SEMIPRO CYCLING

JANUARY 2021 | ISSUE #01

CYCLING SCIENCE

DIGEST

A MONTHLY SUMMARY OF THE LATEST CYCLING PERFORMANCE RESEARCH

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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 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 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...

SEMIPRO Cycling

SEMIPRO CYCLING

Welcome

If you're reading this right now, then I am seriously honoured you decided to invest in yourself and join SEMIPRO+. 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. It's hard to not mention this is the first edition of the Cycling Science Digest. After offering a similar publication to cycling coaches over 6 years ago I am happy to be returning to a publication that will hopefully grow into the go-to cycling science research resource for cyclists, coaches, and all others involved in cycling performance. It seems that now is the right time to launch this digest as the world has only gotten louder since the last version of this publication and the need for trusted curation has only become more important.

2. In this edition the research is split into Performance, Technology & Profiling, Nutrition, and a classic exercise study to remind us that good science never ages. These topics may evolve over time - I am certainly open to requests. But right now they cover some of the most cutting-edge research being done that we can use right now.

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

The Effect of Cycling-specific Vibration on Neuromuscular Performance

Viellehner, J., et al. Medicine & Science in Sports & Exercise. Ahead of Print, 2020.

Less Is More—Cyclists-Triathlete’s 30 min Cycling Time-Trial Performance Is Impaired With Multiple Feedback Compared to a Single Feedback

Bayne, F., et al. Frontiers in Psychology, 2020.

Time Course of Recovery after Cycling Repeated Sprints

Milioni, F., et al. Medicine & Science in Sports & Exercise. Publish Ahead of Print, 2020.

Abstract

The Effect of Cycling-specific Vibration on Neuromuscular Performance

OBJECTIVE

This study aimed to provide an understanding of how surface-induced vibrations in cycling interfere with short-term neuromuscular performance.

In other words, how does riding a road bike on rough surfaces impact your muscles?

WHAT THEY DID

The study was conducted as a cross-sectional single cohort trial.

Thirty trained cyclists participated (mass 75.9 ± 8.9 kg, body height 1.82 ± 0.05 m, VO2max 63 ± 6.8 ml/min/kg).

The experimental intervention included a systematic variation of the two independent variables, vibration and cranking power from individual low to submaximal intensity.

Designed to simulate the metabolic and muscular demands of pedaling at different intensities over rough roads and cobblestones. The cyclists pedaled at various intensities meant to simulate a race situation on a bike attached to two plates that sent vibrations into the front and rear dropouts to replicate what they would experience riding over uneven road surfaces while researchers measured their heart rate, oxygen use, and muscle activation in their arms, legs, and torso.

WHAT THEY FOUND

- The main findings show that all the supporting muscles that normally are not engaged with road riding are used when the road gets rough.
- Activity in the calves, triceps, and forearms especially increased while pedaling on a vibrating bike.
- Pedaling through vibration also took more energy. Oxygen consumption (+2.7%) and heart rate (+ 5 - 7%) increased significantly in the presence of vibration.
- Vibration is a full-body phenomenon. However, the impact of vibration on propulsion is limited as the main propulsive muscles at the thigh are not majorly affected. The demands on the cardiopulmonary and respiratory system increased slightly in the presence of vibration.

Practical Takeaways

- Quantifying the cost of riding on rough roads helps us prepare better for the specific demands of rides and races. The body is working hard to stabilise and move around the terrain.
- The big takeaway is to train the demands of the event. You cannot just race a Roubaix or gravel event without spending time on the road surface you will be riding on in the event. This also means matching the increased energy demands for similar distances on the road. It is also important to practise eating over rough terrain as well.
- Finally, it might be worth the extra weight penalty of wider, tubeless tires, and any other ways to dampen the impact of rough roads. Much like the new breed of mountain bikes, weight is not everything, even if you want to ride fast.

Want to learn more?
Check this out...

Damian's Comments

"It's no surprise to read that the vibrations from riding road bikes or gravel bikes on rough surfaces make supporting muscles in the calves, forearms, and triceps work harder than they do on the road. It is good to get some numbers on how much extra work you have to do on these surfaces, though.

It makes me think twice about just copying a road bike set up for gravel riding. Or wrapping an extra layer of bartape is justified.

It may be hard to quantify the extra weight from wider tires etc. except for subjective feelings of fatigue. But this study definitely makes me want to sacrifice some weight for comfort to see what the difference really is."

Abstract

Less Is More—Cyclists-Triathlete's 30 min Cycling Time-Trial Performance Is Impaired With Multiple Feedback Compared to a Single Feedback

OBJECTIVE

The purpose of this article was to compare different modes of feedback (multiple vs. single) on 30 min cycling time-trial performance in non-cyclists and cyclists-triathletes, and investigate cyclists-triathlete's information acquisition.

WHAT THEY DID

20 participants (10 non-cyclists, 10 cyclists-triathletes) performed two 30 min self-paced cycling time-trials (~5–7 days apart) with either a single feedback (elapsed time) or multiple feedback (power output, elapsed distance, elapsed time, cadence, speed, and heart rate).

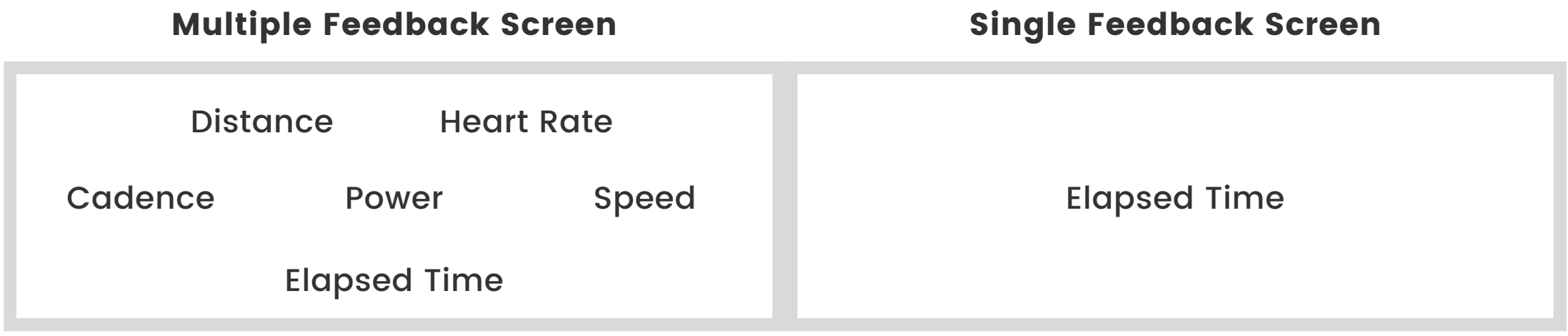
Cyclists-triathlete's information acquisition was also monitored during the multiple feedback trial via an eye tracker.

Perceptual measurements of task motivation, ratings of perceived exertion (RPE) and affect were collected every 5 min.

Performance variables (power output, cadence, distance, speed)and heart rate were recorded continuously.

WHAT THEY FOUND

- Cyclists-triathletes average power output was greater compared to non-cyclists with both multiple feedback (227.99 ± 42.02 W; 137.27 ± 27.63 W; P < 0.05) and single feedback (287.9 ± 60.07 W; 131.13 ± 25.53 W).
- Non-cyclist's performance did not differ between multiple and single feedback (p > 0.05).
- Cyclists-triathletes 30 min cycling time-trial performance was impaired with multiple feedback (227.99 ± 42.02 W) compared to single feedback (287.9 ± 60.07 W; p < 0.05), despite adopting and reporting a similar pacing strategy and perceptual responses.
- Cyclists-triathlete's primary and secondary objects of regard were power (64.95 s) and elapsed time (64.46 s). However, total glance time during multiple feedback decreased from the first 5 min (75.67 s) to the last 5 min (22.34 s).



Practical Takeaways

- It's noted by the researchers that experienced cyclists' indoor 30 min cycling TT performance was impaired with multiple feedback compared to single feedback. Experienced cyclists glanced at power and time which corresponds. The impairment may be related to a mental overload from the multiple feedback variables as information acquisition decreased over time.
- Overloading athletes with feedback is not recommended for cycling performance. Thus, cyclists-triathletes may find benefit from selecting a single feedback variable to inform performance during training and competition compared to using multiple feedback variables together.

Want to learn more?
Check this out...

Damian's Comments

"This article gives athletes and coaches a simple takeaway - select and display one metric when riding a maximal effort time-trial.

This research is a good starting point but as noted by the researchers, "real-world road races use distance-based goals...Therefore, future research should investigate...real road-based cycling events. In addition, during competition experienced cyclists may prefer to ride blind and rely on concurrent feedback from their coach via an earphone. However, the benefit of this type of feedback on performance is yet to be explored in a laboratory or real road-based setting."

Two other findings interest me. The fact that power output and time were the most favored feedback types and they might do further research to determine which type of feedback (Power or Time) contributes to optimal performance. And the unexplained reduction in time spent looking at multiple feedback decreased over time.

Two areas that would help focus these initial findings."

Abstract

Time Course of Recovery after Cycling Repeated Sprints

OBJECTIVE

This study investigated the recovery of performance and neuromuscular fatigue after cycling repeated-sprints.

Enhancing recovery from hard training and competition is an integral aspect of improving athletic performance. Incorporating appropriate recovery strategies after exercise is believed to enhance subsequent performance.

Finding ways to quantify recovery after specific types of workouts becomes a great way to plan training to maximise performance gains.

WHAT THEY DID

Ten participants performed two sessions of repeated-sprints (one session: 10×10 second sprints, 30 seconds recovery) separated by 24 hours and two sessions separated by 48 hours. The recovery condition (i.e. 24 h or 48 h) was randomized and separated by one week. All sessions were performed on a recumbent bike, allowing minimal delay between sprints termination and neuromuscular measurements.

Neuromuscular function of knee extensors was assessed prior to sessions (Pre-session), after 5th sprint (Mid-session), and immediately after (Post-session). Prior to sessions, baseline Neuromuscular function of knee extensors were also carried out on an isometric chair. The Neuromuscular function of knee extensors (bike and chair) were composed of maximal isometric voluntary contraction of knee extension (MVC) and peripheral neuromuscular stimulation during the MVC and on relaxed muscle.

WHAT THEY FOUND

- The sprints performance were not significantly different between sessions and did not present significant interaction between recovery conditions.
- Maximal isometric voluntary contraction of knee extension was significantly lower 24 hours after the second sprint session(-6.5±8.8%) and 48 hours after the second sprint session (-5.6±8.2%), while resting potentiated high-frequency doublet was lower 24 hours after the second sprint session compared to 24 hours after the first sprint session (-10.4±8.3). There were significant reductions in MVC (>30%) and resting potentiated high-frequency doublet (>38%) from Pre- to Post-session in all sessions.
- Overall, cycling repeated-sprints induce significant fatigue, particularly at the peripheral level, which is fully restored after 48 h, but not 24 h, of recovery.

Practical Takeaways

This study helps when planning short repeated sprint workouts. And confirms a common practice of leaving to days for full recovery after a sprint workout. This is not the end of the story, though. Recently the impact of sprint training was assessed with muscle typology in mind.

Another study specifically wanted to know if athletes with more fast-twitch fibres had greater fatigue during a sprint-interval training session than athletes with more slow-twitch fibres? They took 20 trained cyclists and split them based on their muscle fibre type. Each group performed 3×30 second Wingate sprints. Five hours following the workout, each athlete performed repeated muscle testing.

The expected results were seen from the Wingates themselves. But the most practical finding was that the slow twitch and fast twitch groups were dramatically different in how they recovered over the course of 5 hours following this workout.

In the slow-twitch group, there was a slight decrease in maximal knee extension torque at 10 minutes into recovery, but this group recovered to pre-workout levels by 20 minutes. In contrast, the fast-twitch group had a much greater torque reduction at 10 minutes, and torque was still significantly lower than pre-workout levels even 5 h into recovery.

- Short term recovery time following a sprint interval training session is dependent on your muscle fibre typology. It really needs to be factored into how training sessions are distributed in a week. Fast-twitch athletes may require more recovery between workouts. Given that recovery between sessions is considerably slower compared to slow-twitch athletes. And here's where training philosophy may be important. For fast-twitch athletes, when hitting a build phase a polarized approach may work better when doing these types of efforts. While slow twitch athletes may be able to maintain some threshold or sweet spot training in this same period.

Want to learn more?
Check these out...

Damian's Comments

""Having ways to quantify fatigue on a specific system is a positive step towards prescribing an appropriate amount of rest between hard training workouts. Taking this further by understanding how muscle typology impacts these same types of workouts gets us even closer to the personalisation of training.

Uncovering these types of findings highlights in some ways confirms what coaches and athletes have already known to some extent. It does reduce the time it takes to learn how you best respond to training as these things develop over years not weeks - it can shorten the process of truly personalising training. It's early days though, and while I look forward to the day I can do this on day one with a new athlete - until then it's back to the old ways of figuring out what works and what doesn't."

09

Technology & Profiling

This month's top research on technology and profiling

Muscle Typology of World-Class Cyclists across Various Disciplines and Events

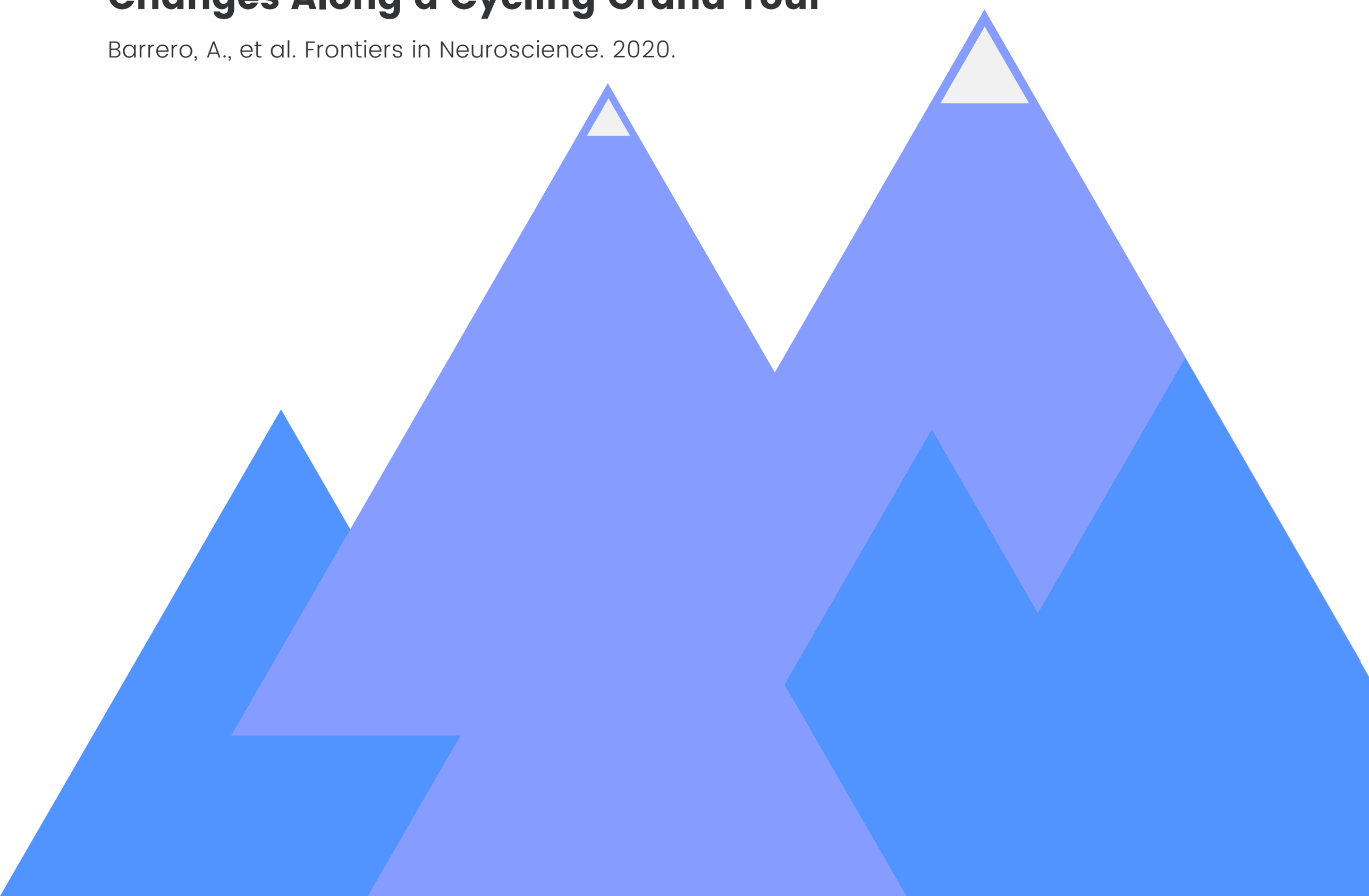
Lievens, E., et al. Medicine & Science in Sports & Exercise. Ahead of Print, 2020.

Training Characteristics and Power Profile of Professional U23 Cyclists throughout a Competitive Season

Leo, P., et al. Sports. 8(12), 167, 2020.

Modeling Stress-Recovery Status Through Heart Rate Changes Along a Cycling Grand Tour

Barrero, A., et al. Frontiers in Neuroscience. 2020.



Abstract

Muscle Typology of World-Class Cyclists across Various Disciplines and Events

OBJECTIVE

Classical track-and-field studies demonstrated that elite endurance athletes exhibit a slow muscle typology, while elite sprint athletes have a predominant fast muscle typology. In elite cycling, conclusive data on muscle typology are scarce, which may be due to the invasive nature of muscle biopsies. The non-invasive estimation of muscle typology through the measurement of muscle carnosine enabled the researchers to explore the muscle typology of 80 world-class cyclists of different disciplines.

WHAT THEY DID

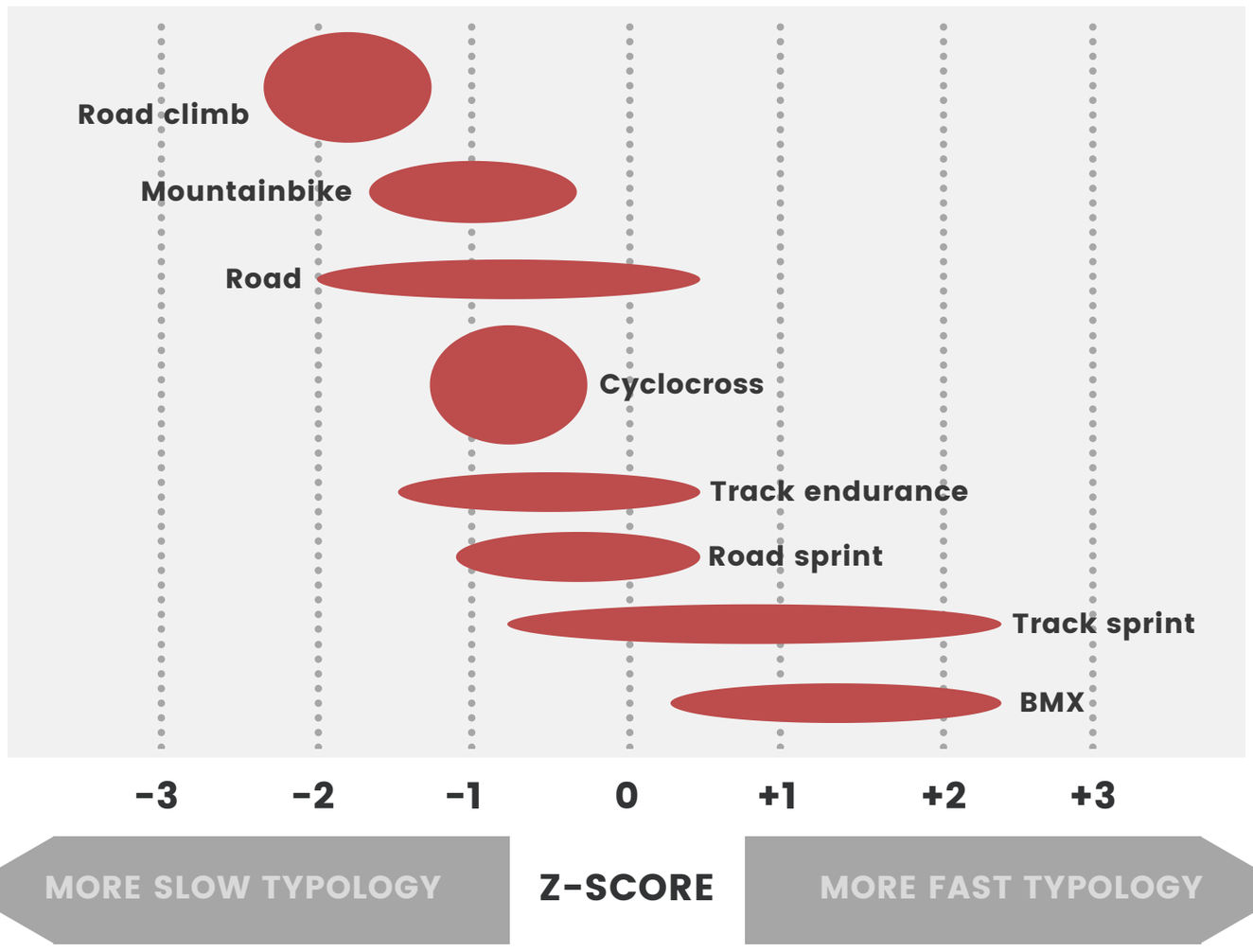
The muscle carnosine content of 80 cyclists (4 bicycle motor cross racing (BMX), 33 track, 8 cyclo-cross, 24 road and 11 mountain bike) was measured in the soleus and gastrocnemius by proton magnetic resonance spectroscopy and expressed as a z-score relative to a reference population. Track cyclists were divided into track sprint and endurance cyclists based on their UCI-ranking. Moreover, road cyclists were further characterized based on the percentage of UCI points earned during either single- and multi-stage races.

WHAT THEY FOUND

- BMX cyclists (carnosine aggregate z-score of 1.33) are characterized by a faster muscle typology than track, cyclo-cross, road and mountain bike cyclists (carnosine aggregate z-score of −0.08, -0.76, -0.96 and −1.02, respectively: $P<0.05$). Track cyclists also possess a faster muscle typology compared to mountain bikers ($P=0.033$) and road cyclists ($P=0.005$). Moreover, track sprinters show a significant faster muscle typology (carnosine aggregate z-score of 0.87) compared to track endurance cyclists (carnosine aggregate z-score of -0.44) ($P<0.001$). In road cyclists, the higher the carnosine aggregate z-score, the higher the percentage of UCI points gained during single-stage races ($r=0.517$, $P=0.010$).

- Prominent differences in the non-invasively determined muscle typology exist between elite cyclists of various disciplines, which opens opportunities for application in talent orientation and transfer.

Muscle Typology of World-Class Cyclists



Practical Takeaways

- The most practical application of these classifications is talent identification. Are you in the wrong discipline?

- It can also be used to identify discipline overlap and inform your choices about which other cycling disciplines you might be successful at. We can see this with a rider like Mathieu Van Der Poel. Coming from a cyclocross background is beneficial to both mountain bike and road sprinting.

Want to learn more?
Check these out...

Damian's Comments

"This new method of estimating fiber composition makes it so easy to get tested we might see it as commonplace for coaches and athletes. It will certainly help with identification and mapping training interventions. One to keep an eye on for sure"

Abstract

Training Characteristics and Power Profile of Professional U23 Cyclists throughout a Competitive Season

OBJECTIVE

The purpose of this study was to investigate differences in the power profile derived from training and racing, the training characteristics across a competitive season and the relationships between training and power profile in U23 professional cyclists.

WHAT THEY DID

Thirty male U23 professional cyclists (age, 20.0 ± 1.0 years; weight, 68.9 ± 6.9 kg; V̇O2max, 73.7 ± 2.5 mL·kg-1·min-1) participated in this study.

The cycling season was split into pre-, early-, mid- and late-season periods. Power data 2, 5, 12 minute mean maximum power (MMP), critical power (CP) and training characteristics (Hours, Total Work, eTRIMP, Work·h-1, eTRIMP·h-1, Time<VT1, TimeVT1-2 and Time>VT2) were recorded for each period.

Power profiles derived exclusively from either training or racing data and training characteristics were compared between periods. The relationships between the changes in training characteristics and changes in the power profile were also investigated.

WHAT THEY FOUND

The absolute and relative power profiles were higher during racing than training at all periods.

Training characteristics were significantly different between periods, with the lowest values in pre-season followed by late-season. Changes in the power profile between early- and mid-season significantly correlated with the changes in training characteristics.

These findings reveal that a higher power profile was recorded during racing than training. In addition, training characteristics were lowest in pre-season followed by late-season. Changes in training characteristics correlated with changes in the power profile in early- and mid-season, but not in late-season.

Practical Takeaways

Overall, the researchers believe practitioners should consider the influence of racing on the derived power profile and adequately balance training programs throughout a competitive season. Given that they found a higher absolute (4.6–8.5%) and relative (4.2–8.4%) power profile was recorded during racing than training for all periods of the season.

The study suggests that power outputs recorded in training and racing may not be reflective of a true maximal power profile in U23 professional cyclists. So it is recommended to verify field-derived MMP values with a minimum of two maximum effort field tests per season (i.e. CP tests) for baseline comparisons.

In summary, MMP and CP values derived from racing efforts in combination with a prior CP field test may offer the best way to longitudinally monitor the power profile in elite cyclists.

Another practical recommendation is that as racing is introduced in early-season, total work should not be further increased; to achieve this, a reduction in the intensity of the overall volume may be beneficial. This approach would also induce a shift towards a polarized training intensity distribution. This is evidenced in the relationship between the change in the power profile and training characteristics from early- to mid-season.

Want to learn more?
Check these out...

Damian's Comments

"This study is a good reminder that nothing beats regular testing when setting power numbers for training zones etc. It is also a good reminder to be mindful of context when deciding what data to use when prescribing training. Having a way to separate training, racing and tests may be a way to fix the confusion - but regular testing really is the best way.

The recommendation to cap total work by reducing intensity when racing starts is a good practical starting point for offsetting fatigue later on in the season. It provides a way to balance the documented increase in intensity that will take place mid-season. It is important to note here that what you lose in specificity in training may be gained in end of season performance. And it is important to balance the two."

Abstract

Modeling Stress-Recovery Status Through Heart Rate Changes Along a Cycling Grand Tour

OBJECTIVE

This study used multivariable linear models using fitness, load, and wellness to provide a new tool for coaches to help them to assess the athlete's individual fatigue level. To do this they used Heart rate (HR) and HR variability (HRV), workload, and a Perceived Fatigue Evaluation (Well-being Questionnaire).

The study's overall aim was to quantify the correlation between:

- the change in HR and HRV indices during an active orthostatic test
- subjective/objective fatigue, physical load, and training level indicators.

Then formulate a model predicting the stress-recovery status based on subjective/objective fatigue indicators, physical load, and training levels.

WHAT THEY DID

Ten female cyclists traveled the route of the 2017 Tour de France, comprising 21 stages of 200 km on average. From 4 days before the beginning of the event itself, and until 1 day after its completion. Every morning, with spontaneous breathing, each cyclist was subjected to HR and HRV measurements while fasted. And completed two successive phases of the test: 7 min in a supine position followed by 7 min in standing position.

The correlation between HR and HRV indices and subjective/objective fatigue, physical load, and training level indicators was then computed.

Finally, several multivariable linear models were tested to analyze the relationships between HR and HRV indices, fatigue, workload, and training level indicators.

WHAT THEY FOUND

The results highlight that variation in HR and HRV indices when changing from supine-to-standing position during an active orthostatic test is strongly correlated with the fatigue status.

HR changes appeared as a reliable indicator of stress-recovery status. Fatigue, training level, and defined as the difference between standing and supine mean RR intervals (the difference between each heartbeat) and LnRMSSD (the root-mean-square difference of successive normal RR intervals) displayed a linear relationship.

The proposed model can help to directly assess the adaptation status of an athlete from RR measurements and thus to anticipate a decrease in performance due to fatigue, particularly during a multistage endurance event.

Practical Takeaways

A decrease in the value of HRV indices is a marker of weak adaptability of the cardiovascular system to stress conditions that it faces. The active orthostatic test is recommended to study HRV in athletes. From the results, it seems that the higher the difference between supine and standing positions, the better is the cardiovascular adaptability to orthostatic stress.

The data also underlined the importance of the pre-event training level to explain the HR adaptability change during a cyclist's multistage event.

The model proposed allowed the researchers to understand the ability to adapt to a repeated endurance exercise.

If the measured difference of the mean time interval between two successive heart beats between supine and standing positions was computed is lower than predicted by the model, they could conclude that the imbalance of stress-recovery status is higher than perceived by the athlete in this context of a cyclist multistage event.

Finally, they also presented this model as more accessible for coaches and team managers, connecting HR changes to a single indicator of fatigue. However, the robustness of this model appears low, and it should be used with caution.

Want to learn more?
Check these out...

Damian's Comments

It's encouraging to see researchers using multivariable models to predict performance. The body (and life) is complex we need complex models, hence the need for something like multivariate models and the closely related machine learning (machine learning offers a range of appropriate non-linear modelling tools). Both of these are part of the future of sports performance prediction.

Why? We need to move past Banister's fitness and fatigue model to describe the relationship between training and performance. The impulse-response models are overly simplified and have not been linked to underlying physiological processes.

Creating robust prediction models is an ongoing task - and a hard one at that. Just see the supplementary reading links to see why. But it's encouraging to get good results and see researchers using parameters specific to cycling.

Nutrition

This month’s top research on nutrition

Effect of citrulline on post-exercise rating of perceived exertion, muscle soreness, and blood lactate levels: A systematic review and meta-analysis

Rhim, H, C., et al. Journal of Sport and Health Science 9 (6), 2020.

Abstract

Effect of citrulline on post-exercise rating of perceived exertion, muscle soreness, and blood lactate levels: A systematic review and meta-analysis

OBJECTIVE

Citrulline is one of the non-essential amino acids that is thought to improve exercise performance and reduce post-exercise muscle soreness. They conducted a systematic review and meta-analysis to determine the effect of citrulline supplements on the post-exercise rating of perceived exertion, muscle soreness, and blood lactate levels.

WHAT THEY DID

A random effects model was used to calculate the effect sizes due to the high variability in the study design and study populations of the articles included. A systematic search of PubMed, Web of Science, and ClinicalTrials.gov was performed.

Eligibility for study inclusion was limited to studies that were randomized controlled trials involving healthy individuals and that investigated the acute effect of citrulline supplements on rating of perceived exertion, muscle soreness, and blood lactate levels.

The supplementation time frame was limited to 2 h before exercise. The types and number of participants, types of exercise tests performed, supplementation protocols for L-citrulline or citrulline malate, and primary (RPE and muscle soreness) and secondary (blood lactate level) study outcomes were extracted from the identified studies.

WHAT THEY FOUND

- The analysis included 13 eligible articles including a total of 206 participants. The most frequent dosage used in the studies was 8 g of citrulline malate.
- Citrulline supplementation significantly reduced RPE ($n = 7$, $p = 0.03$) and muscle soreness 24 hours and 48 hours after post-exercise ($n = 7$, $p = 0.04$; $n = 6$, $p = 0.25$, respectively).
- However, citrulline supplementation did not significantly reduce muscle soreness 72 hours post-exercise ($n = 4$, $p = 0.62$) or lower blood lactate levels ($n = 8$, $p = 0.17$).

Citrulline supplements significantly reduced post-exercise RPE and muscle soreness without affecting blood lactate levels.

Practical Takeaways

- Citrulline supplements are effective in reducing post-exercise rating of perceived exertion (RPE) and muscle soreness.
- A total of 3-4 g of L-citrulline or 8 g citrulline malate are recommended 1 hour before exercise.
- Citrulline supplements are especially recommended for power and strength athletes for them to adequately recover and subsequently train at their desired intensity level.

Want to learn more?
Here are two studies that show benefits for cycling...

Damian's Comments

"The two studies in this review related to cycling found HERE and HERE, did not use elite level athletes. Instead, they used active males to do a single set of sprints.

One study is most relevant to cyclists. The subjects were endurance-trained rowers, cyclists, and triathletes with a V02max of 58 ± 10 and max power of 1000w ± 114w.

Supplementing with 12 g citrulline malate dissolved in 400 ml water or placebo drink to consume over a 15-minute period, 1 hour before exercise,

They completed 10 x 15s maximal sprints / 30s active recovery (60rpm, 30w) between sets.

This intervention was ineffective in enhancing exercise capacity, or in attenuating power output declines during repeated high-intensity exercise.

At the group level, the findings do not justify the use of a single dose (12 g) of citrulline malate in improving repeated sprint ability or endurance capacity in well-trained cyclists.

Practitioners interested in using citrulline malate as a supplement for acute benefits in a well-trained population should consider other alternatives and assess if longer-term supplementation protocols could offer possible ergogenic effects."

Classic

A classic study from the archives

The role of resistance exercise intensity on muscle fibre adaptations

Fry, C., Sports Medicine. Review, 34 (10), 2004.

Abstract

The role of resistance exercise intensity on muscle fibre adaptations

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

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

Thanks for reading

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Cheers!
Damian

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