SEMIPRO CYCLING

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CYCLING SCIENCE

DIGEST

A BIMONTHLY SUMMARY OF THE LATEST ENDURANCE & CYCLING PERFORMANCE RESEARCH

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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 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 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 issue?

1. The big news is the change from monthly to bimonthly issues. This is driven by the production side rather than the number of studies. While there are times of the year when studies do slow down, there is always more than enough to fill each issue.

2. I am keeping the list of articles that don't make it as a review. It's an important reference and even more important to list these somewhere as otherwise, they may go unnoticed.

Thanks for reading, and for being a member :)

Damian

Performance

This month’s top research on cycling performance

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

Rafael de Almeida Azevdo, A., et al. European Journal of Sport Science. Published Online, 2021.

Physiological and Biomechanical Differences Between Seated and Standing Uphill Cycling

Berkemeier, N, Q., et al. International Journal of Exercise Science. 13(2), 2020.

The influence of bicycle lean on maximal power output during sprint cycling

Wilkinson, R., et al. Journal of Biomechanics. Ahead of Print (June), 2021.

The Effect of Polarized Training (SIT, HIIT, and ET) on Muscle Thickness and Anaerobic Power in Trained Cyclists

Hebisz, P., et al. International Journal of Environmental Research and Public Health. 18 (12), 2021.

Abstract

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

OBJECTIVE

The current study analysed the effect of distinct pacing profiles (i.e. U, J, and inverted J) in the perceptual responses and neuromuscular fatigue (NMF) development following a 4-km cycling time trial (TT).

WHAT THEY DID

Twenty-one cyclists with similar training status were allocated into three different groups based on their pacing profile spontaneously adopted during TT. Rating of perceived exertion (RPE), oxygen uptake (V02) and heart rate (HR) were continuously recorded.

The experimental trials were carried out on the participant’s own bicycle attached to a Computrainer™. Before the 4-km TT, participants performed a 5-min cycling warm-up at 150 W at a cadence of 90 rpm, which was followed by 5 min of passive rest on the bike.

Participants were instructed to finish the TT as fast as possible and the distance covered was the only visual feedback available during the trial. Participants were instructed to adopt an upright trunk position and remain seated while cycling.

WHAT THEY FOUND

→ TT performance was not different amongst pacing profiles (U = 377 ± 20 s; J = 392 ± 23 s; J-i = 381 ± 20 s) (all P > 0.05).

RPE, V̇O2 and HR increased similarly throughout the TT regardless the pacing strategy (all P > 0.05).

→ Therefore, endurance athletes with similar training status showed the same perceived responses and neuromuscular fatigue development regardless the pacing profile spontaneously adopted.

It was suggested that these responses occurred in order to preserve a similar rate of change in systemic responses (i.e. RPE, V̇O2 and HR) and neuromuscular fatigue development, ultimately resulting in the same TT performance.

→ **Practical** Takeaways

- Different pacing profiles resulted in the same performance in a 4-km cycling time trial.

  A similar performance might be due to the achievement of the same sensory tolerance limit.

- There was no difference for perceptual, metabolic and neuromuscular fatigue responses.

  "The similar performance might be due to achievement of the same sensory tolerance limit".

Want to learn more?
Check this out...

Damian's Comments

"The findings from this study are a good reminder that a self-selected pacing strategy is very personal and might actually help the athlete achive a better results than forcing a pacing strategy on them.

The authors sum it up nicely..."the main findings of the present study show that athletes can spontaneously adopt distinct pacing profiles without affect the perceived responses and NMF development following a 4-km cycling time trial.

Those results could reflect an attempt to achieve similar physiological strain, as shown by the exercise intensity performed above RCP throughout the TT, in order to develop the same peripheral fatigue level and maximal perceived effort at the finish line."

Abstract

Physiological and Biomechanical Differences Between Seated and Standing Uphill Cycling

OBJECTIVE

Despite differences in economy, cyclists climb in seated and standing positions. Prompted by gaps in research, the authors present the results of three studies.

First, in two prospective studies, they compared VO2 and HR during seated and standing uphill cycling at sub-anaerobic threshold intensity (Study 1), and the differences in muscle activation in seated and standing uphill cycling (Study 2). Then, in a randomized design they compared entrainment of breathing and pedaling between seated and standing uphill cycling (Study 3).

It was hypothesized that there would be a decrease in cycling economy, as well as greater muscle activation amplitudes, changes in muscle activation timing, increased flow rate, and changes in breathing in synchronization with pedal cycle characteristics while climbing in a standing position.

WHAT THEY DID

Subjects rode their bicycles on a treadmill in seated and standing positions.

In Study 1, VO2 and HR of four male cyclists (21.3 ± 1.7 yrs; 69.1 ± 6 ml/kg/min) were collected, alternating positions every 5 minutes for 20 minutes (8 mph, 8% grade).

In Study 2, muscle activations of eight male cyclists (24 ± 5 yrs, 67.6 ± 5.5 ml/kg/min) were collected on Rectus Femoris (RF), Biceps Femoris, Vastus Medialis (VM) and Gastrocnemius alternating positions every minute (8 mph, 8% grade).

In Study 3, flow rate and entrainment of nine male cyclists (28 ± 7 yrs, 62.7 ± 7.7 ml/kg/min) were collected in 2-minute stages at 6, 8 and 10 mph, (8% grade) alternating positions every minute.

WHAT THEY FOUND

- Study 1: Mean VO2 and HR were significantly elevated while climbing in a standing position (3.17± 0.43 L/min) ($p = 0.11$, $d = 0.27$), (175 ± 4 bpm) ($p = 0.91$, $d = 2.03$) as compared to a seated position (3.06 ± 0.37 L/min), (166 ± 5 bpm) ($p < 0.05$)

Study 2: Muscle activation for Rectus Femoris and Vastus Medialis were significantly greater for the standing compared to seated riding position ($p < 0.05$). Mean EMG amplitudes (normalized to peak activation during seated cycling) for RF were 34 ± 4% seated vs. 47 ± 7% standing ($p = 0.97$, $d = 2.11$) while for VM they were 36 ± 6% seated and 55 ± 15% standing ($p = 0.85$, $d = 1.63$)

Study 3: A significant main effect was detected for flow rate including PIF and PEF between climbing positions ($F(2, 8) = 54.09$, $p < 0.05$ ($p = 0.99$, $f = 2.23$) and across speeds ($F(4,16) = 19.36$, $p < 0.05$)

→ **Practical** Takeaways

The combined results from the current studies include increased VO2, HR, increased muscle activation of the quadriceps, as well as increased flow rate while standing.

- These findings suggest that climbing in a standing position may have a negative effect on cycling economy compared to climbing in a seated position.

- The implication for elite cyclists looking to conserve effort during a race would be to stay in a seated riding position for as long as possible and only stand for short bouts to alleviate pressure points and possible muscle soreness. Conversely, the implication for the general population, or for those in a clinical setting looking to maximize the effect of a workout, would be to spend a significant amount of time riding in a standing position as increased VO2, HR, muscle activation, and flow rate might increase caloric expenditure due to greater metabolic demand.

Damian's Comments

"Uphill cycling while standing results in decreased cycling economy due to physiological and biomechanical variations compared to riding seated.

This makes me think about spin classes when the instructor is yelling to everyone to stand up - I guess it works to burn extra calories.

On a more serious note, one aspect of the study that cannot be overlooked is the influence that personal position preferences might have on overall cycling performance. Of the 66% of cyclists who stated that climbing while seated was their preferred position, all but one mentioned that they preferred riding seated across all intensities while climbing.

The 33% who preferred to climb while standing indicated that they felt as if they were able to get into a better rhythm out of the saddle, however all data analyzed from this study point against that preference. It is possible, however, that a mental preference for or against a certain riding position may have an influence on performance, especially during longer, more sustained riding efforts."

Abstract

The influence of bicycle lean on maximal power output during sprint cycling

OBJECTIVE

Competitive cyclists sprint out of the saddle and alternately lean their bikes from side-to-side, away from the downstroke pedal. Cyclists, coaches, and journalists opine that leaning the bicycle improves sprint performance. But, some scientists advise that bicycle lean can impair performance. In their words, “cyclists should decrease bicycle sways”. They base this advice on the assertion that lean increases rolling resistance due to tire deformation. If lean does increase rolling resistance, then indeed minimizing lean might enhance sprint performance. But only if minimizing lean does not substantially reduce power output. To date, there is no direct evidence that leaning or attempting to minimize lean affects maximal power output during sprint cycling.

The question of whether minimizing lean affects maximal power remains open. It was hypothesised that trying to minimize lean would decrease maximal power compared to the ad-lib and locked conditions.

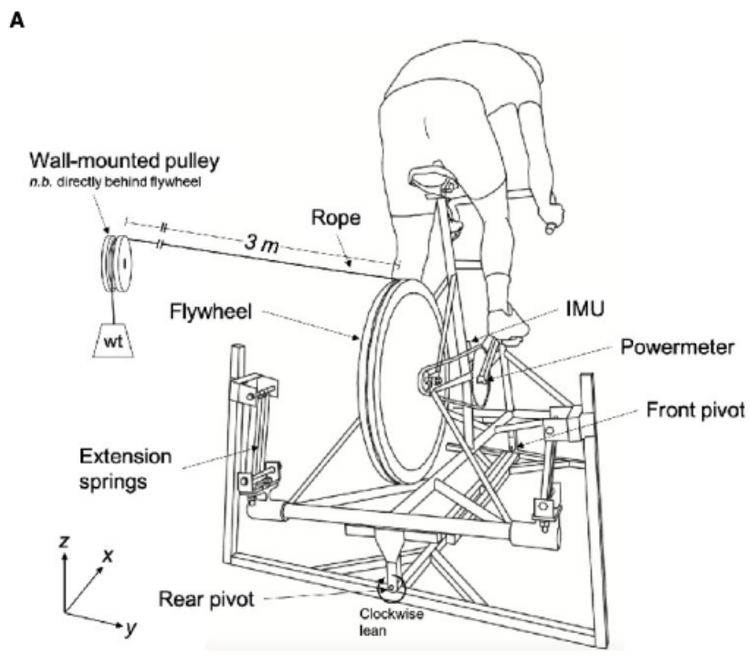
They further hypothesized that in the ad-lib condition, riders would use their arms to lean the ergometer away from the downstroke pedal—as in normal overground cycling.

WHAT THEY DID

Nineteen healthy recreational cyclists volunteered (13 men/6 women, age: 27.6 ± 6.2 years, height: 1.75 ± 0.09 m, mass: 68.9 ± 10.4 kg, mean±SD). Subjects were between 18-49 years old, in good health, cycled > 4 hours per week, and used their own clip-in pedals and shoes.

A modified cycling ergometer so that it can lean from side-to-side but can also be locked to prevent lean. This modified ergometer made it possible to compare maximal 1-s crank power during non-seated, sprint cycling under three different conditions: locked (no lean), ad libitum lean, and minimal lean.

Subjects warmed up by cycling in a seated posture at a low intensity (~ 100 watts) for 5 min. This was followed by 9 experimental sprints—3 locked, 3 ad-lib lean, and 3 minimal lean–with 3-min rest between each.



WHAT THEY FOUND

The authors found that leaning the ergometer ad libitum did not enhance maximal 1-s crank power compared to a locked condition. However, trying to minimize ergometer lean decreased maximal 1-s crank power by an average of 5% compared to leaning ad libitum. IMU-derived measures of ergometer lean provided evidence that, on average, during the ad-lib condition, subjects leaned the ergometer away from the downstroke pedal as in overground cycling. This suggests that our ergometer provides a suitable emulation of bicycle lean dynamics.

They accept their first two hypotheses; the ability to lean the ergometer did not increase maximal power compared to a traditional stationary ergometer and maximal power decreased (by 5%) when attempting to minimize lean compared to when leaning ad libitum or locked.

The similarity in maximal power between the ad-lib and locked condition is consistent with the findings of Gardner et al. (2007) who found no difference in maximal power during non-seated sprint cycling on a traditional stationary ergometer compared to overground cycling in a group of elite track cyclists.

Practical Takeaways

- The finding that maximal 1-s crank power during non-seated, sprint cycling is similar when leaning the bicycle at will compared to a traditional stationary ergometer eliminates the need for a rocker plate on an indoor trainer. A rocker plate is not needed to improve the maximum power of a sprint.

- The more practical finding for overground (outside) sprinting is that trying to minimize bicycle lean decreases maximal 1-s crank power by an average of 5% compared to leaning at will. Attempting to minimize lean when no lateral support is provided appears to be unstable and clearly inhibits power production. Therefore sprinting technique is better focused on enhancing the rider's natural sprint style rather than trying to limit their side-to-side movement.

Want to learn more?
Check this out...

Damian's Comments

"These findings help us understand that bicycle lean is a good thing in a sprint and provides a sufficient level of lateral stability for riders to simultaneously generate maximal power and maintain dynamic balance.

I was reminded of the various techniques employed by cyclists when sprinting recently in the Vuelta as a certain rider would not move his upper body during his sprint. In this case, minimizing bicycle lean and angular momentum of the bicycle, then they must offset this angular impulse by either pulling harder on the handlebar or by reducing the force they exert on the crank. The disadvantage of decreasing crank force in a sprint is obvious. Thus, the choice becomes whether to use the arms to pull harder on the handlebars or to lean the bicycle. The rider mentioned is in the minority as the widespread use of bicycle lean suggests that leaning is the optimal strategy.

There may not be a right or wrong answer here, but it gives a good case for riders that don't move their upper body to try alternative techniques.

Abstract

The Effect of Polarized Training (SIT, HIIT, and ET) on Muscle Thickness and Anaerobic Power in Trained Cyclists

OBJECTIVE

This study was undertaken to investigate the effect of two different concepts in a training program on muscle thickness and anaerobic power in trained cyclists.

The aim of this study was to investigate whether in a group of trained cyclists, the use of polarized training, including two types of interval training, sprint interval training (SIT) and high-intensity interval training (HIIT), as well as endurance training, affects the changes in quadriceps femoris muscle thickness, in addition to maximal and mean anaerobic power, measured during the sprint interval testing protocol (SITP).

WHAT THEY DID

The study involved twenty-six mountain bike cyclists (males). Each participant was characterized by at least three years of training experience in cycling.

The experiment lasted 9 weeks. During the experiment Group E (experimantal) cyclists performed:
- twice a week, sprint interval training (SIT), which consisted of 12–16 repetitions at maximal intensity, taking 30 s.

- once a week, high-intensity interval training (HIIT), which included several (5–7) 5-min activity periods at an intensity of 85–95% maximal aerobic power, interspersed with a 12-min activity at 50% maximal aerobic power.

- twice a week, endurance training (ET), performed at an intensity of 55–60% maximal aerobic power, for a total of 120–180 min.

Group C (control) cyclists performed:
- twice a week, HIIT training (trainings were performed as described above, the same as in group E).

- three times per week, ET training (trainings were performed as described above, the same as in group E).

WHAT THEY FOUND

As a result of the applied training program, the muscle thickness decreased and the mean anaerobic power increased in the experimental group. By contrast, no significant changes were observed in the control group.

Analysis of variance demonstrated statistically significant main effects for interactions between groups and repeated measures in terms of the right quadriceps femoris muscle thickness ($F = 8.68$; $p = 0.007$; $\eta 2 = 0.27$), left quadriceps femoris muscle thickness ($F = 14.80$; $p = 0.000$; $\eta 2 = 0.38$), mean anaerobic power determined from all four repetitions (Pmean4) of the sprint interval testing protocol ($F = 8.67$; $p = 0.007$; $\eta 2 = 0.27$), maximal oxygen uptake ($F = 8.30$; $p = 0.008$; $\eta 2 = 0.27$), and maximal aerobic power ($F = 6.69$; $p = 0.017$; $\eta 2 = 0.23$).

Based on post hoc tests, the thickness of the right and left quadriceps femoris muscles decreased statistically significantly in the E group. In addition, Pmean4 increased significantly in the E group. In contrast, no significant changes in muscle thickness or anaerobic power values were observed in the C group. Maximal oxygen uptake and maximal aerobic power increased significantly only in the E group.

Practical Takeaways

From a practical takeaway standpoint, the biggest concern here is the decrease in muscle thickness in the experimental group. As the authors report, the decrease in the quadriceps femoris muscle thickness in the presented study is a different effect compared to the results of studies published in other scientific articles.

There are many studies that show a combination of regular strength, endurance, and interval training increases muscle thickness. The main difference between these other studies and this one is the study participants as they were non-training individuals. In contrast, the study described in this manuscript involved cyclists who systematically trained prior to the experiment.

These factors suggest more work is needed to assess the link between SIT, HIIT, ET, and strength training in trained individuals when it comes to maintaining and increasing muscle thickness as the authors report is important in mountain bike performance.

Want to learn more?
Check this out...

Damian's Comments

"Regardless of how you read these results it is clear to me that there are always compromises to be made when selecting training direction and sessions. These results are encouraging for mixed modes to help maintain the variety and interest of an athlete but more research around the addition of strength training would be an interesting addition as this is an area that I struggle to maintain all year with athletes.

In addition, muscle thickness is not an area I have explored before and thick it deserves further research on my behalf as quantifying muscle thickness may help when prescribing on and off bike strength sessions as I have seen rapid muscle gains which need to be better controlled for there W/Kg implications."

Technology & Profiling

This month's top research on technology and profiling

The Validity of Ultrasound Technology in Providing an Indirect Estimate of Muscle Glycogen Concentrations Is Equivocal

Bone, L, J., et al. Nutrients. 13(7), 2021.

Monitoring and adapting endurance training on the basis of heart rate variability monitored by wearable technologies: A systematic review with meta-analysis

Düking, P., et al. Journal of Science and Medicine in Sport. Online, 2021.

Pitfalls in interpreting red blood cell parameters in elite high-altitude and sea-level athletes: A unique case series

Mireille Baart, A., et al. Physiological Reports. (May) 2021.

Abstract

The Validity of Ultrasound Technology in Providing an Indirect Estimate of Muscle Glycogen Concentrations Is Equivocal

OBJECTIVE

Researchers and practitioners in sports nutrition would greatly benefit from a rapid, portable, and non-invasive technique to measure muscle glycogen, both in the laboratory and field. This explains the interest in MuscleSound®, the first commercial system to use high-frequency ultrasound technology and image analysis from patented cloud-based software to estimate muscle glycogen content from the echogenicity of the ultrasound image.

The aim of this review is to examine the available literature on the use of this ultrasound technology to measure muscle glycogen concentrations in athletic populations.

WHAT THEY DID

Twelve competitive male cyclists participated in this study. These subjects (32.6 ± 5.1 years; 79.2 ± 9.5 kg; 5.1 ± 0.6 L/min maximum oxygen consumption, and 639 ± 115 W maximum power output).

This study was a parallel group design to investigate the effect of creatine loading, followed by a within-group cross-over application of carbohydrate loading on muscle substrate, water content, and performance.

The participants came in for four separate biopsy and ultrasound measurements. Furthermore, a supervised cycling protocol of ~3.5 h was undertaken to deplete muscle glycogen stores.

The cycling protocol involved a 120 km time trial, with alternating 1 km and 4 km sprints every 10 km, followed by a ride to exhaustion at 8% gradient and 88% V02max.

WHAT THEY FOUND

- There was a significant main effect for the different dietary treatments on biopsy-derived muscle glycogen concentrations ($F(3,29) = 61.2$, $p < 0.001$). Values of biopsy-derived glycogen concentrations for glycogen depletion were lower than baseline, CHO loaded, and normal conditions ($p < 0.001$), while values for carbohydrate loading were significantly greater than normal ($p = 0.013$).

- In summary, evidence supporting the use of ultrasound technology, and particularly the MuscleSound® proprietary technique, as a valid measure of muscle glycogen stores is equivocal. In terms of its use as a research tool, two data sets involving laboratory-based cycling protocols validated a correlation with measurements of the glycogen content of a biopsy-derived mixed muscle sample, providing a measure of muscle glycogen from 0–100 in arbitrary units under controlled conditions. Furthermore, the changes in muscle glycogen stores were in line with the expected outcomes of various diet and exercise protocols.

Practical Takeaways

- Scenarios of use of MuscleSound® measurement of muscle glycogen

- Optimal Scenarios
  Pre and immediately post-exercise
  • Several hours after the end of moderate to high intensity/long duration exercise (such as cycling that does not involve extensive eccentric contractions)

  • One to two days or more after high intensity/long duration sports such as soccer, football, rugby, and basketball

  • One to two days before a competition

  Sub-Optimal Scenarios
  Within several hours of the end of moderate to high intensity/moderate duration steady state exercise

  • The day after high intensity/long duration competition in sports such as soccer, football, rugby, and basketball

Want to learn more?
Check this out...

Damian's Comments

"I'm sure Iñigo San Millán, the founder of MuscleSound will be happy to see this study. But more interestingly, with all the discussion recently around CGM I have been wondering more about the benefits of glucose measurement in the muscle versus the blood. To me, it offers more information to help plan for racing and training. So tI see the value of having a portable, and non-invasive method to measure muscle glycogen I just can't get over the price. $5,000 USD is high for individual coaches. Hopefully the price comes down as more people are able to make use of the device."

Abstract

Monitoring and adapting endurance training on the basis of heart rate variability monitored by wearable technologies: A systematic review with meta-analysis

OBJECTIVE

Monitoring heart rate variability (HRV) as an indicator of daily variations in the functioning of the autonomic nervous system (ANS) may assist in individualizing endurance training to produce more pronounced physiological adaptations in performance.

This study aimed to systematically perform a meta-analysis of the scientific literature to determine whether the outcomes of endurance training based on HRV are more favourable than those of predefined training.

WHAT THEY DID

PubMed, and Web of Science were searched systematically using keywords related to endurance, the ANS, and training. To compare the outcomes of HRV-guided and predefined training.

All investigations involving healthy endurance athletes.

To be eligible for consideration, the interventions were required to have the following characteristics, with appropriate reporting:

• Predominant involvement of endurance training
• Continuous adjustment of training by the intervention group on the basis of alterations in HRV
• Inclusion of a control group that performed a predefined program of training
• Utilization of wearable sensors
• Either null hypothesis significance testing (NHST) and/or magnitude-based inference (MBI) statistical analysis

WHAT THEY FOUND

A total of 8 studies (198 participants) were identified encompassing 9 interventions involving a variety of approaches.

Compared to predefined training, most HRV-guided interventions included fewer moderate- and/or high-intensity training sessions.

Fixed effects meta-analysis revealed a significant medium-sized positive effect of HRV-guided training on submaximal physiological parameters (g=0.296, 95% CI 0.031 to 0.562, p=0.028), but its effects on performance (g =0.079, 95% CI -0.050 to 0.393 p= 0.597) and V̇O (g =0.171, 95% CI -0.213 to 0.371, p= 0.130) are small and not statistically significant.

Moreover, with regard to performance, HRV-guided training is associated with fewer non-responders and more positive responders.

Practical Takeaways

The effects of endurance training guided by heart rate variability (HRV) as an indicator of the functioning of the autonomic nervous system on parameters of performance are somewhat, although not statistically significantly better than those of predefined training. If you want to prescribe training based on HRV, here are some practical recommendations.

It is pointless to measure HRV once or twice and think you got a baseline or you know what's a person's HRV. Many studies especially before today's technology was available would measure HRV once then perform a several months study and measure HRV once again, to look at differences. This is not the best way to HRV given the day to day variability in these metrics as well as the fact that HRV should be used as a continuous feedback loop, not as some marker to optimise in the long term.

Using up to 4 weeks of measurements to determine a person's HRV. This way, you always know what's a person normal range at a given time, and based on the current baseline, can easily implement changes.

Looking at medium and long term trends, and in particular at where your daily data (either daily score or daily baseline) stands with respect to your historical data seems to be the way to go. This makes a lot of sense as comparing your daily scores with respect to your historical data is a simple statistical way to determine when a daily score or baseline is significantly different from what is normal for you, and therefore this seems an optimal moment to adjust training so that we can truly individualise it.

We have seen studies that say you should hold back when your HRV is significantly lower than your normal. Using your baseline instead of your daily score to make the decision, seems a better way as you probably are capturing stronger forms of stress (as they affect an entire week of data, not just a day).

Want to learn more?
Check this out...

Damian's Comments

"As more studies investigate different protocols to prescribe training based on individual physiological responses, a clearer picture is emerging.

One of my main issues with HRV has always been the lack of clear guidelines on its use. I am using it more and more with all levels of athletes and use these new studies and meta-analyses to refine my use of the metric even though I have not committed my entire coaching practice to using only HRV as the sole driver of daily training decisions.

This is a long and ongoing process but we are slowly uncovering the benefits of getting those daily HRV numbers."

Abstract

Pitfalls in interpreting red blood cell parameters in elite high-altitude and sea-level athletes: A unique case series

OBJECTIVE

Standard routine hematological measurements are commonly used to investigate differences in blood parameters between high-altitude athletes (HAA) and sea-level athletes (SLA), and to monitor the effect of high-altitude training. In this way, red blood cell (RBC) parameters are usually expressed as relative parameters (concentration) rather than absolute parameters (total amount). In this unique case series of elite HAA and SLA, we describe how different ways of parameter expression can affect the interpretation of blood tests.

WHAT THEY DID

In a group of 42 elite athletes, relative and absolute RBC parameters were compared between HAA and SLA. Absolute parameters were calculated by multiplying relative values with formula-based estimated blood volume (BV-e). Additionally, in two individual athletes, one HAA and one SLA, absolute parameters were also calculated with blood volume (BV) obtained by measurement with a dilution method (BV-m).

WHAT THEY FOUND

- In men, HAA had a significantly higher hemoglobin (Hb) concentration (+7.8%; p = 0.001) and total Hb mass per kg body weight (BW) (+12.0%; p = 0.002). When not corrected for BW, HAA had a lower, non-significant, total Hb mass (-7.8%; p = 0.055).

In women, no significant differences between HLA and SLA were observed. The two individual athletes showed that, based on BVm, in the HAA, total Hb mass and total Hb mass per kg BW were respectively 14.1% and 31.0% higher than in the SLA, whereas based on BV-e, in the HAA, total Hb mass was 20.8% lower and total Hb mass per kg BW was only 2.4% higher.

Similar inconsistencies were observed for total RBC count. Thus, different ways of parameter expression, and different methods of BV assessment for the calculation of absolute parameter values, influence the interpretation of blood tests in athletes, which may lead to misinterpretation and incorrect conclusions.

Practical Takeaways

- The authors recommend not to use relative RBC parameters to investigate hematological differences between high altitude and sea level, and to express the absolute values per kg BW.

  The optimized CO-rebreathing method is nowadays the default and least burdensome method to do this.

  These recommendations may also be applicable for monitoring the effect of high-altitude training in athletes.

- In conclusion, different ways of parameter expression, and different methods of BV assessment for the calculation of absolute parameter values, influence the interpretation of blood tests in athletes. Inappropriate parameter expression or BV assessment may lead to misinterpretation and incorrect conclusions.

Want to learn more?
Check this out...

Damian's Comments

"This unique case series found something I feared - relative blood measures are not as reliable as absolute measures.

As I do not have access to the lab equipment needed to get measurements like total hemoglobin mass. Instead of relying on standard concentration measures.

However, the optimized CO-rebreathing method might still not always be available in sports practice.

I agree with the authors when they say..."Future effort should be targeted at developing an easy and accurate BV measurement method with quickly available results. Since this is not yet available, it remains impossible to recommend a feasible and reliable method to measure the effects of high-altitude training in blood."

Nutrition

This month's top research on nutrition & supplements

Iron considerations for the athlete: a narrative review

Sim, M., et al. European Journal of Applied Physiology. 119(7), 2019

Nutrition and indoor cycling: a cross-sectional analysis of carbohydrate intake for online racing and training

King, A, J., et al. British Journal of Nutrition. Online (June), 2021

Flattened cola improves high-intensity interval performance in competitive cyclists

Fowles, J, R., et al. European Journal of Applied Physiology. Online (June), 2021

*Classic study

Abstract

Iron considerations for the athlete: a narrative review

OBJECTIVE

This review summarises the current state of research with respect to the aforementioned factors, drawing conclusions and recommendations for future work.

Iron plays a significant role in the body, and is specifically important to athletes, since it is a dominant feature in processes such as oxygen transport and energy metabolism. Despite its importance, athlete populations, especially females and endurance athletes, are commonly diagnosed with iron deficiency, suggesting an association between sport performance and iron regulation.

Although iron deficiency is most common in female athletes (~15-35% athlete cohorts deficient), approximately 5-11% of male athlete cohorts also present with this issue.

Furthermore, interest has grown in the mechanisms that influence iron absorption in athletes over the last decade, with the link between iron regulation and exercise becoming a research focus.

Practical Takeaways

In an attempt to classify the various stages of ID using these three hematological variables, Peeling et al. (2007) proposed the following for athletic populations:
• Stage 1 - Iron deficiency (ID): Iron stores in the bone marrow, liver, and spleen are depleted (ferritin <35 µg/L, Hb >115 g/L, transferrin saturation >16%).
• Stage 2 - Iron-deficient non-anemia (IDNA): Erythropoiesis diminishes as the iron supply to the erythroid marrow is reduced (ferritin <20 µg/L, Hb >115 g/L, transferrin saturation <16%).
• Stage 3 - Iron-deficient anemia (IDA): Hb production falls, resulting in anemia (ferritin <12 µg/L, Hb <115 g/L, transferrin saturation < 16%).

When faced with an ID, there are three primary strategies for iron supplementation (Castell et al. 2018); these include (a) increasing dietary iron intake, (b) supplemental oral iron, or (c) parenteral iron administration.

Generally, the overall response to oral iron supplementation in athlete cohorts appears positive (40-80% increases to ferritin) when consumed over an 8-12 week time frame, utilising doses of ~100 mg per day (Garvican et al. 2014; Dawson et al. 2006). However, alternate day supplementation may increase the efficacy of effect via an improvement in the fractional absorption of iron from a given dose, which over time, results in a greater cumulative response (Stoffel et al. 2017). Such regimens, in combination with iron absorption enhancers such as vitamin-C, should be considered. Furthermore, under extreme environmental stress (e.g., exposure to altitude), a greater dose of oral iron may be required to sustain iron stores and assist in the haematological adaptation

Also worth considering is the concept of maximising iron stores through supplementation during periods of lower activity (e.g. off-season). Inevitably, as training load and iron demands increase during the competitive season, higher iron reserves may limit the negative influence that exercise training has on the bioavailability of iron

Damian's Comments

"Iron deficiency is important for endurance athletes as it is typically associated with impaired aerobic power. Specifically, aerobic performance is likely to be most severely affected when iron stores are depleted and Hb production is compromised. Consequently, reduced oxygen transport to the exercising skeletal muscle may place higher demands on anaerobic metabolism, which could negatively influence performance.

This review is a reminder that iron is not just important 6 weeks out from altitude training but all year in part to be ready for altitude training."

Abstract

Nutrition and indoor cycling: a cross-sectional analysis of carbohydrate intake for online racing and training

OBJECTIVE

The aim of this study was to determine if athletes racing and training indoors with online platforms meet current CHO recommendations for exercise performance.

It was hypothesised that cyclists would not meet overall current CHO recommendations but would meet during exercise targets, planned session intensity would relate to higher CHO intake, cyclists of higher ability would achieve better pre, during and post-ride CHO intake, and cyclists identifying as well-trained and identifying the session as a 'key' session or race would be more likely to meet CHO recommendations.

WHAT THEY DID

This cross-sectional, observational study assessed food intake pre, during and post a cycling based training session conducted using an indoor trainer by using a mixed-methods (qualitative and quantitative) questionnaire. The study was available to cyclists of any ability who had completed an indoor training ride or online race in the preceding 24 hours (to reduce recall bias). Study recruitment was through professional networks, word-of-mouth, and social media platforms (Twitter/Facebook).

The questionnaire was in English and consisted of 81 questions encompassing demographics, ride details, food recall, fluid and supplements consumed in 3 distinct time periods around the session; hours prior (pre), during and following (post).

WHAT THEY FOUND

A total of 106 responses were collated between 26/06/2020 and 19/08/2020.

Mean CHO intake pre and post-ride was 0·7 (sd 0·6) and 1·0 (sd 0·8) g kg/BM and 39·3 (sd 27·5) g/h during training. CHO intake was not different for races (pre/during/post, P = 0·31, 0·23, 0·18, respectively), 'key sessions' (P = 0·26, 0·89, 0·98) or higher ability cyclists (P = 0·26, 0·76, 0·45).

The total proportion of cyclists who failed to meet CHO recommendations was higher than those who met guidelines (pre = 79 %, during = 86 %, post = 89 %).

Practical Takeaways

The primary outcome of this cross-sectional analysis of athletes' food intake is that cyclists do not implement CHO recommendations for endurance performance despite the ideal environment of riding indoors.

It is recommended that cyclists undertaking 'key' training sessions should consume adequate CHO around the session, in order to provide optimal fuel for exercise power output and to support recovery and glycogen resynthesis. This will depend on the duration but we are talking indoors it is most likely 2 hours or less. In which case you are looking at 60g per hour as the CHO recommendation.

If you are racing indoors, due to the short and frequently high-intensity nature of some sessions, opportunity for during exercise feeding may be limited or unnecessary.

One interesting thing to note is because of the unique indoor environment it allows athletes to have sufficient CHO within reach to achieve higher intake without the demands of carrying it on the bike. Indoor training also allows athletes to practice on-bike feeding within the relative comfort of their own home, whereby immediately terminating training due to GI distress is possible (a short run to the toilet).

Damian's Comments

" I'm not sure if I am surprised that cyclists aren't getting enough fuel when riding indoors. It is a good reminder that you cannot take proximity to food for granted and must plan for all sessions, especially if they are important.

It is also a good reminder that coaches and practitioners should also be aware that athletes may not achieve suggested CHO intakes around 'key' training sessions requiring high CHO availability despite good knowledge of session demands. Athletes should focus on consuming sufficient CHO before & during sessions to increase glycogen storage and exercising CHO oxidation where maximum performance outcomes involving prolonged high intensity or high quality outputs are required."

Abstract

Flattened cola improves high-intensity interval performance in competitive cyclists

OBJECTIVE

Some cyclists consume flattened cola during competitive events, but limited research has investigated if cola beverages elicit ergogenic effects, particularly on high-intensity exercise performance. Whether the potentially beneficial effects of cola are due to the caffeine and/or the carbohydrate content is also unclear.

This study assessed the ergogenic effects of different cola beverages on performance during a constant power bout (CPB) and subsequent high-intensity interval efforts in competitive cyclists.

WHAT THEY DID

In a randomized, double-blind, cross-over design, competitive cyclists (n = 13; VO2max 65.7 ± 5.9 ml kg-1 min-1) completed a 45-min CPB at 69% of maximum workload (Wmax), followed by four maximal 1-min high-intensity intervals (HII) against a resistance of 0.5 N kg-1.

Participants consumed 16 ml kg-1 total (intermittantly at four time points) of flattened decaffinated diet cola (PLA), caffeinated diet cola (CAF) or cola containing caffeine and carbohydrates (CAF + CHO).

WHAT THEY FOUND

- During the CPB, ratings of perceived exertion were lower in the CAF + CHO and CAF conditions compared to PLA (both, P < 0.04). Compared to PLA, CAF + CHO and CAF similarly increased (all, P < 0.049) mean power (CAF + CHO: 448 ± 51 W; CAF: 448 ± 50 W; PLA: 434 ± 57 W), minimum power (CAF + CHO: 353 ± 45 W; CAF: 352 ± 51 W; PLA: 324 ± 49 W) and total work (CAF + CHO: 26.9 ± 3.1 kJ; CAF: 26.9 ± 3.0 kJ; PLA: 26.0 ± 3.4 kJ), but not peak power (CAF + CHO: 692 ± 117 W; CAF: 674 ± 114 W; PLA: 670 ± 113 W; all, P > 0.57) during the HII.

→ **Practical** Takeaways

- Cola containing caffeine with or without carbohydrates favorably influenced perceived effort during the CPB and enhanced mean and minimum power during repeated maximal intervals. They provide evidence supporting the consumption of commercially available cola for high-intensity cycling in competitive cyclists.

They also determined whether the ergogenic effects, if any, were a result of the caffeine or the sugar. It turned out that Coke, or more precisely, cola drinks, really are ergogenic.

What their findings suggest is that it was the caffeine that provided all the ergogenic assistance; that sugar didn't do anything.

If you want to try this, then the dose was 16ml per kg. For a 70kg cyclist that is 1120ml - which is a lot to stomach.

Damian's Comments

"This is a curious finding. I remember cola being studying in the late 1990s on my ridning buddies and to this day it is common practice to use cola in the late stages of a long ride or race. But to see it used for the specific purpose of improving performance in shorter efforts is new to me.

Now, I have to admit that it's a bit surprising that the sugar in the colas didn't provide any additional ergogenic benefits in the form of temporary energy. But it does make me think that if it's the caffeine and running the numbers, there is much less than the equivalent in coffee.

Combining these two and the fact there was no peak power output change, I don't think I will be rolling this one out to my athletes. I'll save the caffeine for when it really counts."

Strength

The latest in strength research

Effects of Alternating Unilateral vs. Bilateral Resistance Training on Sprint and Endurance Cycling Performance in Trained Endurance Athletes: A 3-Armed, Randomized, Controlled, Pilot Trial

Sanghyeon, J., et al. Journal of Strength and Conditioning Research. Online (July), 2021

Abstract

Effects of Alternating Unilateral vs. Bilateral Resistance Training on Sprint and Endurance Cycling Performance in Trained Endurance Athletes: A 3-Armed, Randomized, Controlled, Pilot Trial

OBJECTIVE

Traditional preparatory resistance training for cyclists mainly relies on simultaneous bilateral movement patterns. This lack of movement specificity may impede transfer effects to specific aerobic and anaerobic requirements on the bike. Hence, this study investigated the effects of resistance training in alternating unilateral vs. simultaneous bilateral movement pattern on strength and anaerobic as well as aerobic cycling performance indices.

WHAT THEY DID

Twenty-four trained triathletes and cyclists (age: 31.1 ± 8.1 years; VO2max: 57.6 ± 7.1 ml·min-1·kg-1) were randomly assigned to either an alternating unilateral (AUL), a simultaneous bilateral (BIL) training group or a control group (CON).

Ten weeks of resistance training (4 × 4-10 repetition maximum) were completed by both training groups, although CON maintained their usual training regimen without resistance training.

Maximal strength was tested during isometric leg extension, leg curl, and leg press in both unilateral and bilateral conditions.

To compare the transfer effects of the training groups, determinants of cycling performance and time to exhaustion at 105% of the estimated anaerobic threshold were examined.

WHAT THEY FOUND

Maximal leg strength notably increased in both training groups (BIL: ~28%; AUL: ~27%; $p < 0.01$) but not in CON (~6%; $p > 0.54$).

A significant improvement in cycling time trial performance was also observed in both training groups (AUL: 67%; BIL: 43%; $p < 0.05$) but not for CON (37%; $p = 0.43$).

Bilateral group exhibited an improved cycling economy at submaximal intensities (~8%; $p < 0.05$) but no changes occurred in AUL and CON (~3%; $p > 0.24$).

While sprint cycling performance decreased in CON (peak power: -6%; acceleration index: -15%; $p < 0.05$), improvement in favor of AUL was observed for acceleration abilities during maximal sprinting (20%; $d = 0.5$).

Practical Takeaways

This is the main takeaway from this study..."Our pilot data underpin the importance of resistance training independent of its specific movement pattern both for improving the endurance cycling performance and maximal leg strength."

If are not using strength training I recommend starting with this book:

- Concurrent Aerobic and Strength Training
  Scientific Basics and Practical Applications
  Editors: Schumann, Moritz, Rønnestad, Bent R. (Eds.)

Damian's Comments

"I was really hoping I'd see unilateral movement come out on top here. So it's is a surprise that it didn't matter except that doing anything was better than doing nothing, and that ~8% cycling economy at sub-maximal intensities in the bilateral group. This is not the result I was expecting given the seemly specific nature of unilateral exercises and cycling putting the power down one leg at a time.

Overall though, there is nothing here for me to change the way I am already prescribing strength sessions."

The Rest List

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

Cold Water Immersion Offers No Functional or Perceptual Benefit Compared to a Sham Intervention During a Resistance Training Program

Durability and repeatability of professional cyclists during a Grand Tour

The effects of evening high-intensity exercise on sleep in healthy adults: A systematic review and meta-analysis

Validating an Adjustment to the Intermittent Critical Power Model for Elite Cyclists—Modeling W′ Balance During World Cup Team Pursuit Performances

Real Versus Ideal: Understanding How Coaches Gain Knowledge

Caffeine, genetic variation and anaerobic performance in male athletes: a randomized controlled trial

The impact of daytime napping on athletic performance - a narrative review

You are as fast as your motor neurons: speed of recruitment and maximal discharge of motor neurons determine the maximal rate of force development in humans

Acute high-intensity exercise and skeletal muscle mitochondrial respiratory function: The role of metabolic perturbation

Commercially available carbohydrate drink with menthol fails to improve thermal perception or cycling exercise capacity in males

Power Profile of Top 5 Results in World Tour Cycling Races

Coffee Increases Post-Exercise Muscle Glycogen Recovery in Endurance Athletes: A Randomized Clinical Trial

Exercise training reduces resting heart rate via downregulation of the funny channel HCN4

Background Inactivity Blunts Metabolic Adaptations to Intense Short-Term Training

Protein Requirements for Master Athletes: Just Older Versions of Their Younger Selves

W′ Recovery Kinetics after Exhaustion: A Two-Phase Exponential Process Influenced by Aerobic Fitness

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

Effects of graded hypoxia during exhaustive intermittent cycling on subsequent exercise performance and neuromuscular responses

A comparison of heat acclimation by post-exercise hot water immersion and exercise in the heat

Methods of accounting the cycling intensity: Advantages and disadvantages

Red Spinach Extract Supplementation Improves Cycle Time Trial Performance in Recreationally Active Men and Women

Five-Minute Power-Based Test to Predict Maximal Oxygen Consumption in Road Cycling

One-Week High-Dose β-Alanine Loading Improves World Tour Cyclists' Time-Trial Performance

What is known about the FTP20 test related to cycling? A scoping review

Effect of Cycling Cadence on Neuromuscular Function: A Systematic Review of Acute and Chronic Alterations

Reduced Endurance Capacity and Suboptimal Energy Availability in Top-Level Female Cyclists

Physical Demands and Performance Indicators in Male Professional Cyclists During a Grand Tour: WorldTour Versus ProTeam Category

The Rest List

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

Assessment of bike handling during cycling individual time trials with a novel analytical technique adapted from motorcycle racing

W’ Recovery Kinetics after Exhaustion: A Two-Phase Exponential Process Influenced by Aerobic Fitness

Sex-Specific Effects of Respiratory Muscle Endurance Training on Cycling Time Trial Performance in Normoxia and Hypoxia

Caffeine Mouth Rinse Does Not Improve Time to Exhaustion in Male Trained Cyclists

Effect of Concurrent Power Training and High-Intensity Interval Cycling on Muscle Morphology and Performance

Development of a Revised Conceptual Framework of Physical Training for Use in Research and Practice

Cannabis and Athletic Performance

Understanding the Physiological Requirements of the Mountain Bike Cross-Country Olympic Race Format

Nausea after Repeated Sprints: Is Lactic Acidosis Really the Culprit?

International Society of Sports Nutrition position stand: sodium bicarbonate and exercise performance

Variability in Submaximal Self-Paced Exercise Bouts of Different Intensity and Duration

Differences in execution and perception of training sessions as experienced by (semi-) professional cyclists and their coach.

Effects of combined hot and hypoxic conditions on muscle blood flow and muscle oxygenation during repeated cycling sprints

Provision of instructions to drink ad libitum or according to thirst sensation: impact during 120 km of cycling in the heat in men

Early change in thermal perception is not a driver of anticipatory exercise pacing in the heat

Performance indicators and functional adaptive windows in competitive cyclists: effect of one-year strength and conditioning training programme

Influences of compression cycling skinsuit on energy consumption of amateur male cyclists

The Validity and Reliability of a Tire Pressure-Based Power Meter for Indoor Cycling

Functional Threshold Power Is Not Equivalent to Lactate Parameters in Trained Cyclists

Reliability and Validity of the CORE Sensor to Assess Core Body Temperature during Cycling Exercise

Comparison of Physiological Responses and Muscle Activity During Incremental and Decremental Cycling Exercise

Thanks for reading

Next issue will be published on the first of every other month.

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Cheers!
Damian

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