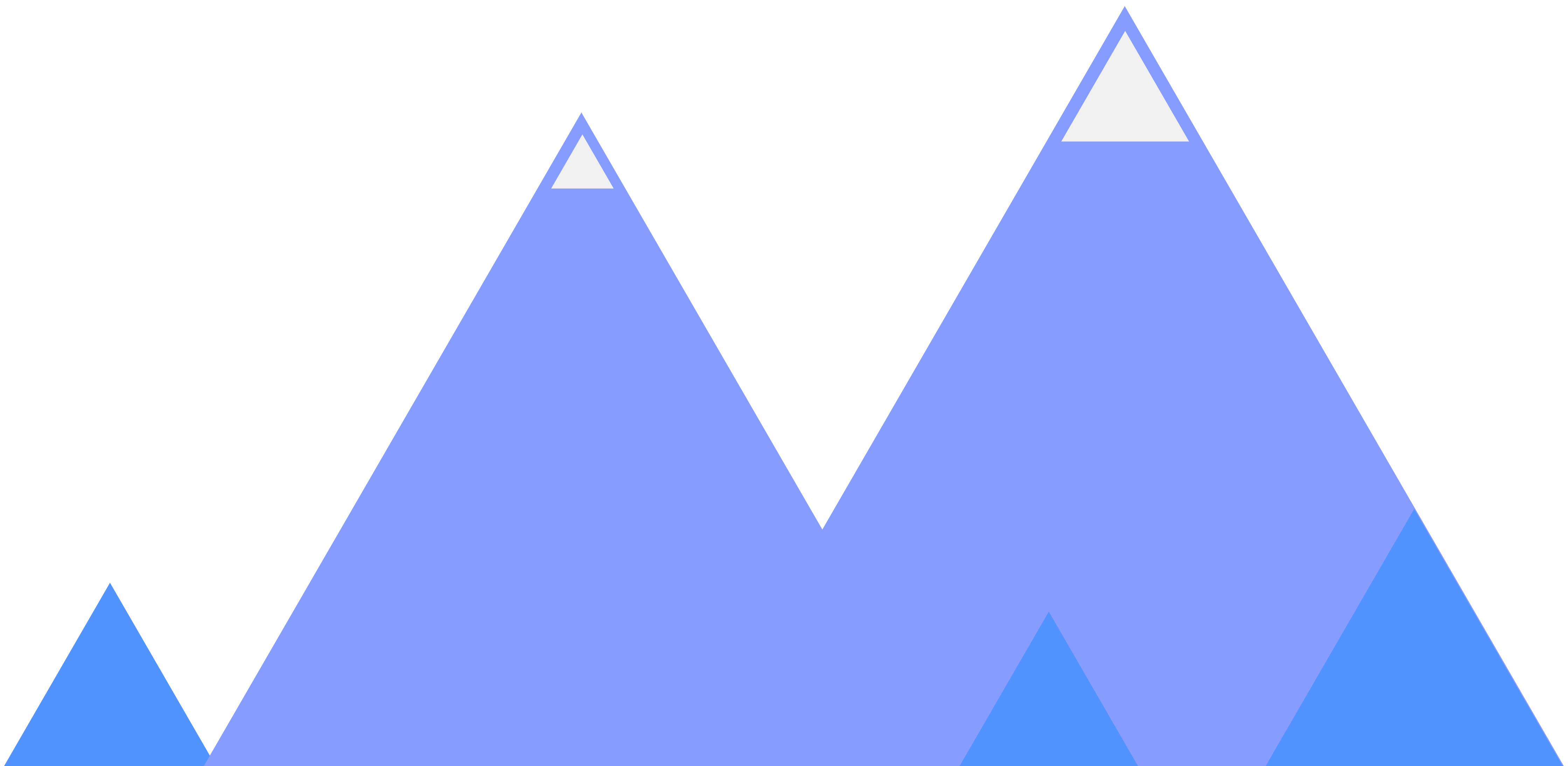
Gerrett, N., et al. Medicine & Science in Sports & Exercise: 53 (7), 2021.

To Nap or Not to Nap? A Systematic Review Evaluating Napping Behavior in Athletes and the Impact on Various Measures of Athletic Performance

Lastella, M., et al. Nature and Science of Sleep. 13, 2021.

Short term intensified training temporarily impairs mitochondrial respiratory capacity in elite endurance athletes.

Cardinale, D., et al. Journal of Applied Physiology. Ahead of Print (June), 2021.



Abstract

Programming Interval Training to Optimize Time-Trial Performance: A Systematic Review and Meta-Analysis

OBJECTIVE

The objective of this paper was to perform a systematic review and meta-analysis of interval training studies to determine the influence that individual characteristics and training variables have on time-trial (TT) performance.

We all know about interval training how essential it is for endurance training programs. Despite extensive research on the two forms of interval training high-intensity interval training (HIIT) and sprint interval training (SIT), there is no consensus concerning the optimal method to manipulate the interval training programming variables to maximize endurance performance for differing individuals.

WHAT THEY DID

The following criteria were used to select studies appropriate for the review:

1. the studies were prospective in nature;

2. included individuals between the ages of 18 and 65 years;

3. included an interval training (HIIT or SIT) program at least 2 weeks in duration;

4. included a TT test that required participants to complete a set distance;

5. and programmed HIIT by power or velocity

WHAT THEY FOUND

- Twenty-nine studies met the inclusion criteria for the quantitative analysis with a total of 67 separate groups. The participants included males (n=400) and females (n=91) with a mean group age of 25 (range 19–45) years and mean VO2max of 52 (range 32–70) mL·kg-1·min-1.

  The training status of the participants comprised of inactive (n=75), active (n=146) and trained (n=258) individuals.

- Training status played a significant role in improvements in TT performance with trained individuals only seeing improvements of approximately 2% whereas individuals of lower training status demonstrated improvements as high as 6%.

  The change in TT performance with HIIT depended on the duration but not the intensity of the interval work-bout. There was a dose–response relationship with the number of HIIT sessions, training weeks and total work with changes in TT performance. However, the dose–response was not present with SIT.

Practical Takeaways

So what are the best intervals? If you want a good, evidence-based HIIT workout to make you faster in races, Rosenblat and his colleagues recommend:

- 5 x 5:00 with 2:30 recovery, twice a week, for at least four weeks.

If you want to sprint instead:

- 4 x 30 seconds with 4:00 recovery, twice a week for at least two weeks.

There is a lot of smaller details in this paper that are worth highlighting. For example, how hard should HIIT workouts be? The range could be anywhere from threshold pace to V02max power. The meta-analysis suggests the best pace doesn't actually matter. Harder HIIT sessions produce basically the same gains as lower intensity ones.

Within the parameters of a HIIT workout, you can get the stimulus you need by pushing harder during shorter intervals and not quite as hard during longer intervals—something that happens naturally. (For SIT, in contrast, it's simple: sprint as hard as you can!)

- Finally, when you narrow the search to studies including only trained participants, longer HIIT intervals produce better results than shorter ones.

Want to learn more?
Check this out...

Damian's Comments

"The strict parameters set by Rosenblat helps coaches make use of the findings in this review. He only included studies that directly measured performance in a time trial, instead of looking at indirect measures like changes in VO2 max. The training programs had to last at least two weeks, and they fell into two categories: high-intensity interval training (HIIT) or sprint interval training (SIT).

So it's no surprise that there are two clear 'winners'. Although, as with any training prescription when and whom you use there recommended intervals will depend on the individual athlete."

Abstract

Heat Reacclimation Using Exercise or Hot Water Immersion

OBJECTIVE

The aim of this study was to compare the effectiveness of exercise versus hot water immersion heat reacclimation (HRA) protocols.

WHAT THEY DID

Twenty-four participants completed a heat stress test (HST; 33°C, 65% RH), which involved cycling at a power output equivalent to 1.5 W·kg-1 for 35 min. This was followed by a graded exercise test until exhaustion.

Heat Stress Test 1 was before a 10 day controlled hyperthermia (CH) heat acclimation (HA) protocol and Heat Stress Test 2 immediately after.

Participants completed Heat Stress Test 3 after a 28 day decay period without heat exposure and were then separated into three groups to complete a 5 day Heat Reacclimation protocol:

1. a control group (CH-CON, n = 8);
2. a hot water immersion group (CH-HWI, n = 8), and
3. a controlled hyperthermia group (CH-CH, n = 8).

This was followed by Heat Stress Test 4.

WHAT THEY FOUND

- Compared with Heat Stress Test 1, time to exhaustion and thermal comfort improved; resting rectal temperature (Tre), end of exercise Tre, and mean skin temperature (Tsk) were lower; and whole body sweat rate (WBSR) was greater in Heat Stress Test 2 for all groups ($P < 0.05$).
- After a 28-d decay, only WBSR, time to exhaustion, and mean Tsk returned to pre-HA values. Of these decayed variables, only WBSR was reinstated after HRA; the improvement was observed in both the CH-CH and the CH-HWI groups ($P < 0.05$).

Practical Takeaways

- The data suggest that heat reacclimation protocol may not be necessary for cardiovascular and thermal adaptations within a 28 day decay period, as long as a 10 day controlled hyperthermia heat acclimation protocol has successfully induced these physiological adaptations.
- For sweat adaptations, a 5 day controlled hyperthermia heat acclimation or hot water immersion heat reacclimation protocol can reinstate the lost adaptations.

  Passive heating, using hot water (40°C) immersion for 40 min, was selected based on its high practical value; baths are accessible to most, and the protocol will have minimal effect on training schedules. The water temperature of 40°C is below the thermal pain threshold, and pilot testing confirmed that the proposed protocol was challenging but tolerable. This seemed a good balance between providing a strong enough stimulus but still achievable for all to complete.
- In habitually trained individuals, most of the physiological adaptations acquired during an initial 10 day CH-HA protocol were not lost during a 28 day decay period.

  Note: If there is reason to believe that the sweat adaptation has started to decay, then a 5 day passive or active HRA protocol can reinstate the lost adaptations.

Damian's Comments

"As Jamie Stanley tweeted, if you get the 10 day heat acclimation right and induce the desired physiological adaptations, they may be maintained for >28 days. Sudomotor adaptations (anything that stimulates the sweat glands)that are lost can be reinstated with 5 day of HWI or active heat acclimation.

These are the type of findings that help coaches and athletes feel more confident to add these protocols, especially as the reacclimation period is much shorter than the original heat acclimation protocol".

Abstract

To Nap or Not to Nap? A Systematic Review Evaluating Napping Behavior in Athletes and the Impact on Various Measures of Athletic Performance

OBJECTIVE

The objective of this systematic review was to 1) determine how studies evaluated napping behavior in athletes (frequency, duration, timing and measurement); 2) explore how napping impacted physical performance, cognitive performance, perceptual measures (eg, fatigue, muscle soreness, sleepiness and alertness), psychological state and night-time sleep in athletes.

WHAT THEY DID

Five bibliographic databases were searched from database inception to 11 August 2020. Observational and experimental studies comprising able-bodied athletes (mean age ≥12 years), published in English, in peer-reviewed journal papers were included. The Downs and Black Quality Assessment Checklist was used for quality appraisal.

WHAT THEY FOUND

Thirty-seven studies were identified of moderate quality. Most studies did not include consistent information regarding nap frequency, duration, and timing.

Napping may be beneficial for a range of outcomes that benefit athletes (eg, physical and cognitive performance, perceptual measures, psychological state and night-time sleep).

In addition, napping presents athletes with the opportunity to supplement their night-time sleep without compromising sleep quality

Practical Takeaways

The biggest takeaway - athletes may consider napping between 20 to 90 min in duration and between 13:00 and 16:00 hours. Secondly, athletes should allow 30 min to reduce sleep inertia prior to training or competition to obtain better performance outcomes.

Sleep inertia is a transitional state of impaired cognitive performance and reduced alertness upon waking. Often colloquially described as a feeling of "grogginess", the level of sleep inertia impairment is greatest upon waking and usually takes 15–30 min to fully dissipate. Note that no studies to date have specifically investigated the impact of sleep inertia following napping opportunities on measures of performance in athletes. In some cases, it may be possible to accelerate this dissipation by employing known sleep inertia countermeasures, which can be employed proactively (ie, before the nap) or reactively (ie, after a nap). Examples of these countermeasures include caffeine, bright light, sound, temperature and physical activity. It should be noted that none of these strategies can reliably dissipate sleep inertia within the first 15 min upon waking

Additionally, a recent study investigated the possibility of whether athletes exercising prior to their night-time sleep periods would exhibit greater amounts of slow-wave sleep in their night-time sleep period, which could subsequently impact the severity and/or duration of sleep inertia. This hypothesis could potentially mean that athletes may be more susceptible to the impacts of sleep inertia given (in most cases) that their level of exercise is greater than the general population. However, this study concluded that exercise of a moderate-intensity performed 90 min before bed did not negatively impact sleep inertia and there was no relationship between the amount of slow wave sleep in the preceding sleep period and sleep inertia. Therefore, it seems unlikely that athletes have a greater likelihood of experiencing enhanced duration and/or severity of sleep inertia compared to non-athletes.

Want to learn more?
Check this out...

Damian's Comments

"I am happy to see papers like this as this information is important for athletes and practitioners who provide advice and education to athletes regarding napping.

It's no surprise that research investigating napping behaviors indicates that napping is common practice among athletic populations. While napping presents athletes with the opportunity to supplement their night-time sleep, evidence also indicates that napping may be beneficial for a range of measures (eg, physical performance, cognitive performance and mood) in athletes

Although the overall evidence included in this review was of moderate quality with the majority of experimental or longitudinal studies, it was observed that most of the studies: a) did not include detailed information for nap timing and duration, b) had inconsistencies in reporting of nap frequency, c) focused specifically on the night-time sleep period, and d) relied on self-report data (ie, sleep diaries or questionnaires) to explore napping behavior.

As stated previously, the optimal time to nap is when the maximum period of circadian sleepiness occurs in the mid-afternoon (13:00–16:00 h), this timing should also protect delays in sleep onset latency and any intrusion into the night-time sleep period.

I've actually spoken with several athletes about starting their training earlier on in the day to use this window for napping. This is a good paper to point athletes to if they are considering optimising their napping routine."

Abstract

Short term intensified training temporarily impairs mitochondrial respiratory capacity in elite endurance athletes

OBJECTIVE

The maintenance of healthy and functional mitochondria is the result of a complex mitochondrial turnover and herein quality-control program which includes both mitochondrial biogenesis and autophagy of mitochondria.

The aim of this study was to examine the effect of an intensified training load on skeletal muscle mitochondrial quality control in relation to changes in mitochondrial oxidative capacity, maximal oxygen consumption and performance in highly trained endurance athletes.

WHAT THEY DID

27 highly trained male triathletes (n = 22) and road cyclists (n = 6) (age 24.7 ± 4.3 years, height 182.7 ± 5.9 cm, body mass 74.8 ± 6.5 kg, VO2max 64.9 ± 4.8 ml · kg-1 · min-1 130).

Four weeks of training composed of two to four days with routine low-to-moderate intensity endurance training with high CHO availability and three days including two cycling sessions and CHO manipulation (i.e., Monday, Wednesday, and Friday).

The three days including CHO manipulation were composed of high-intensity interval training (HIIT) in the morning followed by 7 hrs of recovery and a moderate intensity cycling session in the afternoon. The HIIT session consisted of a 10-min warm-up, followed by eight 5-min cycling intervals, separated by two minutes of active recovery. The initial six intervals were accomplished with a target intensity of 85% of maximum heart rate (HRmax), while the final two 5-min blocks consisted of five 15s maximal sprints to recruit type II fibres, separated by 45s of active recovery.

WHAT THEY FOUND

- The intensified training period increased several autophagy markers suggesting an increased turnover of mitochondrial and cytosolic proteins. In permeabilized muscle fibers, mitochondrial respiration was ~20 % lower after training although some markers of mitochondrial density increased by 5-50%, indicative of a reduced mitochondrial quality by the intensified training intervention. The antioxidative proteins UCP3, ANT1, and SOD2 were increased after training, whereas we found an inactivation of aconitase. In agreement with the lower aconitase activity, the amount of mitochondrial LON protease that selectively degrades oxidized aconitase, was doubled.

Practical Takeaways

- The results suggest that mitochondrial respiratory function is impaired during the initial recovery from a period of intensified endurance training while mitochondrial quality control is slightly activated in highly trained skeletal muscle.

  Mitochondria, the "powerhouses of the cells," are structures that produce energy in the body. Mitochondrial capacity is a term used to describe the body's ability to generate energy. Greater mitochondrial capacity is one factor associated with increased athletic performance during endurance exercise. Previous research by scientists in Denmark and Sweden (see link below) found that untrained recreational athletes had a decrease in mitochondrial capacity after sprinting exercises.

- Other findings of the study included:
  - Reduced mitochondrial capacity did not affect exercise performance, which may indicate that oxygen delivery from the heart to the muscles plays a more important role than mitochondrial function in performance.
  - Expression of three proteins with strong antioxidant properties increased in the muscles after intense training.

Want to learn more?
Check this out...

Damian's Comments

"The surprise here was how the highly trained participants' mitochondrial capacity was impaired after the month-long training period. The authors thought that elite athletes should be more resistant against these kind of alterations.

Athletes may be able to prevent temporary mitochondrial impairment by listening to their bodies. Paying attention to changes such as "mood disturbances, reductions in maximal heart rate [during exercise] and muscles that feel heavy and unresponsive" may help athletes pull back and avoid overtraining situations that could contribute to reduced mitochondrial content and function, Larsen explained. "Exercise is good for you, but too much unaccustomed training might have mitochondrial consequences."

Technology & Profiling

This month's top research on technology and profiling

Modelling the relationships between arterial oxygen saturation, exercise intensity and the level of aerobic performance in acute hypoxia

Woorons, X., et al. European Journal of Applied Physiology 121, 2021.

A comparative analysis of critical power models in elite road cyclists

Boris, Paul., et al. Current Research in Physiology 4, 2021.

Cyclist aerodynamics through time: Better, faster, stronger

Malizia, F., et al. Journal of Wind Engineering and Industrial Aerodynamics. 214, 2021.

Abstract

Modelling the relationships between arterial oxygen saturation, exercise intensity and the level of aerobic performance in acute hypoxia

OBJECTIVE

The aim of this study was to establish a model to estimate the level of arterial oxygen saturation (SpO2) and help determine the appropriate hypoxic dose in humans exercising in acute hypoxia.

WHAT THEY DID

Fourteen men volunteered for this study. Seven of the participants were endurance-trained subjects (ETS) who practiced triathlon in competition. At the time of the experiment, they performed seven training sessions a week on average, for a weekly training volume of about 10 h. Their physical characteristics were age 27.2±6.5 years, height 177.3 ± 7.9 cm, weight 72.7 ± 7.6 kg and sealevel VȮ 2max 64.5±4.8 mL kg-1 min-1. The seven other participants were untrained subjects (UTS) with no or light physical activity (age 28.5 ± 3.2 years, height 178.3±6.2 cm, weight 79.2±9.4 kg and sea-level VȮ 2max 43.4 ± 5.1 mL kg-1 min-1). All subjects were sea-level natives and residents.

SpO2 values were collected in seven untrained (UTS) and seven endurance-trained male subjects (ETS) who performed six cycle incremental and maximal tests at sea level and at simulated altitudes of 1000, 1500, 2500, 3500 and 4500m. Oxygen uptake was continuously measured and maximal oxygen uptake VO2max was determined in each subject and at each altitude. Intensity was expressed as a percentage of VO2max.

WHAT THEY FOUND

- There were strong non-linear relationships between altitude and SpO2 at low, moderate and high intensity both in ETS and UTS (r = 0.97, p < 0.001).

  SpO2 was significantly correlated to exercise intensity at sea level and at all simulated altitudes in ETS but only from 2500m in UTS.

- There were inverse correlations between SpO2 and sea-level VO2max at all altitudes, which were stronger from 2500m and with the increase in exercise intensity.

  The three-variable model they established predicts (p < 0.001) the SpO2 level of individuals exercising in acute hypoxia based on their sea-level VO2max , the intensity of exercise and the altitude level.

Practical Takeaways

- The results show, in particular, the existence of a strong relationship between sea-level VȮ2max and the level of SpO2, mainly at high altitude (i.e.,≥2500 m) and at high exercise intensities. They also reveal that SpO2 is closely related to exercise intensity at sea level and at altitudes up to 4500m in endurance-trained subjects, unlike untrained ones.

  The results show that this model is highly significant to predict SpO2 in a given subject exercising at altitude based on his/her sea-level performance. Based on the collected data, the authors could establish a three-variable model for predicting or targeting the SpO2 level of individuals exercising in acute hypoxia based on their sea-level VO2max.

  An example of how this would work, a cyclist with a sea-level VO2max of 60 mL min-1 kg-1, corresponding to 300 W, who plans to exercise at 3000m and at 60% of his sea-level VO2max (i.e., 180 W) can expect a SpO2 of 82%. By reversing the equation, it is also possible to determine the exercise intensity or the level of altitude for a minimum or a maximum SpO2 level. For example, if the cyclist above exercises at the same altitude, he should not exceed an intensity of 88% of sea-level VO2max for his SpO2 not to drop below 80%. Likewise, if he cycles at the same exercise intensity, the altitude level should be between 1680 and 3500m for a SpO2 below 90% and above 80%, respectively.

- We don't have access to this model but such model may be useful in athletes using the LLTH method. It could help them avoid too strong arterial desaturation, and therefore the risk of acute mountain sickness, while obtaining a sufcient hypoxic stimulus (i.e., SpO2 below 90%). The use of SpO2 rather than the altitude per se could represent an interesting approach to individualise the hypoxic dose in humans exercising in hypoxia.

Damian's Comments

"The interplay of intensity, fitness & altitude as a stimulus is something that's not considered enough during altitude training because ideally a camp should have access to multiple altitudes with low intensity work done up high and high intensity work done low.

As this model demonstrates that the drop of SpO2 during exercise in acute hypoxia is larger with the increase in both sea-level VO2max and exercise intensity. The model could help make training decisions better across all altitudes. It also highlights that the pivotal altitude from which the fall in SpO2 is exacerbated is between 2000 and 2500m, depending on both sea-level VO2max and exercise intensity.

Finally, such model may help determine or target a SpO2 level compatible with a safe and efficient (acute) hypoxic training."

Abstract

A comparative analysis of critical power models in elite road cyclists

OBJECTIVE

The aims of this study were to compare four different critical power model's ability to ascertain critical power and W′ in elite road cyclists, while making comparison to power output at respiratory compensation point, work rate (J·sec-1) at Wmax, and the work done above critical power during the Wmax test in relation to the W′.

WHAT THEY DID

Ten male, nationally-internationally competitive endurance cyclists (3–15 years racing/training experience, age = 25 ± 5 years; height = 178.7 ± 3.5 cm; weight = 70.3 ± 7.7 kg; $\dot{V}O_{2}max$ = 71.9 ± 5.9 ml kg-1·min-1) all familiar with critical power testing, participated in 3 laboratory testing sessions comprising:

1. 15-s isokinetic (130 rpm) sprint on a Cyclus 2 ergometer (Avantronic, Leipzig, Germany), 1-min time trial, plus a ramp style test to exhaustion; and

2–3. A 4-min or 10-min self-paced maximal time trial separated by at least 24-h but limited to a 3-week period.

Thus, the efforts (1, 4, and 10-min) used to calculate critical power were in line with previous research on elite cyclists (Bartram et al., 2017).

WHAT THEY FOUND

- The main findings show that all critical power models provided different W′ ($F_{(1.061,8.486)}$ = 39.07, p = 0.0002) and critical powers ($F_{(1.022,8.179)}$ = 32.31, p = 0.0004), while there was no difference between each model's critical power and power output at respiratory compensation point ($F_{(1.155, 9.243)}$ = 2.72, p = 0.131).

  Differences between models or comparisons with respiratory compensation points were deemed not clinically useful in the provision of training prescription or performance monitoring if the aim is to equal work rate at compensation point.

  There was also no post-hoc difference between work completed at Wmax (kJ) (p = 0.890) and W′ using the nonlinear-3 model.

Practical Takeaways

- The main findings show that: (a) all critical power models provided significantly different W′ and critical powers; (b) there was no significant difference between each model's critical power and power output at respiratory compensation point; (c) differences between models or compared to respiratory compensation point were not clinically useful in the provision of training prescription or performance monitoring if the aim is to equal work rate at compensation point; and (d) converting Wmax test to work done (kJ) was not significantly different to W′ using the nonlinear-3 model.

- While there were no differences between the work rate at respiratory compensation point and critical power determined by each model, the ability to produce comparable results was unachievable. More detailed analysis deemed work rate at critical power inappropriate to prescribe training at a physiological transition as per respiratory compensation point. Likewise, W′ was significantly different between models, not related to work rate at Wmax or between critical power and Wmax as determined from an incremental, short staged ramp test to exhaustion.

  Further research is required to investigate the physiological markers of intensity associated with respiratory compensation point and critical power work rate and the bioenergetic contribution to W′.

Want to learn more?
Check these out...

Damian's Comments

"I don't think this paper is a reason to not use CP. Like all other measurements in human exercise physiology, there is technical errors and biological variability inherent in estimating it. When these are minimised by via consistent testing procedures CP is capable of separating exercise intensity domains.

If the CP is estimated using the conventional approach, important considerations include the number of trials and their duration. It is essential that athletes give their maximum effort in each trial and that cadence is consistent across all trials. Ideally, the shortest trial should be 2–3 min and the longest should be more than 10 but no longer than 15 min.

Minor differences are to be expected given that tests at different durations can only provide an approximation of the power to time relationship. These differences do not undermine the validity of CP but instead underline the importance of employing appropriate strategies to reduce any measurement errors."

Cyclist aerodynamics through time: Better, faster, stronger

OBJECTIVE

The goal of this paper is to demonstrate the evolution of aerodynamic knowledge in cycling from the early days to the most recent state-of-the-art to efficiently drive future studies. Therefore, this paper provides a comprehensive review of the history and state-of-the-art in cyclist aerodynamics, focused on three aspects:

(i) cycling flow topology and the wind influence;

(ii) the aerodynamics of a single cyclist and his/her wearable components; and

(iii) the aerodynamic interaction between a cyclist and other cyclists or nearby vehicles. Finally, some future perspectives about cyclist aerodynamics are provided.

WHAT THEY DID

This is a comprehensive review of cyclist aerodynamics throughout history starting in late 1800s and early 1900s; and going through until today.

The paper is structured as follows.

Section 2 provides some basic information about cycling fluid dynamics, flow topology and the impact of the environmental wind on cycling.

Section 3 focuses on the aerodynamics of a single cyclist and of wearable components like skinsuits and helmets.

Section 4 addresses the aerodynamics of multiple cyclists and the aerodynamic interaction between a cyclist and nearby vehicles such as cars and motorcycles.

Section 5 contains the conclusions and future perspectives.

WHAT THEY FOUND

- The paper indicates how, through the course of time, field tests, wind tunnel tests (WT) and computational fluid dynamics (CFD) simulations have made cyclists and their performances better, faster and stronger.

Practical Takeaways

- First, this review has shown that most research in cycling aerodynamics over the past decades has been performed by means of WT tests and field tests. However, especially in the past 10 years, the application of CFD to cycling aerodynamics has grown substantially, with studies focusing on cyclist positions, helmets and the interaction between multiple cyclists and between cyclists and nearby vehicles. This growth has been facilitated by the availability of high-fidelity and increasingly fast 3D body scanners and by the continuous increase and availability of computational power.

- The second item is that WT tests, CFD simulations and even field tests (either on an indoor track or outdoor velodrome) in the best case are a good representation of the reality under the specific conditions present in these tests or set in the simulations (e.g. meteorology, cyclist position, turbulence intensity). The reality of an actual race, especially outdoors, is evidently much more complicated, as the cyclist moves at different cycling speeds and yaw angles and is subjected to varying meteorological conditions, varying interaction with nearby cyclists and vehicles, varying environmental wind due to circuit or road geometry and wind shelter by nearby cyclists, buildings, trees, spectators, etc.

Damian's Comments

"All cyclists would be aware of the increasing focus on aerodynamics in every aspect of cycling. This paper is an amazing look at how far the study of aerodynamics has come.

It is worth a read but I will leave the final word about how this field is still progressing and what the future may hold to the authors."

"The complexity of cyclist aerodynamics does not only entail difficulties in terms of WT tests, CFD simulations, field testing and practical design considerations. It also provides continuing challenges and opportunities, as this complexity and the many degrees of design freedom that remain leave ample room for further aerodynamic innovations and improvements for the foreseeable future."

Nutrition

This month's top research on nutrition & supplements

The Effect of Dietary Supplements on Endurance Exercise Performance and Core Temperature in Hot Environments: A Meta-analysis and Meta-regression

Peel, J., et al. Sports Medicine. Online, 2021

Effect of Exercise-Diet Manipulation on Muscle Glycogen and its Subsequent Utilization During Performance*

Sherma, W., et al. International Journal of Sports Medicine. 2, 1981

Repeated High-Intensity Cycling Performance Is Unaffected by Timing of Carbohydrate Ingestion

Shei, R-J., et al. Journal of Strength and Conditioning Research. 32(8), 2018

*Classic study

Abstract

The Effect of Dietary Supplements on Endurance Exercise Performance and Core Temperature in Hot Environments: A Meta-analysis and Meta-regression

OBJECTIVE

The ergogenic effects of dietary supplements on endurance exercise performance are well-established; however, their efficacy in hot environmental conditions has not been systematically evaluated. This paper has to aims:

(1) To meta-analyse studies investigating the effects of selected dietary supplements on endurance performance and core temperature responses in the heat. Supplements were included if they were deemed to: (a) have a strong evidence base for 'directly' improving thermoneutral endurance performance, based on current position statements, or (b) have a proposed mechanism of action that related to modifiable factors associated with thermal balance. (2) To conduct meta-regressions to evaluate the moderating effect of selected variables on endurance performance and core temperature responses in the heat following dietary supplementation.

WHAT THEY DID

A search was performed using various databases in May 2020. After screening, 25 peer-reviewed articles were identified for inclusion, across three separate meta-analyses:

(1) exercise performance;

(2) end core temperature;

(3) submaximal core temperature. The moderating effect of several variables were assessed via sub-analysis and meta-regression.

WHAT THEY FOUND

- Overall, dietary supplementation had a trivial significant positive effect on exercise performance (Hedges' g = 0.18, 95% CI 0.007–0.352, P = 0.042), a trivial non-significant positive effect on submaximal core temperature (Hedges' g = 0.18, 95% CI - 0.021 to 0.379, P = 0.080) and a small non-significant positive effect on end core temperature (Hedges' g = 0.20, 95% CI - 0.041 to 0.439, P = 0.104) in the heat.
- There was a non-significant effect of individual supplements on exercise performance (P = 0.973) and submaximal core temperature (P = 0.599). However, end core temperature was significantly affected by supplement type (P = 0.003), which was attributable to caffeine's large significant positive effect (n = 8; Hedges' g = 0.82, 95% CI 0.433–1.202, P < 0.001) and taurine's medium significant negative effect (n = 1; Hedges' g = - 0.96, 95% CI - 1.855 to - 0.069, P = 0.035).

Practical Takeaways

Supplements such as caffeine and nitrates do not enhance endurance performance in the heat, with caffeine also increasing core temperature responses.

Some amino acids might offer the greatest performance benefits in the heat. Exercising in the heat negatively affected the efficacy of many dietary supplements, indicating that further research is needed and current guidelines for performance in hot environments likely require revision.

The supplements with the greatest ergogenic effect on exercise performance in the heat were AAs, with BCAAs (Hedges' g = 0.32, P = 0.232) and tyrosine (Hedges' g = 0.21, P = 0.404) having a small non-significant effect and taurine (Hedges' g = 0.55, P = 0.209) having a medium non-significant effect.

Damian's Comments

"This meta-analysis and meta-regression suggest the effectiveness of otherwise established ergogenic dietary supplements may be negated by the severity of hot environmental conditions.

Certain supplements, such as caffeine and nitrate, lack sufficient data to support their use as ergogenic aids in the heat. The most surprising is caffeine which also shows increasing core temperature responses.

The author's note that potential risk is posed to those in physical performance domains (i.e., athletes) due to the limited guidance on how to supplement appropriately for endurance exercise in hot environments."

Abstract

Effect of Exercise-Diet Manipulation on Muscle Glycogen and its Subsequent Utilization During Performance*

OBJECTIVE

This study examined the effect of three exercise-diet regimens on muscle glycogen supercompensation and subsequent performance during a 20.9-km run.

WHAT THEY DID

A diet containing 15% carbohydrate (,L), 50% CHO (M), or 70% CHO (H) was arranged in three trials as follows:

trial A = 3 days L, 3 days H;

trial B = 3 days M, 3 days H;

trial C = 6 days M.

For each trial a 5-day depletion-taper exercise sequence was conducted on the treadmill at 73% VO2max. The runs were 90, 40, 40, 20, and 20 mm, respectively. A day of rest preceded the 20.9-km performance run.

Muscle biopsies were obtained from the gastrocnemius on days 4 and 7 (both prior to and after the performance run).

WHAT THEY FOUND

Trials A, B, and C elevated muscle glycogen to 207, 203, and 159 mmol glucosyl units! kg wet tissue)mmG), respectively. The performance run in both trials A and B utilized significantly more glycogen than in trial C: 5.0 and 5.1 mmG/km vs. 3.1 mmG/km.

There were, however, no differences in either performance run times or post-performance run glycogen levels between the trials. These data demonstrate that (1) muscle glycogen can be elevated to high levels with a moderate exercise-diet regimen; (2) initial muscle glycogen levels influence the amount subsequently utilized during exercise; (3) carbohydrate loading is of no benefit to performance for trained runners during a 20.9-km run.

Practical Takeaways

This study found similar magnitudes of performance increases, but employed a much less severe protocol since it did not involve the exhaustive exercise and carbohydrate restriction phase of previous research. Sherman et al. found a carbohydrate intake of 5 g/kg of body mass for several days followed up by an even higher intake at 8 g/ kg body mass for three days produced similar effects compared to the more extreme glycogen supercompensation methods originally performed.

More recent work from Burke et al. has recommended carbohydrate intake ranges of 5 – 7 g/kg/day for general training needs and 7 – 12 g/kg/day for the increased needs of endurance athletes when performing intense physical exercise of 2 – 3 hours daily.

Want to learn more?
Check this out...

Damian's Comments

"We all know that carbohydrates are essential for more intense exercise, this classic study from 1980 helped define how much carbohydrates are needed.

This early work in this area used the invention of the needle biopsy technique that allowed a sample of fresh muscle tissue to be extracted and analyzed for glycogen content. This lead to research into the concept of glycogen supercompensation that typically employed very high levels of exercise and intensity in conjunction with various amounts of carbohydrates during the week leading up to an endurance event."

Abstract

Repeated High-Intensity Cycling Performance Is Unaffected by Timing of Carbohydrate Ingestion

OBJECTIVE

The purpose of this research study was to determine whether carbohydrate (CHO) feeding taken immediately before, early, or late during high intensity cycling affects time-time performance.

A second purpose was to decipher whether blood glucose response to CHO differed in reference to the time of ingestion.

WHAT THEY DID

This study used a repeated-measures, randomized, double-blinded experimental design.

A total of 16 trained, male cyclists performed 3-, 4-km cycling time trials (TT1, TT2, and TT3) separated by 15 minutes of active recovery on 4 separate occasions.

Carbohydrate feeding (An 80 g) was given either

15 minutes before TT1 (PRE1),
15 minutes before TT2 (PRE2),
15 minutes before TT3 (PRE3), or
not at all (control, CTL). Sugar free sweet placebo was given during the control.

WHAT THEY FOUND

There were no significant interactions between conditions and time for Pmean or TTC. There was also no significant difference among conditions. A significant main effect for time was found for Pmean and TTC.
All performances decreased following TT1. Pmean was significantly higher for TT1 than TT2 ($p=0.001$) and TT3 ($p=0.004$). Pmean for TT2 was not significantly different for TT3 ($p=0.69$). TTC1 was completed significantly faster than TT2 ($p=0.01$).
Significant interaction effects were found for blood glucose ($p=0.001$). PRE ingestion did not have an impact on blood glucose relative to control. Inter-trial ingestion of carbodyrates resulted in blood glucose elevation during the subsequent trial. PRE2 blood glucose was significantly greater for TT2 than TT1 ($p=0.006$), TT3 compared to TT1 ($p=0.001$), and TT3 compared to TT2 ($p=0.01$). PRE3 blood glucose was significantly elevated for TT3 compared to TT1($p=0.001$) and TT2 ($p=0.001$). Blood glucose for PRE1 was significantly greater prior to TT1 compared to PRE3. Lastly, blood glucose for TT3 in PRE2 and PRE3 were significantly greater than the control ($p=0.001$)

Practical Takeaways

The main finding of this study was CHO feeding, regardless of timing, failed to produce performance benefits in trained cyclists. The data did demonstrate various timing of CHO ingestion produced rises in blood glucose during subsequent time trials. This rise in blood glucose failed to play a role in improving performance.

The fact Pmean decreased following TT1 indicates fatigue was not attenuated via CHO ingestion. The reason for this failure may be due to the intensity of exercise. In this study, the high-intensity nature of the time trial may have caused a preferential shift to use muscle glycogen rather than blood glucose as a fuel source. The inter-trial ingestion of carbohydrates may have been affected by a blunted insulin response, resulting in a failure to shuttle CHO into the muscles.

Future work should include insulin levels to reaffirm this theory. The authors acknowledged most of the work done on CHO has used glucose as the main source. The authors used sucrose because of its ability to upregulate CHO transport from the gut. They also acknowledged the potential role of a particular CHO may influence performance. The authors chose 80 g of sucrose to provide ~ 1.2 g/kg, which has been shown to replenish CHO.

In conclusion, it appears carbohydrate ingestion, regardless of timing does not appear to influence anaerobic repeat performance in trained cyclists.

Future work should focus on determining the impact of different CHO types, exercise modes, and diet.

Damian's Comments

"This study was simple, yet practical. The authors came up with a study that can be applied to many different settings. It doesn't appear acute ingestion of CHO impacts anaerobic performance.

It will be interesting if future research is in agreement with the authors' hypothesis that muscle glycogen is most likely the preferred energy source vs. blood glucose.

It appeared the CHO was difficult for the body to digest during the exercise. This was shown as the blood glucose remained sustained for periods longer than anticipated. This is probably because the decreased rate of digestion, thus greater sustained release of CHO.

For now, it appears if an athlete is at risk for being in a state of reduced muscle glycogen, loading may be effective (via supercompensation). If they are not, then carbohydrate timing and loading will probably be ineffective."

Strength

The latest in strength research

Aerobic exercise intensity does not affect the anabolic signaling following resistance exercise in endurance athletes

Jones, T., et al. Scientific Reports. Online (11), 2021

Abstract

Aerobic exercise intensity does not affect the anabolic signaling following resistance exercise in endurance athletes

OBJECTIVE

The 'interference effect' describes attenuated strength development within a concurrent strength and endurance training paradigm, in comparison to that following isolated resistance training. This conflict between opposing sides of the training adaptation continuum can be troublesome for elite and recreational athletes alike.

The aims of this study were twofold. Firstly, to examine whether combining strength and endurance training (independent of intensity) results in the inhibition of anabolic signaling proteins, relative to strength stimuli performed in isolation.

Secondly, to observe whether the intensity of the endurance stimuli influences the phosphorylation of signaling proteins associated with the mTOR and AMPK networks. These aims were addressed in a sample of endurance trained, yet strength training naïve cyclists, under more rigorous dietary control than previous work investigating concurrent training and signaling. It was hypothesized that greater phosphorylation of the mTOR and AMPK networks would be observed following more intense endurance stimuli.

WHAT THEY DID

The study utilised a within-subject, repeated measures design.

Eight males (age 32 ± 5 years; stature 1.79 ± 0.04 m; mass 70.6 ± 7.0 kg; V̇O2peak 55.4 ± 7.1 ml·kg-1·min-1; power output at V̇O2peak 358 ± 28 W).

All participants were trained endurance cyclists with 4 ± 3 years competitive cycling experience, were currently performing 4 ± 1 cycling training sessions·wk-1 and were regularly competing (at least a Category 3 British Cycling license holder or an estimated 16.1 km time trial of ≤ 23 min).

(1) resistance exercise (RES), 6 × 8 squats at 80% 1-RM;

(2) resistance exercise and moderate intensity cycling of 40 min at 65% V̇O2peak, (RES + MIC);

(3) resistance exercise and high intensity interval cycling of 40 min with 6 alternating 3 min intervals of 85 and 45% V̇O2peak (RES + HIIC), in a cross-over design.

WHAT THEY FOUND

- There was a main effect of condition for AMPKα2T172 ($p = 0.041$), with a greater response in RES + MIC, relative to both RES + HIIC ($p = 0.026$) and RES ($p = 0.046$).

There were no other condition effects for the remaining protein kinases assessed ($p > 0.05$).

These data do not support a molecular interference effect in cyclists under controlled conditions. There was no intensity-dependent regulation of AMPK, nor differential activation of anabolism with the manipulation of endurance exercise intensity.

Practical Takeaways

The major findings were that 1) despite differential AMPK and mTOR signaling between conditions, this was not suggestive of a molecular interference effect i.e., an antagonistic relationship; 2) despite differential activation status of the AMPK and mTOR signaling cascades, this did not support the hypothesis of an intensity-dependent regulation of AMPK.

In conclusion, these data do not support an acute molecular interference effect in a trained endurance cohort. The data also fail to support the intensity-dependent regulation of AMPK, when comparing a work and duration-matched moderate and high intensity concurrent exercise stimulus. Finally, the findings add to the growing body of literature, suggestive of mTORC1 and AMPK to be poor correlates to investigate the mechanism explaining concurrent interference, particularly in an acute exercise paradigm.

- These data suggest that endurance athletes need not be concerned with the intensity of their endurance session (moderate vs. high intensity) affecting their strength adaptation, when the two exercise modes are performed in close proximity to one another.

Damian's Comments

"This is an interesting area as strength training is something I have struggled to prescribe consistently as a coach. From my personal experience I would say it can have a big impact, especially in terms of being able to complete the planed work with sufficient quality. So these acute signalling studies rarely gives a complete picture.

But it does help confirm that finding a training rhythm that works mentally and practically outweighs any small interference effects. So if you are a trained endurance athlete worrying about the optimal timing of strength training sessions, the best advice may well be to stop worrying as the endurance/strength session signalling "interference" problem is perhaps overrated.

Some limitations of this study are the 'low' V02max of the subjects and the short endurance sessions of 40 minutes, and low intensity 'HIIT' sessions of 6 x 3 minutes just below FTP. So I would like to see this study replicated with elite athletes and larger training intensities and volumes.

Nevertheless good to have confirmation that for cycling there might not be much to worry about."

List

These are the papers that did not make it into the Digest.

Post-Exercise Ingestion of Low or High Molecular Weight Glucose Polymer Solution Does Not Improve Cycle Performance in Female Athletes

Maintaining Power Output with Accumulating Levels of Work Done Is a Key Determinant for Success in Professional Cycling

Acute Effects of Work Rest Interval Duration of 3 HIIT Protocols on Cycling Power in Trained Young Adults

The effects of pre- and per-cooling interventions used in isolation and combination on subsequent 15-minute time-trial cycling performance in the heat

Beta-alanine did not improve high-intensity performance throughout simulated road cycling

Effects of Including Sprints in LIT Sessions during a 14-d Camp on Muscle Biology and Performance Measures in Elite Cyclists

Heart rate variability kinetics during different intensity domains of cycling exercise in healthy subjects.

Fragile bones of elite cyclists: to treat or not to treat?

Comparison of coach-athlete perceptions on internal and external training loads in trained cyclists

Distinct pacing profiles result in similar perceptual responses and neuromuscular fatigue development: Why different "roads" finish at the same line?

The Aerobic and Anaerobic Contribution During Repeated 30-s Sprints in Elite Cyclists

The effect of β-alanine supplementation on high intensity cycling capacity in normoxia and hypoxia

Training wearing thermal clothing and training in hot ambient conditions are equally effective methods of heat acclimation

Functional Threshold Power: Relationship With Respiratory Compensation Point and Effects of Various Warm-Up Protocols

High-intensity exercise training — too much of a good thing?

No evidence of association between HRV and training load in a pool of professional athletes before, during, and after the first COVID-19 lockdown.

A Systematic Review on Markers of Functional Overreaching in Endurance Athletes

The Effects of an Acute "Train-Low" Nutritional Protocol on Markers of Recovery Optimization in Endurance-Trained Male Athletes

Carbohydrate-Restricted Exercise With Protein Increases Self-Selected Training Intensity in Female Cyclists but Not Male Runners and Cyclists

Temperate performance and metabolic adaptations following endurance training performed under environmental heat stress

Effect of Exercise-Induced Reductions in Blood Volume on Cardiac Output and Oxygen Transport Capacity

Relationship Between Critical Power and Different Lactate Threshold Markers in Recreational Cyclists

Effect of heat pre-conditioning on recovery following exercise-induced muscle damage

Morning Preconditioning Exercise Does Not Increase Afternoon Performance in Competitive Runners

Heart rate dynamics and lactate following high-intensity race-pace continuous vs interval workouts in highly trained athletes

Effect of acute altitude exposure on ventilatory thresholds in recreational athletes

How Much Sleep Does an Elite Athlete Need?

Thanks for reading

Next issue will be published on the first of next month.

If you liked all the great content, then make sure to share it and spread the knowledge to your friends and colleagues who you know will also find it useful!

Cheers!
Damian

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