JUNE 2021 | ISSUE #06

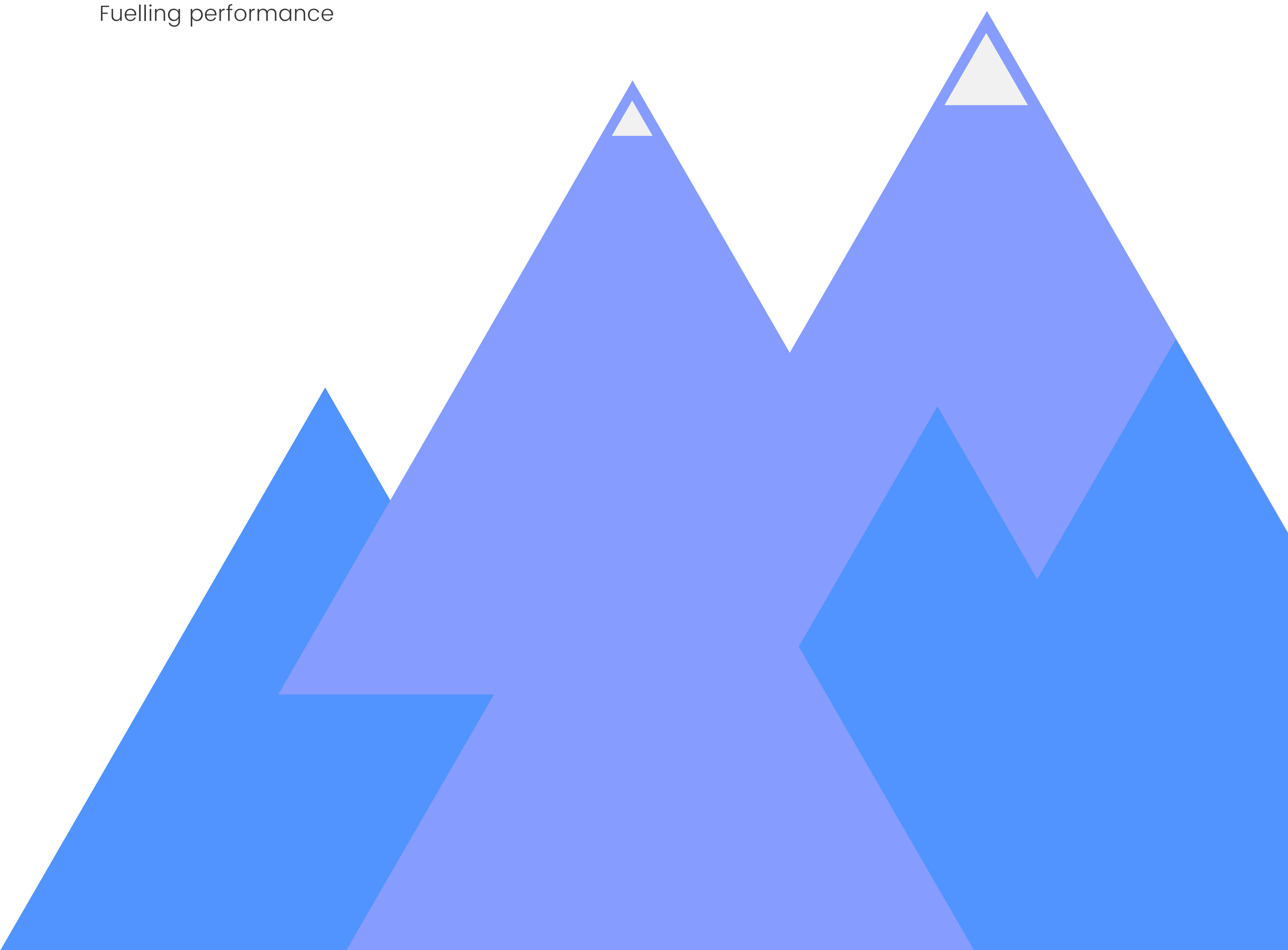
SEMIPRO CYCLING

CYCLING SCIENCE

DIGEST

A MONTHLY SUMMARY OF THE LATEST CYCLING PERFORMANCE RESEARCH

Contents



How to read the digest

Page number

Classic

Section

Abstract

Link to abstract

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

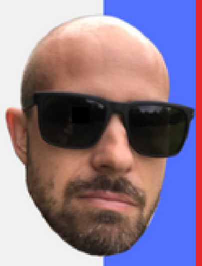
Practical Takeaways

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 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.

Thanks for reading, and for being a member :)

Damian

Cycling Science Digest

Designed to help cyclists and their coaches ride better, faster. The Cycling Science Digest curates cutting-edge cycling science research and turns it into actionable advice.

The monthly Cycling Science Digest crafts each research review into one easy to read page. It only takes 2 minutes to dissect and read, freeing up plenty of time for you to implement and maximise performance from the advice.

Not a member of SEMIPRO+ yet?

Learn more

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.

Meet your experts

The Coach

Damian Ruse

Founder and Head Coach of SEMIPRO Cycling

Damian has a Batchelor of Psychology from the University of New England and 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.

The Athlete

Cyrus Monk

FUll-time Athlete with a Bachelor of Exercise Science

Cyrus has a Bachelor of Science with a Physiology Major from the University of Melbourne and is now a full-time athlete with UCI Professional cycling team EvoPro Racing. As a former U23 Australian champion Cyrus knows how to get the best out of himself.

Performance

This month's top research on cycling performance

Excessive exercise training causes mitochondrial functional impairment and decreases glucose tolerance in healthy volunteers

Flockhart, Ml., et al. Cell Metabolism. 33 (5), 2021.

Performance effects of periodized carbohydrate restriction in endurance trained athletes – a systematic review and meta-analysis

Gejl, K.D., Nybo, L. Journal of the International Society of Sports Nutrition. 18 (37), 2021.

Determinants of endurance in well-trained cyclists*

Coyle, E. F., et al. Journal of Applied Physiology 64 (2622–2630), 1988.

The Acute Physiological and Perceptual Effects of Individualizing the Recovery Interval Duration Based Upon the Resolution of Muscle Oxygen Consumption During Cycling Exercise

Christopher, R.J., et al. International Journal of Sports Physiology and Performance. Ahead of Print, 2021.

*This is a classic study.

Abstract

Excessive exercise training causes mitochondrial functional impairment and decreases glucose tolerance in healthy volunteers

OBJECTIVE

The size and function of the mitochondrial pool are vital for metabolic health and muscular function. Mitochondrial capacity is tightly correlated to whole-body maximal oxygen uptake, which itself is a strong proxy for metabolic function and health.
Exercise training has proven to be a powerful tool to stimulate mitochondrial biogenesis and can act as a preventative treatment against many metabolic disorders by stimulating glucose uptake. However, an upper limit where the exercise stimuli no longer results in further positive metabolic outcomes has not been clearly identified.
The authors hypothesized that there is a bell-shaped relationship between exercise training load and mitochondrial function, glucose metabolism, and physiological adaptation to exercise training in human subjects, during a training program with a progressive increase in training load.

WHAT THEY DID

Six female and five male healthy subjects (VO2max 48.4 ± 1.3) took part in a 4-week training intervention consisting of high-intensity interval training (HIIT). During the first 3 weeks, exercise sessions were prescribed more and more often and the authors were thereby able to study the physiological responses to different loads of exercise training. During the fourth week, the exercise load was reduced to allow for recovery.
Subjects were prescribed 36 min of HIIT in week 1, 90 min in week 2, 152 min in week 3, and 53 min in week 4.
Throughout the intervention, muscle biopsies and oral glucose tolerance tests (OGTTs) were performed to assess the metabolic response in different phases.

WHAT THEY FOUND

- In the phase of excessive training (ET), despite increasing the training load, the improvement in physical performance stagnated, indicating what others have described as accumulating fatigue and maladaptation to the exercise stimuli.
In contrast to the dynamic response in physical performance, maximal oxygen consumption increased consistently throughout the study, regardless of the training phase. Maximal attainable heart rate during HIIT training was suppressed after ET but was restored after the recovery (RE), and heart rate response to submaximal work followed a similar pattern.
Following the week with the highest exercise load, authors found a striking reduction in intrinsic mitochondrial function that coincided with a disturbance in glucose tolerance and insulin secretion.
ET appears to inhibit cycling performance through a blunted glycolytic response to intense exercise, despite normal muscle glycogen levels and unaltered metabolic stimulation through plasma FFA supply.

Practical Takeaways

- There is an upper limit of the amount of intensive exercise that can be performed without disrupting metabolic homeostasis. Beyond this limit, negative effects on metabolic health and adaptation of physical performance, seemingly caused by a mitochondrial partial shutdown of both respiration and H2O2 production, start to manifest.

  Changes in intrinsic mitochondrial respiration (IMR) were closely paralleled by changes in glucose tolerance. These results support the hypothesis that mitochondrial dysfunction indeed causes disturbances in glucose metabolism.
  The ET phase activated mitochondrial biogenesis pathways and more mitochondrial proteins were synthesized, but they had a lower IMR. Therefore, the mitochondrial dysfunction observed in this study does not seem to involve a disturbance in the biogenesis of mitochondria or a decreased mitochondrial number, as shown in some early studies on insulin resistance, but is rather an intrinsic mitochondrial defect, as shown in patients with type II diabetes.

- The authors do not advise against intensive exercise training as former elite athletes have lower mortality rates and seem to live longer compared with the general population. Nevertheless, both athletes and those looking to improve their health through exercise should carefully monitor the response to training, as too much exercise might have negative effects. Using changes in glucose tolerance or careful tracking of glucose homeostasis using CGM could be a minimally invasive and a novel approach to optimize the amount of exercise associated with the greatest benefits.

Want to learn more?
Check this out...

Cyrus' Comments

"At first glance I was very critical of this study design as the potential applications of the findings could be far more useful if it weren't for a few shortcomings. Firstly, use of lowly-trained participants in a study investigating over-training may make it easy to succeed in achieving the over-training, but likely does not translate accurately for highly trained athletes. Secondly, the method of inducing this over-training, or 'excessive training' in this study is a fairly blunt stick. A ~450% increase in HIIT over a two week period is something seldom seen in a real world training scenario so it may be impractical to assume the physiological responses found in this study are likely to occur during a heavy training phase.
However, the study does succeed in shedding light on the underlying mechanisms behind the reduction in performance seen with over-training, and provides some suggestions on ways to detect possible warning signs."

Abstract

Performance effects of periodized carbohydrate restriction in endurance trained athletes – a systematic review and meta-analysis

OBJECTIVE

Endurance athletes typically consume carbohydrate-rich diets to allow for optimal performance during competitions and intense training. However, acute exercise studies have revealed that training or recovery with low muscle glycogen stimulates factors of importance for mitochondrial biogenesis in addition to favourable metabolic adaptations in trained athletes.
Compromised training quality and particularly lower intensities in peak intervals seem to be a major drawback from dietary interventions with chronic carbohydrate (CHO) restriction. Therefore, the concept of undertaking only selected training sessions with restricted CHO availability (periodized CHO restriction) has been proposed for endurance athletes. However, the overall performance effect of this concept has not been systematically reviewed in highly adapted endurance-trained athletes.

WHAT THEY DID

The authors conducted a meta-analysis of training studies that fulfilled the following criteria: a) inclusion of females and males demonstrating a $VO_2max \geq 55$ and 60 $ml \cdot kg^{-1} \cdot min^{-1}$, respectively; b) total intervention and training periods ≥ 1 week, c) use of interventions including training and/or recovery with periodized carbohydrate restriction at least three times per week, and d) measurements of endurance performance before and after the training period. The literature search resulted in 407 papers of which nine studies fulfilled the inclusion criteria.

The primary search syntax included elements about populations, interventions and outcomes relevant to the purpose of the present review, and was constructed as follows: ((elite) OR (athlete*) OR (trained) OR (triathlete*) OR (cyclist*) OR (runner*)) AND (("train low") OR ("train-low") OR ("sleep low") OR ("sleep-low") OR ("periodized nutrition") OR ("carbohydrate availability") OR ("CHO availability") OR ("carbohydrate periodization") OR ("CHO periodization") OR ("carbohydrate manipulation") OR ("CHO manipulation") OR ("glycogen availability") OR ("glycogen manipulation") OR ("low muscle glycogen") OR ("glycogen depletion")) AND ((performance) OR ("time to exhaustion") OR ("time trial*")).

WHAT THEY FOUND

The meta-analysis revealed that the overall effect of periodizing CHO availability on performance in well-trained endurance athletes was not significant, when compared to a chronic high CHO diet.

Two of the nine studies showed that performance was improved by training with CHO periodization and not by training in a CHO fed state, but no group x time interactions were reported in these studies.

Practical Takeaways

- The present meta-analysis does not support periodic CHO restriction as a superior approach for enhancing endurance performance in well-trained athletes. Thus, the physiological stimuli prompted by undertaking an acute exercise bout with low CHO availability (as observed in acute exercise studies) does not translate into clear measurable enhancements of performance in already adapted endurance-trained athletes compared to training with high CHO availability.

- Since superimposition of periodized CHO restriction on routine training will likely affect the priority of other important parts of training, the potential benefits hereof must be carefully considered. In particular, the comprehensive strategies presented in the literature may be challenging to implement routinely among endurance athletes training 20–30 h each week). In this regard, it is worth noticing that the four studies using designs that reflect the actual training of elite endurance athletes have all shown that the effects of "real-life" training on performance were not augmented by CHO periodization.

  Low energy availability during prolonged periods may cause negative health-effects that will eventually compromise performance in other cases (e.g., endocrine perturbations and impaired bone health). This emphasizes the necessity of paying attention to the overall energy balance when introducing deliberate CHO restriction in endurance athletes with high training loads.

Want to learn more?
Check this out...

Cyrus' Comments

"This type of study is one of my favourites to find published in the peer-reviewed, scientific literature. Not because it's about CHO restriction, nor because it's a review, nor because it relates to cycling performance; because it publicises a 'negative result' or absence of a relationship that many may expect. Not only do papers like this help to bust myths that may be otherwise gathering momentum, they save coaches and athletes the time (and often discomfort) implementing interventions with no proven benefit for the athlete.
The results of this meta-analysis in particular are likely to be welcomed by many athletes as it indicates they will be best served by fuelling well prior to and during each workout. This means not having to compromise on intensity, as is a necessity with many CHO-restricted training bouts.

The meta-analysis notably failed to find any suitable studies with a performance test >2h (likely because these are notoriously difficult to conduct). Before scrapping CHO restriction completely it would be good to see further work assess whether CHO restriction during training may generate performance gains for these longer time periods.

Abstract

Determinants of endurance in well-trained cyclists

OBJECTIVE

Maximal oxygen consumption (VO2max) is considered an important measurement for determining aerobic performance, as it determines the upper limit of aerobic ability. However, oxygen consumption (VO2) maintained at the maximum work rate held during endurance competition is associated with the accumulation of blood lactate (i.e. lactate threshold). What is interesting about the relationship between VO2max and lactate threshold in endurance athletes, is that two athletes with similar VO2max can differ in the velocity they perform at during competition.
In this classic study conducted by Edward Coyle et al. (one of the co-authors being Dr. Andrew Coggan), the researchers sought to determine whether endurance performance is related to blood lactate responses and glycogen utilization during sub-maximal exercise. Additionally, they wanted to know the extent that physiological and performance responses (e.g. glycogen utilization & time to fatigue) varied between trained cyclists when exercising at a given percentage of VO2max (88% VO2max) Lastly, they compared cellular and anatomical characteristics of the cyclists (e.g. mitochondrial activity, capillary density, fiber type) with differences in physiological (e.g. glycogen utilization, lactate production) and performance responses.

WHAT THEY DID

Fourteen male endurance athletes that had trained for a range of 3 to 12 years participated in this study. Participants were similar in terms of VO2max and able to elicit a true VO2max (as opposed to a VO2peak) during a cycling graded exercise test. Participants were categorized into one of 2 groups depending on whether they had a high (n= 7) or low (n=7) lactate threshold.

Participants performed running and cycling graded exercise tests to determine VO2max and blood lactate threshold, and a time to exhaustion test at 88% of VO2max. Additionally participant, glycogen utilization, % Type I & II muscle fiber, mean muscle fiber area, capillary density, and mitochondrial enzyme activity where measured.

WHAT THEY FOUND

Time to exhaustion for the high lactate threshold group was over twice the duration completed by the low lactate threshold group. A large portion of this longer time until exhaustion can be explained by a lower production of lactate at the intensity and a greater capillary density (i.e. better lactate removal).

The low lactate threshold group experienced a greater rate of glycogen utilization and blood lactate concentration, indicating higher stress in the working muscles. Mitochondrial quality was similar between groups, but the high lactate threshold group had a greater percentage of Type I muscle fibers and more years of training.

These findings demonstrate that even when individuals have similarly high VO2max values, their physiological responses, and subsequent endurance performance, can vary greatly. This study also emphasizes the importance of peripheral muscle anatomy and adaptations in endurance athletes.

Practical Takeaways

- There are a number of practical takeaways that can be derived from this paper, albeit they are not explicitly stated in the paper's discussion.

  If you are contemplating doing a VO2max test, or have had one done, it is important to realize this measure is only part of the overall picture when it comes to being a successful bike racer. Not only that, it's only part of the picture when it comes to being able to produce a lot of watts (i.e. having a high FTP). For example, my highest tested VO2max is actually higher than that of my Semi-Pro Cycling colleague, Cyrus Monk. Yet, compared to me, he has a much higher FTP... and a pro contract... and a U23 national championship.

- This paper also gives great insight into the specific anatomical characteristics and adaptations that result in a high lactate threshold. This allows for us to 1) screen individuals for these particular characteristics when evaluating athlete talent, and 2) have a better idea of what physiological adaptations we should focus our training interventions on.

Want to learn more?
Check these out...

Jason's Comments

"In my first appearance on the Semi-Pro Cycling podcast, Damian and I discussed the process of applying science to cycling training. He asked me if I had any recommendations for papers that his listeners could read in order to start down the path of consuming primary literature. I recommended reading any number of the papers with Edward Coyle as an author; and this is one of the specific papers I had in mind when I made that recommendation. I first read this paper when it was given as a reading assignment for my Advanced Exercise Physiology course during my Master's. Dr. Stephen McGregor taught that course. So with Steve's praise of this paper, and Coyle and Coggan as co-authors, other than just the important findings, you can hopefully see why I categorize this paper as a must read classic for those interested in learning more about endurance performance from primary literature."

Abstract

The Acute Physiological and Perceptual Effects of Individualizing the Recovery Interval Duration Based Upon the Resolution of Muscle Oxygen Consumption During Cycling Exercise

OBJECTIVE

There has been little research investigating the individualization of recovery interval duration during cycling-based high-intensity interval training (HIIT). The main aim of the study was to investigate whether individualizing the duration of the recovery interval based upon the resolution of muscle oxygen consumption would improve the performance during work intervals and the acute physiological response of the HIIT session, when compared with a standardized (2:1 work recovery ratio) approach.

WHAT THEY DID

A total of 16 well-trained cyclists (maximal oxygen consumption: 60 [7] mL·kg-1·min-1) completed 6 laboratory visits:

(Visit 1) incremental exercise test,

(Visit 2) determination of the individualized (IND) recovery duration, using the individuals' muscle oxygen consumption recovery duration to baseline from a 4- and 8-minute work interval,

(Visits 3-6) participants completed a 6 × 4- and a 3 × 8-minute HIIT session twice, using the IND and standardized recovery intervals.

WHAT THEY FOUND

Recovery duration had no effect on the percentage of the work intervals spent at >90% and >95% of maximal oxygen consumption, maximal minute power output, and maximal heart rate, during the 6 × 4- and 3 × 8-minute HIIT sessions. Recovery duration had no effect on mean work interval power output, heart rate, oxygen consumption, blood lactate, and rating of perceived exertion. There were no differences in reported session RPE between recovery durations for the 6 × 4- and 3 × 8-minute HIIT sessions.
Conclusion: Individualizing HIIT recovery duration based upon the resolution of muscle oxygen consumption to baseline levels does not improve the performance of the work intervals or the acute physiological response of the HIIT session, when compared with standardized recovery duration.

Practical Takeaways

- When planning interval training sessions the goal of the session takes priority when prescribing recovery between intervals. As this study has not delivered any evidence that measuring muscle oxygen consumption is worthwhile starting with the following work:rest ratios can help build the first session in a block and then making adjustments from there.

- Max Power: 7-12 minutes for full recovery
Anaerobic Power: 7-8 minutes for full recovery
Anaerobic Capacity: 1:2 to 1:10 work recovery ratio
Max Aerobic: 1:1 work to recovery ratio
Aerobic Power: Less than 5 minutes
Aerobic Capacity: NA

Again these are guidelines and a good starting point but other factors such as the athlete's response and ability to hit the prescribed numbers which are also important factors to consider.

Damian's Comments

"Muscle oxygenation training appears to be a valuable tool for cycling coaches and athletes. The most commonly used technology appears to be near-infrared spectroscopy (NIRS), examples of which are the Moxy monitor and Graspor, respectively. Using the real-time data collected from the devices, in certain circumstances, appear to be a valid and somewhat reliable tool for seeing how the athlete's body responds to loads and changes in loads.

However, it is not proven technology and studies like this help us understand where is may be useful in a training context. So whilst this training tool appears to have many useful functionalities, the power meter is still the best technology to gauge performance and training progression."

Technology & Profiling

This month’s top research on technology and profiling

Fractal Correlation Properties of Heart Rate Variability: A New Biomarker for Intensity Distribution in Endurance Exercise and Training Prescription?

Gronwald, T., et al. Frontiers in Physiology. 2020.

Abstract

Fractal Correlation Properties of Heart Rate Variability: A New Biomarker for Intensity Distribution in Endurance Exercise and Training Prescription?

OBJECTIVE

Given the challenges and pitfalls of determining individual training zones on the basis of subsystem indicators (e.g., blood lactate concentration, respiratory parameters), the question arises whether there are alternatives for intensity distribution demarcation. Considering that training in a low intensity zone substantially contributes to the performance outcome of endurance athletes and exceeding intensity targets based on a misleading aerobic threshold can lead to negative performance and recovery effects, it would be desirable to find a parameter that could be derived via non-invasive, low cost and commonly available wearable devices.

Detrended fluctuation analysis of HRV (heart rate variability) and its short-term scaling exponent alpha1 (DFA-alpha1) seems suitable for applied sport-specific settings including exercise from low to high intensities. DFA-alpha1 may be taken as an indicator for exercise prescription and intensity distribution monitoring in endurance-type sports. The present perspective illustrates the potential of DFA-alpha1 for diagnostic and monitoring purposes as a “global” system parameter and proxy for organismic demands.

WHAT THEY DID

This is a perspective study, similar to a review in that it summarises the relevant literature to date but the authors devote a greater portion of the paper toward practical applications of current knowledge and directions for further research.

Unlike most reviews and meta-analyses a description of inclusion criteria for previous studies is not present in this paper and no statistical analyses of multiple data sets across papers were performed by the authors.

WHAT THEY FOUND

The study results to date demonstrate a general loss of complexity and variability of R-R interval (the time elapsed between two successive R-waves of the QRS signal on the electrocardiogram) fluctuations with increasing exercise intensity.
More precisely, from low to high intensity exercise, DFA-alpha1 indicates a biphasic course. Depending on the resting value (usually around 1.0 and 1.5), constant or moderately increasing values (up to 1.5) have been reported at very low to moderate intensities, and strongly, almost linearly decreasing values down to around 0.3 from moderate to high exercise intensity.
This behavior indicates an intensity-dependent change of HR dynamics from strongly correlated to uncorrelated/stochastic or anti-correlated behavior due to a notably strong vagal withdrawal and/or sympathetic activation as well as other factors such as possible intracardiac biochemical changes or coupling mechanisms of different physiological subsystems

Practical Takeaways

According to the state of research DFA-alpha1 may provide valuable information for monitoring organismic internal load and individualizing endurance exercise and training prescription. After a slight rise from rest, DFA-alpha1 falls rapidly with increasing work rates near the aerobic threshold demonstrating the potential usefulness of this parameter for low intensity zone demarcation.

Within the context of different training models (e.g., polarized, pyramidal, or threshold training-intensity distribution) this may offer a new perspective, based on systemic autonomic regulation, to determine exercise and training zones for endurance-type sports guided by DFA-alpha1.
If future investigation confirms that a specific value of DFA-alpha1 is associated with the VT1 transition, observation of this index in real time during activity, or after completion may be useful to both athletes and coaches.

Given the restricted dynamic range of DFA-alpha1 at high work rates, it is not ideally suited as a measure of a high intensity threshold. Alternate methods for zone 2 to zone 3 transition (in a 3-zone model) are available including measurement of the RCP/LT2 by means of gas exchange, lactate testing or simply by functional threshold power (FTP) interval testing.

Cyrus' Comments

"Being able to accurately define training zones is essential to any coach or athlete and a non-invasive, easily applied tool for this purpose will ultimately benefit both parties.

The methods behind determining HRV and the subsequent detrended fluctuation analysis are very heavy on the mathematics but the focus for any algorithm-shy physiologist (including the one writing this) should remain on practical applications for novel technologies such as this rather than memorising each and every equation or integral behind them.

The research to date is promising for the utilisation of DFA-alpha1 to determine LT1 however the authors do make note that it still should not be used as a stand-alone determinant without confirmation through other means (step/ramp test, blood lactate analysis, etc.).
As a coach, being aware and comfortable with the use of new athlete-friendly methods of defining training zones is a major strength so I look forward to seeing further research confirming the reliability of this measure in different scenarios outside of the laboratory."

Nutrition

This month's top research on nutrition

The effect of probiotic supplementation on performance, inflammatory markers and gastro-intestinal symptoms in elite road cyclists

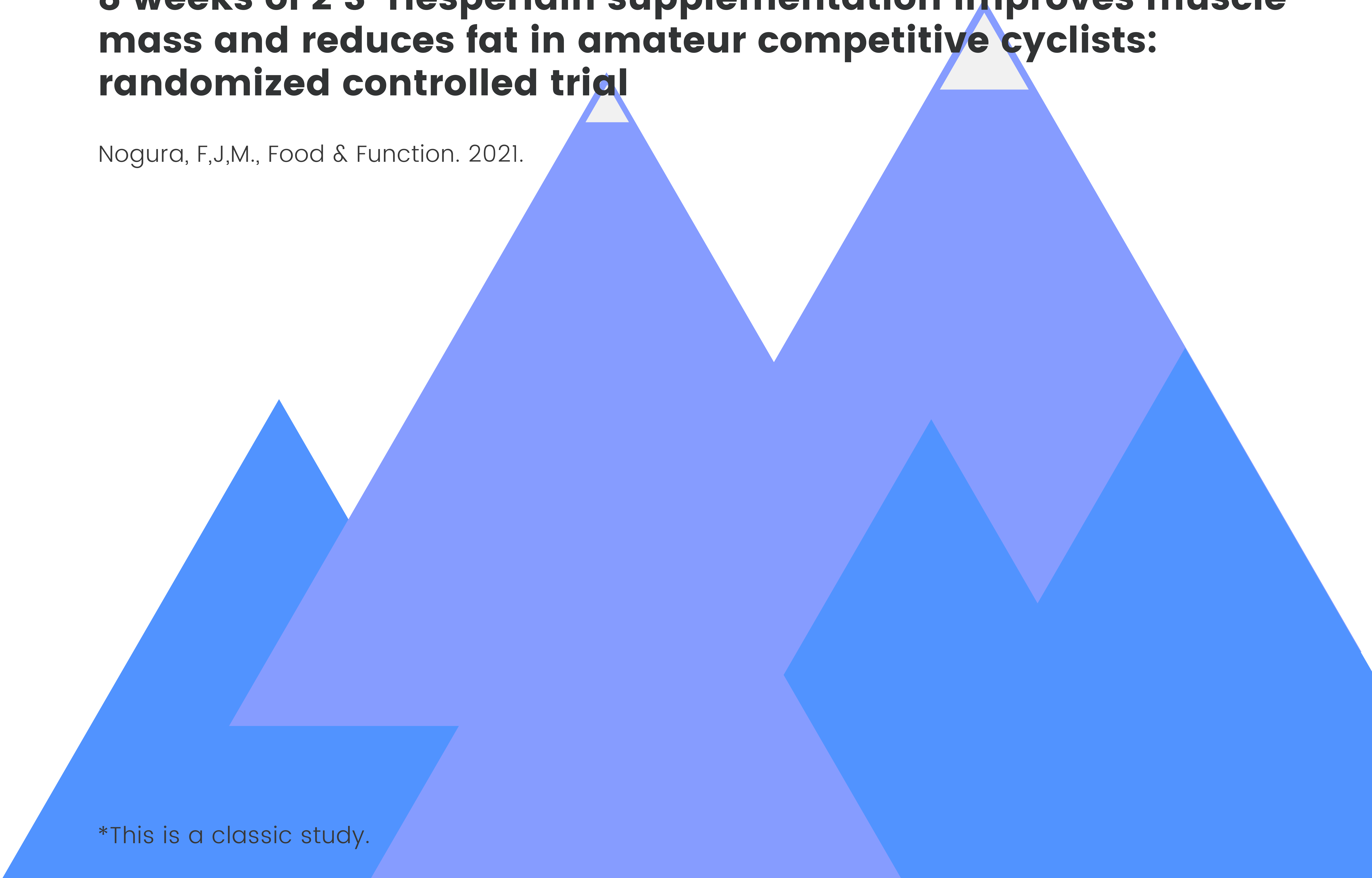
Schreiber, C., et al. Journal of the International Society of Sports Nutrition. 18 (36), 2021.

Effect of fat adaptation and carbohydrate restoration on metabolism and performance during prolonged cycling

Burke, L., et al. Journal of Applied Physiology. 89 (6), 2000.

8 weeks of 2 S-Hesperidin supplementation improves muscle mass and reduces fat in amateur competitive cyclists: randomized controlled trial

Nogura, F,J,M., Food & Function. 2021.



*This is a classic study.

Abstract

The effect of probiotic supplementation on performance, inflammatory markers and gastro-intestinal symptoms in elite road cyclists

OBJECTIVE

Elite athletes may suffer from impaired immune function and gastro-intestinal (GI) symptoms, which may affect their health and may impede their performance. These symptoms may be reduced by multi-strain probiotic supplementation.
Increased attention has recently been given to probiotic supplementation using single or multi-strain products as a potential remedy for improving health and athletic performance in athletes undergoing high intensity training The aim of the current study was to identify potential health and physical performance benefits conferred by probiotic supplementation in elite cyclists by testing the effect of a multi-strain probiotic supplementation for 90 d on the cyclists' GI symptoms, body composition, inflammatory markers and examine possible effects on maximal aerobic power (VO2max) and on time to fatigue.

WHAT THEY DID

Twenty-seven male cyclists, ranked elite or category 1 level competitions, were randomly assigned to a multi-strain probiotic-supplemented group (E, n = 11) or placebo group (C, n = 16). All participants visited the laboratory at the beginning of the study and after 90 d of supplementation/placebo. Prior to testing, all participants completed a GI symptoms questionnaire and underwent physical and medical examination, and anthropometric measurements. Venous blood was drawn for inflammatory markers analysis. The cyclists then underwent maximal oxygen consumption (VO2max) test and time-to-fatigue (TTF) test at 85 % of maximal power, 3 h following the VO2max test. All testing procedures were repeated after 90 d of probiotic / placebo treatment (double blind design).
The probiotic supplement contained about 15 billion colony forming units (CFU) of a probiotic blend consisting of 5 strains: at least (≥) 4.3 × 10^9 CFU Lactobacillus helveticus Lafti L10 (28.6 %), ≥4.3 × 10^9 CFU Bifidobacterium animalis ssp. lactis Lafti B94 (28.6 %), ≥3.9 × 10^9 CFU Enterococcus faecium R0026 (25.7 %), ≥2.1 × 10^9 CFU Bifidobacterium longum R0175 (14.3 %) and ≥0.4 × 10^9 CFU Bacillus subtilis R0179 (2.8 %).

WHAT THEY FOUND

Lower incidence of nausea, belching, and vomiting at rest, and decreased incidence of GI symptoms during training were found in E group vs. C Group. This decrease was more pronounced as exercise intensity increased.
Mean rate of perceived exertion (RPE) values during the TTF were lower in E group. Authors speculated the lower RPE values reported by the E group participants during the TTF test may be related to changes in GI symptoms and/or immune system function, which may have influenced their overall subjective feeling during the TTF testing.

No significant changes were measured between and within groups in VO2max and TTF values, mean levels of C-reactive protein (CRP), IL-6-and tumor necrosis factor alpha (TNFα) values following treatment.

Practical Takeaways

Probiotic supplementation presents an encouraging approach to reduce the incidence and severity of GI symptoms, and RPE of elite endurance athletes (e.g., cyclists) undergoing intense training and competitions.
While the findings of this study do not show any direct performance benefits, athletes may find daily probiotic supplementation a small price to pay for lessened GI symptoms and increased gut health during training and competition.
Future research should be carried out using a higher dosage of multi-strain probiotic products. Furthermore, performing similar studies during competition seasons may lead to tighter control over training phases and may result in meaningful and applicable results.
In order to improve our understanding of probiotic effect on gut permeability and endotoxemia, future studies should investigate the effect of intensive exercise on inflammation markers, along with serum LPS levels and other markers of GI permeability. Furthermore, gut microflora and food consumption should be analyzed in order to follow the relationship between changes in gut microflora and athletic performance, thus contribute to better understanding of the effects of probiotic supplementation on symptoms, wellbeing and performance in athletes.

Want to learn more?
Check these out...

Cyrus' Comments

"Unfortunately, gut flora changes were not analyzed, limiting the understanding of the direct supplementation effects on gut flora and microbiome. This would have been very useful to see the change in microbiome caused by the dosage in this study and therefore aid in dosage prescriptions to athletes in future.
As with any proposed supplementation, a cost-benefit analysis should be undertaken by coaches and athletes. In many instances I would first evaluate whether similar benefits can be gained through diet in general rather than a pill. Awareness of food intake throughout training and competition may allow athletes to identify which foods are likely to cause GI upset initially and eliminate these from the diet altogether.
Given the low cost and ease of access to probiotics for most athletes in conjunction with the findings of this study I would put this supplementation in the 'no harm done either way' category. It probably won't win you a bike race but it won't lose you any either."

Abstract

Effect of fat adaptation and carbohydrate restoration on metabolism and performance during prolonged cycling

OBJECTIVE

Short-term(1–3 days) adherence to a high-fat, low-carbohydrate (CHO) diet reduces resting muscle glycogen stores and impairs capacity for prolonged (>90 min) submaximal [~70% maximal oxygen uptake (V̇o2 max)] exercise, longer periods of adherence (>7 days) to such diets are associated with metabolic adaptations that enhance fat oxidation during exercise and compensate for the reduced CHO availability. Burke et al. decided to investigate a 5-day timeframe as it represents a more manageable period for radical dietary change and should minimize the potential health and training disadvantages arising from longer periods on high-fat intakes.
The aims of this study were to investigate the effects of 5-day adaptation to high-fat diet, followed by 1 day of CHO restoration, on metabolism and performance of prolonged cycling. To allow the authors to investigate baseline metabolic conditions and to provide an exercise situation that might benefit most from glycogen sparing, cyclists undertook the cycling bout without further CHO intake.

WHAT THEY DID

Eight well-trained male cyclists and triathletes were recruited for this study.
Subjects undertook 5 days of a supervised diet and training program. On the fat-adaptation treatment (Fat-adapt), they were prescribed a high-fat (>65% of energy), low-CHO (<20% of energy) diet supplying 0.22 MJ/kg body mass. The control treatment (HCHO) was an isoenergetic diet providing 70–75% of energy from CHO and <15% of energy from fat.
On day 6, subjects cycled for 20 min at 70% VO2max. After completing the 20-min cycle, subjects were provided with a high-CHO diet providing 10 g CHO/kg body mass and rested for the next 24 h. This phase was an attempt to normalize muscle glycogen stores independent of the previous dietary treatment.
On day 7, subjects reported to the laboratory after an overnight fast to undertake a performance ride that consisted of 2 h of cycling at 70% V̇o2 max (SS) followed by a 7 kJ/kg body mass time trial (TT).

WHAT THEY FOUND

- With Fat-adapt, 5 days of high-fat diet reduced respiratory exchange ratio (RER) during cycling at 70% maximal O2 consumption (SS); this was partially restored by 1 day of high CHO.
During SS, estimated fat oxidation increased while CHO oxidation decreased for Fat-adapt compared with HCHO.

  Tracer-derived estimates of plasma glucose uptake revealed no differences between treatments, suggesting muscle glycogen sparing accounted for reduced CHO oxidation. Direct assessment of muscle glycogen utilization showed a similar order of sparing.

- There was no difference in time to complete 7 kJ/kg of work during the TT component of the day 7 testing.

Practical Takeaways

- 5 days of adherence to a high-fat, low-CHO diet enhanced fat oxidation during exercise, with these adaptations being independent of CHO availability. Indeed, adaptations increasing fat oxidation during exercise persisted despite the restoration of muscle glycogen levels and were associated with muscle glycogen sparing. However, despite striking changes in fuel utilization during exercise, fat-adaptation and glycogen-restoration strategies did not produce a clear benefit to the performance of a TT undertaken at the end of 2 h of cycling.
Despite the brevity of the adaptation period, the dietary fat treatment utilized in this study achieved large shifts in fat oxidation during exercise. Five days of high-fat intake combined with training produced an almost twofold increase in the rate of fat oxidation during cycling at 70% V̇o2 max compared with baseline values. This increase is particularly impressive in light of the already enhanced capacity for fat oxidation in the highly trained subjects.

- The study did not find evidence of improved cycling performance despite observing marked changes in fuel utilization during the steady-state ride preceding the TT. It appears that fat adaptation may be of benefit to individuals who are at risk of developing symptomatic hypoglycemia during prolonged exercise when deprived of CHO, in so far as that it may allow better maintenance of blood glucose concentration. However, these subjects will also benefit from strategies to consume CHO during prolonged exercise, practices that are commonly recommended and easier to achieve than 5 days of extreme dietary change.

Cyrus' Comments

"Finding a physiologist in Australia that isn't a Louise Burke fan is akin to finding a needle in a haystack, I'm certainly no exception to the rule. This study, published two decades ago now, is some of her finest work and still highly relevant today with the ever-present high-fat, low-carb agenda being pushed by many inside and outside of the sports nutrition world. It demonstrates sound findings through a well thought out study design despite a brief timeframe and small sample size.

The study focuses on practical applications to the athlete rather than physiological changes that could be seen in a much longer intervention period but impossible to apply in the real world.

Despite finding that this dietary intervention creates remarkable changes to fat oxidation during exercise the authors stress numerous times that this does not directly translate to increased performance and even suggest other (less drastic) means by which athletes can perfect fueling for endurance performance."

Abstract

8 weeks of 2 S-Hesperidin supplementation improves muscle mass and reduces fat in amateur competitive cyclists: randomized controlled trial

OBJECTIVE

Hesperidin, a flavonoid found in citrus fruits (oranges), offers antioxidant and anti-inflammatory properties and has been found to modulate leukocyte gene expression, therefore showing a nutri-genomic effect. The antioxidant effect of hesperidin is mainly related to its radical scavenging capabilities, as well as the increase in antioxidant cellular defense catalase (CAT), superoxide dismutase (SOD), reduced glutathione (GSH) and oxidized glutathione (GSSG) via the nuclear respiratory factor 2 (NRF2) signaling pathway.

Its anti-inflammatory effect is produced by a decrease in inflammatory markers, such as nuclear factor kappa B (NF-κB), interleukin 6 (IL6), tumor necrosis α (TNFα) and inducible nitric oxide synthase (iNOS). Studies have shown that acute and chronic intake of 2S-hesperidin in amateur cyclists improve anaerobic and aerobic performance, respectively. The current research aimed to explain the metabolic, biochemical and molecular mechanisms by which this happens.

WHAT THEY DID

The randomised, double-blind, parallel clinical trial involving forty healthy male, amateur cyclists (training 6–12 hours a week). Participants were randomised into two groups - 2S-heperidin (n = 20) and placebo (n = 20) - and participants consumed two 250 mg capsules of either Placebo (microcellulose, 500 mg) or 2S-hesperidin (500 mg Cardiose, 85% 2S- hesperidin, by HealthTech BioActives) at breakfast for eight weeks.

Participants visited the laboratory on five occasions. Visit one consisted of a medical examination and blood extraction to determine health status. On visits two and four, a 24-h diet recall was conducted, followed by an incremental test until exhaustion on a cycle ergometer to estimate the rectangular test zones. On visits three and five, the 24-h diet recall was repeated, and participants performed a rectangular test on the cycle ergometer. The rectangular test was performed on a cycle ergometer using power output values achieved during maximal test at different intensity zones.

Researchers took blood and urine samples to measure overall health, as well as anti- oxidant and anti-inflammatory parameters and levels of hesperidin metabolites. The following antioxidant and inflammatory state markers were used: TBARS (Lipoperoxidation Biomarker), Catalase (CAT), Superoxide Dismutase (SOD), Glutathione Reduced (GSH) and Oxidized (GSSG), Hemoxygenase 1 (HO1), Measurement of Cytokines IL6, TNFα and MCP1, and C reactive Protein (CRP).

WHAT THEY FOUND

- The researchers found that, in the rectangular test, oxidative status improved after the 2S-hesperidin intervention, but not with the placebo. In addition, significant improvements in antioxidant capacity after maximal exercise and inflammatory status after the acute recovery phase were found in the 2S-hesperidin group compared to the placebo.

  The results also revealed that, unlike other polyphenols, 2S-hesperidin supplementation does not appear to interrupt adaptations produced by training in amateur cyclists, enhancing their performance.

- The researchers believe this to be the first study that examine the effect of chronic 2S-hesperidin intake on the antioxidant and inflammatory status of athletes at baseline, during and after exercise.

Practical Takeaways

- Most studies using hesperidin tend to use 500mg of supplemental hesperidin, and use the standard form of hesperidin if taking it as a daily preventative.

  If using it for acute improvements in blood flow (ie. before a workout) then the form of G-Hesperidin may be preferred since it is absorbed faster and reaches higher levels in the blood. It does not have significantly better absorption overall, but it is faster at peaking in the blood.

  Supplementation of hesperidin should be around 500mg and preferably taken with food.

  When looking at food products, it is unlikely that the benefits of hesperidin can be mediated by standard orange consumption except maybe for antiallergic effects.

- Sundrying the peels of tangerines or oranges, however, can yield enough hesperidin for supplemental purposes.

  Finally, hesperidin is known to interact with a variety of drug metabolizing enzymes so it should be approached cautiously if also using pharmaceuticals.

Damian's Comments

"Something to keep an eye on because it is known that almost 0.15% of the oxygen consumed is converted into ROS (Reactive oxygen species also called oxygen free radicals), which can be detrimental to muscle and mitochondrial function. In sports physiology, it is hypothesised that rapid increases in ROS during intensive exercise may be a contributor to fatigue.

A new theory proposes that antioxidant supplementation (vitamins A, C, E, thiols, ubiquinones and flavonoids) may delay fatigue. However, this mitigation of ROS generation may disrupt cellular signalling involved in training adaptations. ROS are intracellular messengers and activators of transcription factors that promote the expression of genes related to training adaptations and performance improvement."

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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