SEMIPRO CYCLING

APRIL 2020 | ISSUE #04

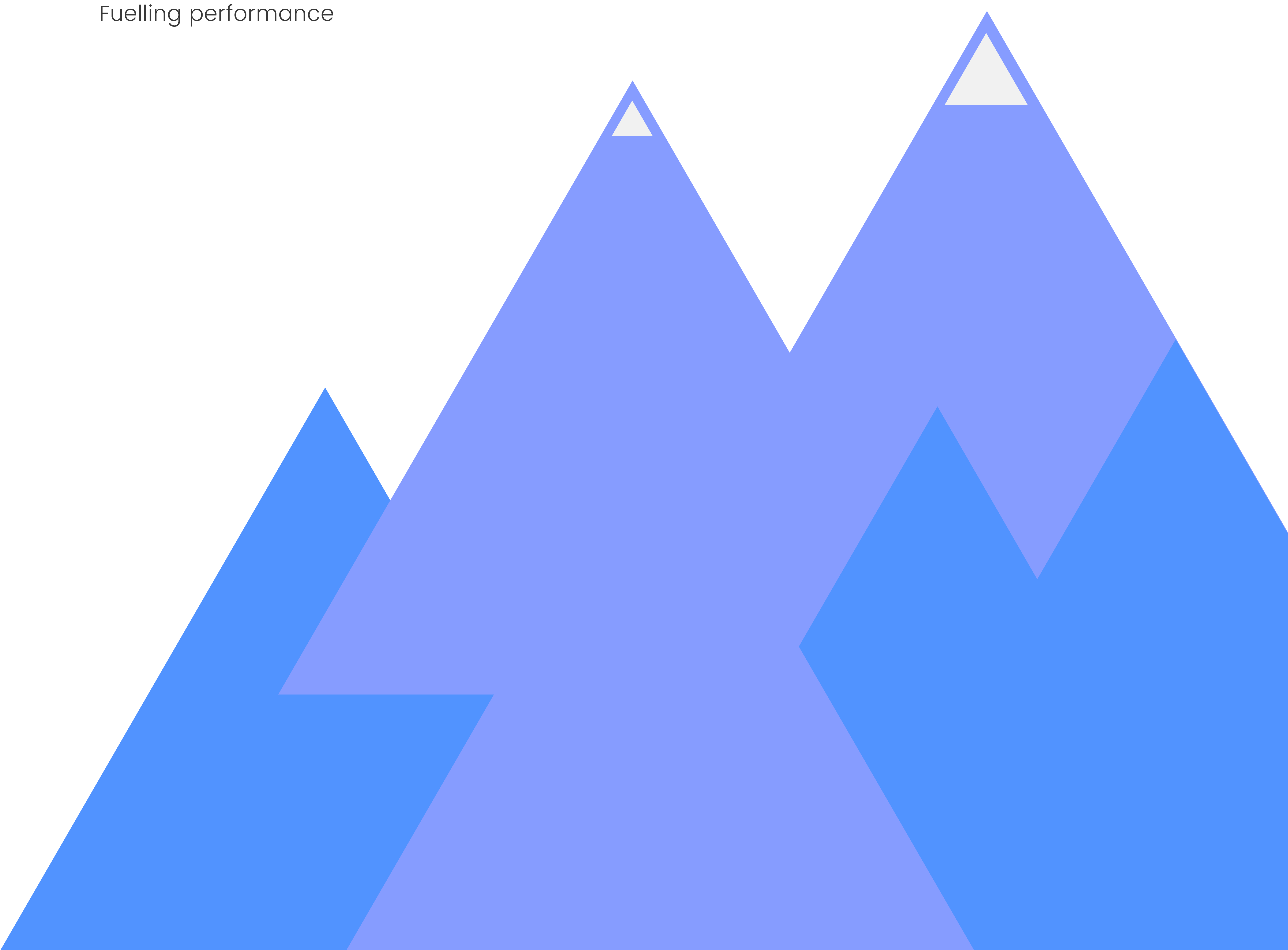
# CYCLING SCIENCE

DIGEST

A MONTHLY SUMMARY OF THE LATEST CYCLING PERFORMANCE RESEARCH

# Contents





# How to read the digest

Page number

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Title



Abstract

## 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

Practical takeaways from study

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

Reviewers comments on the study

"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 | Torque | % of Peak Torque |
|---|---|---|
| Nm/kg | Nm | % |
| 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 | Torque | % of Peak Torque |
|---|---|---|
| Nm/kg | Nm | % |
| 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 |

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.

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

1. This month we are very performance and profiling focussed. Lots of practical takeaways to consider in training prescriptions.

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 Scientist

### Jason Boynton Ph.D

Sport Scientist & Cycling Coach

Jason Boynton has a PhD is Exercise and Sport Science and is a USA Cycling level 1 certified coach. Jason is also a published researcher in the area of cycling performance. Jason earned his Ph.D. at Edith Cowan University in Perth, Australia. His academic supervisors were Associate Professor Chris Abbiss, Dr. Paolo Menaspà (Cycling Australia), and Associate Professor Jeremiah Peiffer. His thesis research investigated the effects of environmental temperature on high-intensity interval training.

## 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

### Recovery from Different High-Intensity Interval Training Protocols: Comparing Well-Trained Women and Men

Hottenrott, L., Möhle, M., Ide, A., Ketelhut, S., Stoll, O., Hottenrott, K.. Sports. 9 (3), 2021.

### Temporal Location of High-Intensity Interval Training in Cycling Does Not Impact the Time Spent Near Maximal Oxygen Consumption

Mckee, J., et al. International Journal of Sports Physiology and Performance. Ahead of print, 2021.

### Sprint tactics in the Tour de France: A case study of a world-class sprinter (Part II)

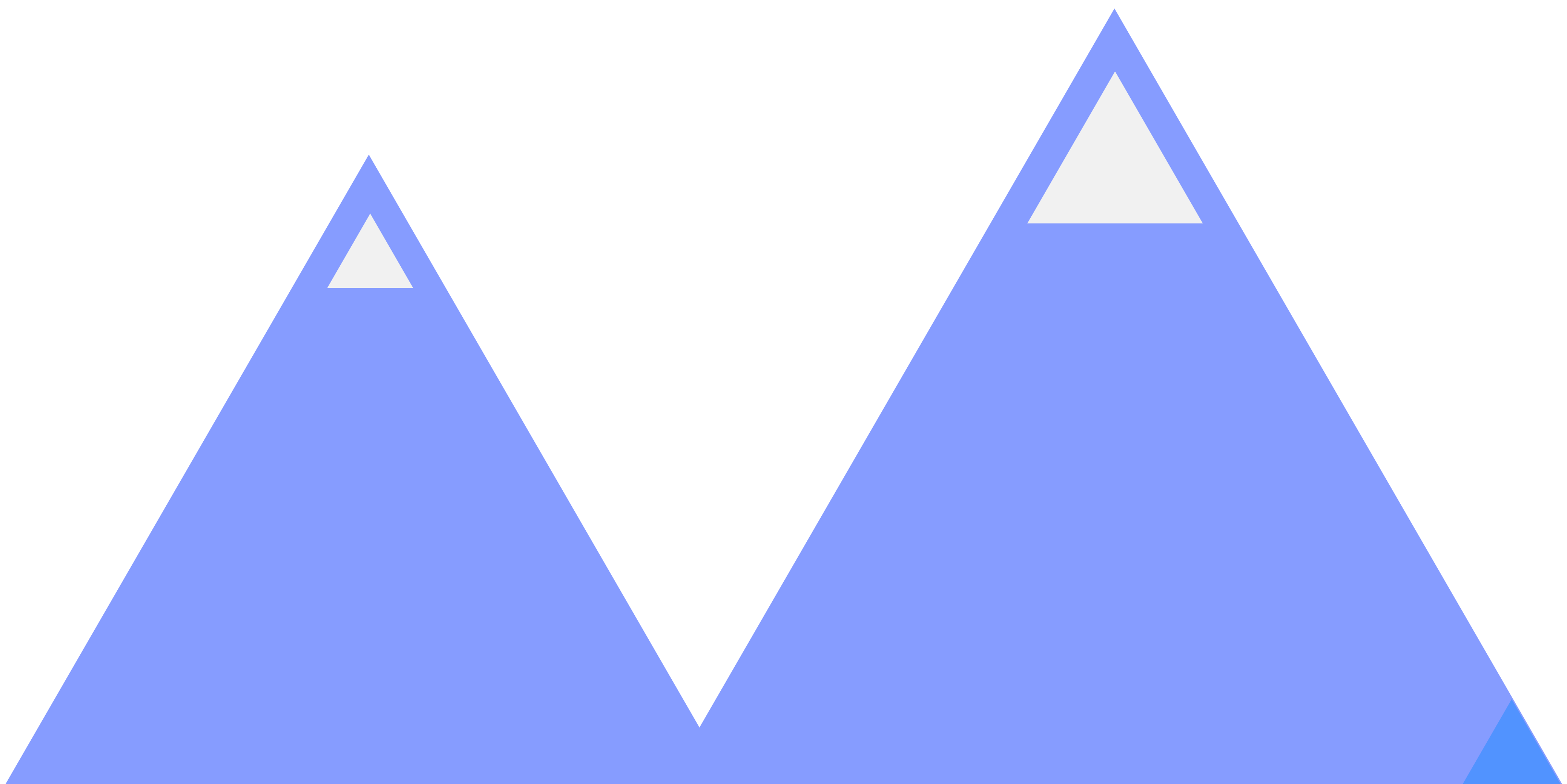
Erp, T., et al. International Journal of Sport Physiology 1 (8), 2020.

### Correlation analysis between lower limb muscle architectures and cycling power via ultrasonography

Lee, H.-J., et al. Sci Rep-uk 11 (5362), 2021.

### Exercise in the heat blunts improvements in aerobic power

Slivka, D. et al. European Journal Applied Physiology. 1 (9), 2021.



Abstract

# Recovery from Different High-Intensity Interval Training Protocols: Comparing Well-Trained Women and Men

### OBJECTIVE

Due to physiological and anatomical sex differences, there are variations in the training response, and the recovery periods following exercise may be different.

Currently, there are no specific recommendations that differentially address the recovery of endurance-trained women and men during and after intensive intermittent endurance exercise.
There have been no studies assessing sex differences in recovery after different HIIT protocols. Thus, investigating repeated 30-s HIIT periods to examine sex differences in recovery variables addresses a gap in the literature.

This study aims to examine whether there are sex-specific differences in metabolic, cardiovascular, and subjective recovery following 30-s high-intensity intervals interspersed with recovery phases of different lengths. Furthermore, it will be assessed whether the different recovery periods influence the maximal power output of female and male athletes.

### WHAT THEY DID

Twenty-four well-trained endurance athletes (cyclists and triathletes), including 12 females (mean age: 32.1 ± 9.7 years) and 12 males (mean age: 33.2 ± 9.9 years), were recruited to take part in this study.

Participation required a training volume of at least 6 h/week of endurance exercise and cycling training for at least six months prior to the intervention and a VO2max above the 80th percentile.

A 30 s Wingate anaerobic test (WAnT) was performed four times, separated by different resting periods (1, 3, or 10 min).

Participants performed the three different HIIT protocols under standardized conditions in a randomized order regarding the three recovery times (1, 3, or 10 min) with one week recovery in between.

Power, heart rate, and ventilatory parameters were continuously recorded throughout the test period and blood lactate was recorded at regular intervals during recovery.

For subjective rating of exertion and state of recovery, the Rating of Perceived Exertion (RPE) scale and the Total Quality Recovery scale (TQR) were utilized.

### WHAT THEY FOUND

- Females compared to males consistently had a smaller decrease in performance between the first and last WAnTs.

For the recovery times of three minutes ($p = 0.04$) and ten minutes ($p = 0.004$), men showed significantly higher lactate concentrations.

Women had significantly higher %HRmax in the recovery times of three minutes ($p < 0.001$) and ten minutes ($p < 0.001$).

Women subjectively reported lower TQR for the one-minute ($p < 0.001$) and ten-minute ($p = 0.03$) recovery periods.

## **Practical** Takeaways

- The main findings of this study were that after 30 s of high-intensity all-out cycling exercise, metabolic recovery was faster in women than in men.
The underlying mechanisms for these findings could be explained by previous studies reporting that women break down 42% less muscle glycogen in type 1 fibers during a single WAnT sprint compared to men.

The instructed intensity of the WAnT protocols was an "all-out" effort. Therefore, subjective power input between female and male participants should have always been the same. However, the RPE results showed lower ratings of perceived exertion in the ten-minute recovery protocol for women and an overall decline in RPE with an increase in recovery time for both sexes. While this could be dismissed as subjects not adhering to the test protocol it does have real-world applications: "all-out" repeated anaerobic efforts are great in theory but when applied in testing and training, central regulation from the athlete may throttle the intensity back.

- The results of this study point toward a minor sex difference between men and women here however this should be followed up with a study involving professional level athletes where possible.

## Cyrus' Comments

""Further studies like this could shape the way coaches prescribe interval sessions to their respective male and female athletes.

While this is a good start it would be great to see further research in athletes at a higher training status (more than the 6h/week requirement of this study) to elucidate whether the sex-differences observed here are found in elite athletes.

If further literature supports these findings we could begin to see similar HIIT sessions prescribed differently for women as opposed to men (shorter recovery between each interval) to obtain the same desired training stimulus.

It's also important to note that the demands of mens and womens professional cycle races are vastly different, so a one-size-fits-all approach to interval training should never be used, regardless of physiological differences between sexes."

Abstract

# Temporal Location of High-Intensity Interval Training in Cycling Does Not Impact the Time Spent Near Maximal Oxygen Consumption

### OBJECTIVE

For trained endurance cyclists, high-intensity interval training (HIIT) is a common strategy to increase aerobic fitness and cycling performance. To maximise aerobic adaptation (ie, increases in cardiac output and maximal oxygen consumption [VO2max]), the total time an individual spends at or near their VO2max is an important consideration.

From a logistical perspective; it is unlikely that a cyclist will complete HIIT in isolation and instead will incorporate the intervals within a longer session; that is, ≥90 minutes, with a significant portion of the session completed at or below VT1 intensity to meet training volume demands.

The purpose of this study was to examine the influence of completing HIIT at the beginning, middle, or end of a 90-minute cycling session on physiological and perceptual responses.

### WHAT THEY DID

Thirteen male cyclists (age = 42 [8] y, height = 180 [5] cm, body mass = 78 [9] kg, VO2max = 56 [6] mL·kg-1·min-1, and maximum aerobic power output = 403 [40] W) and 3 female cyclists (age = 36 [9] y, height = 163 [4] cm, body mass = 60 [7] kg, VO2max = 51 [4] mL·kg-1 ·min-1, and maximum aerobic power output = 294 [8] W) volunteered to participate in the study. All participants reported to cycle ≥150 km/wk.

This study was conducted using a randomized and counterbalanced crossover design. All participants completed one preliminary testing session involving a cycling-based graded exercise test. Participants then completed 3 experimental sessions consisting of a 90-minute cycling session with three 3-minute high-intensity intervals (90% of power at VO2max; 311 [48] W) completed at the beginning (19 min), middle (36 min), or end (69 min) of the session.

Recovery between intervals was 3 minutes. All experimental sessions were separated by 6 (2) days and completed at a similar time of day.

### WHAT THEY FOUND

No differences were observed for mean oxygen consumption (P=.479) or time spent ≥90% maximal oxygen consumption (P = .753) between conditions.

The mean rate of perceived exertion of all intervals were greater in the Middle (P < .01, effect size = 0.83) and End (P < .05, effect size = 0.75) compared with Beginning conditions.

Mean minute ventilation was greater in the End compared with Beginning condition (P = .015, effect size = 0.63).

## **Practical** Takeaways

The timing of high-intensity interval completion during a training session is unlikely to influence the cardiovascular stress associated with changes in aerobic fitness. However, as a consequence of higher ventilation and fatigue, intervals completed at the end of a session may require greater anaerobic energy contribution and be perceived as more difficult.

Coaches and athletes should be aware of these findings as the relative aerobic and anaerobic energy contributions for HIIT may differ depending on location within a session, and interval placement could impact an athlete's willingness to complete prescribed sessions.

The authors suggest that 2 to 5 intervals completed at ≥90% of peak aerobic power for a duration between 1 and 5 minutes with a work to rest ratio of at least 1:1 can provide a high level of cardiovascular stress and time spent at or near VO2max.

## Cyrus' Comments

""Again, this study looks at trained athletes but far from the training level seen in the professional cycling peloton. It would be great to see a similar study in athletes with a higher training status to see if similar results are found.

There is also scope for extending the length of the sessions within this study. Most elite cyclists would train for far greater than 90 min per training session so intervals may often take place in the 4th or 5th hour of a training session. This would magnify effects of temporal placement of HIIT within a session and may generate different results.

Other improvements for further studies of this type would be the use of lactate monitoring and electromyography to assess the interplay between aerobic and anaerobic energy systems with HIIT conducted at differing periods throughout a training session."

Abstract

# Sprint tactics in the Tour de France: A case study of a world-class sprinter (Part II)


### OBJECTIVE

This paper was the Part II of the previous paper which focused primarily on the demands world-class sprinter Marcel Kittel faced in the Tour de France (TdF). If you have not yet checked out the summary of that article in this issue, definitely do that first as it will give additional context for this summary.

The purpose of this study was to describe and assess the sprint tactics of Kittel during multiple editions of the TdF. Sprint tactics and performance metrics were assessed relevant to two different teams he was a member of (identified as Quick-step and Shimano in this article), and whether he won or lost the sprint.

The support of teammates is extremely important in road cycling competition. However, the multi-stage nature of the TdF and the finite number of riders a team is allowed to enter into the competition affects how many support riders a sprinter might have working for them. For example, a team with a general classification (GC) specialist and sprinter will only have 2-3 riders supporting each of their designated leaders. This is different than a single day race or a TdF team with a single sprinter as their leader. In these scenarios more support riders would be allotted as support for the team's sprinter, potentially increasing the chances of the sprinter being successful. In the case of Kittel, Quick-step split their support between him and a GC rider, while with Shimano he played the role of sole team leader.

### WHAT THEY DID

Researchers collected power output (PO) and video footage of 21 sprints over the course of four editions of the TdF (2013-2017). PO was assessed for different time frames from the finish (e.g. 10 to 5 min, 30 to 15 sec), along with maximal mean PO for different durations during the last 20 seconds of the sprint stage. From the videos, sprinter position, and the presence or absence of teammates were assessed.

### WHAT THEY FOUND

Of the 21 sprints that Kittel participated in, he managed to win 14 of them. Sprints ranged from 7 to 17 seconds in duration and with high ranges for mean PO, speed, and cadence being observed (1026 to 1576 W; 52 to 73 km/h; 103 to 121rpm; respectively). When Kittel competed with team Shimano 8 out of 10 sprints were successful (80%), while in contrast, his win to loss ratio with Quick-step was 6 out of 11 sprints (55%), respectively. Sprint characteristics did not differ between teams. However, the difference in magnitude for the number of supporting teammates was notably lower with Quick-step compared to Shimano at 3 min, 2 min, 1.5 min and 15 sec from the finish line.

Tactics between teams differed substantially. Whereby, Kittel rode further from the front with Quick-step than Shimano at 10 min, 3 min, 2 min, 1.5 min, 1 min, 30 sec, and 15 sec from the finish. Additionally, compared to Shimano, with Quick-step his PO was lower at 10-5 min, 3-2 min, 1.5-1 min, and higher at 30-15 sec.

No difference in PO, cadence, speed, and sprint duration between won and lost sprints. Additionally, no significant differences were noted in the number of teammates which supported the sprinter when he won or lost. However, a greater difference in position from the front of the pack during the last 30 seconds of the race did contribute to a significantly higher number of lost sprints.

Power output for the period of time coming into the sprint (sprint preparation period) and final sprint were similar during the stages at the beginning and end of the TdF.


## Practical Takeaways

Firstly, and to reiterate from Part I of this analysis, high explosive PO is necessary to compete as a sprinter at the highest level in the TdF. With this knowledge coaches and teams can better identify and train potential future world-class sprinters.

This analysis also speaks to the importance of team tactics, and increasing the wins a sprinter can attain by increasing the number of teammates that are supporting them. Shimano's tactic was to ride the last 3-2 km at the front of the peloton with the help of 5 or 6 teammates. Contrary to this Quick-step would ride between positions 20 to 10 and move to the front during the last 30 seconds of the bike race. However, while this appears to be good evidence that the number of teammates changes tactics and improves chances for sprint wins at the surface, it is important to remember this a case study (i.e. n= 1). Experience of the sprinter and teammates, along with the number of top sprinters in the competition have to also be considered.

From this study, for this sprinter, the difference between a win and loss performance seemed mostly dependent on their position during the last 30 seconds of the bike race. This finding and the findings of Menaspà et al. highlight the importance of being cognizant of one's relative position in the pack as the finish line approaches.

**Want to learn more?**
Check this out...

## Jason's Comments

""I think of this paper as a nice continuation of the research Paolo Menaspà did during his PhD. His thesis is a very good preliminary investigation into the professional road cyclist sprint. In my opinion, his findings are so important to helping success in a sprint that I routinely send summaries of his research to the sprinters I work with. Check out his thesis at the link provided below."

Abstract

# Correlation analysis between lower limb muscle architectures and cycling power via ultrasonography

### OBJECTIVE

The primary purpose of this study was to examine the muscle architectural characteristics of short versus long distant cyclists using ultrasonography (US), and then determine their relationship with 20-sec cycling power. An additional purpose of this study was to refine the understanding of leg muscle variables that predict cycling sprint power.

### WHAT THEY DID

This study examined twenty-four collegiate cyclists that were classified as either "long-distance" (n= 12) or "short-distance" (n= 12) cyclists. These cyclists had more than 5 years of cycling experience and trained for 24 ± 1 hrs per week. The participants had either won a national collegiate competition or had participated in an international level collegiate championship. US was utilized to measure the muscle architecture (fascicle length and angle) of the rectus femoris, vastus medialis, vastus lateralis, and medial head of the gastrocnemius. A cycle ergometer (Wattbike) was used to determine all-out 20-sec power of the cyclists after an ad libitum warm-up.

### WHAT THEY FOUND

The data obtained during this study highlighted the correlation between muscle architectural characteristics and power output of cyclists. Researchers found that fascicle length within the rectus femoris explained a large portion of the variance for the 20-sec power output in short-distance cyclists. Conversely, fascicle angle within the rectus femoris explained a large portion of the variance for the 20-sec power output in long-distance cyclists. Both of these findings highlight the significance of rectus femoris muscle architecture to cycling power. Indeed, the fascicle length of the rectus femoris in the short-distance cyclists could account for 86% of the 20-sec power output variance, while fascicle angle in the long-distance cyclists accounted for 68% of the 20-sec power output variance.

Various areas of the rectus femoris, vastus medialis, and medial head of the gastrocnemius were significantly thicker in short-distance cyclists versus long-distance cyclists. Additionally, short-distance cyclists, compared to long-distance cyclists, possessed greater fascicle angles in the vastus lateralis and medial head of the gastrocnemius, and longer fascicles in their rectus femoris.

## Practical Takeaways

Based on the findings of this study the authors proposed that specific training should be considered for short-distance and long-distance cyclists. For short-distance cyclists the authors hypothesized eccentric cycling and stretching of the rectus femoris could enhance cycling performance. Conversely, for long-distance cyclists they recommended specific training that would improve the fascicle angle of the rectus femoris, as opposed to increasing muscle thickness through high-resistance strength training.

I had high expectations going into this paper. Being able to utilize US as a method for talent identification, and/or measuring the progress of an individual's training could prove to be valuable to practitioners. However, in my opinion, the ambiguous labels used for the cyclist categories and a lack of important relevant information about the participants, potentially reduces the usefulness of this paper for the practitioner. For example, what constitutes a "short-distance" versus "long-distance" cyclists is unclear. These labels could be determined as track cyclists versus endurance cyclists (e.g. road and mountain bikers), or as track sprinters versus endurance track cyclists, respectively. Does the group label refer to the durations of the events the cyclists participate in, or the duration of their training rides? It was not exactly clear. The paper provides the average overall hours the cyclists trained, but this value is not broken down into the type of training the participants of each group performed (e.g. strength training, versus low intensity cycling exercise, versus HIIT). So it begs the question, if we lack certainty around the type of training these participants engaged in, how much weight can we give to this paper?

Additionally, this paper did not mention the biological sex of the participants. Knowing there are clear power output and anatomical differences between male and female cyclists, it would have been good to know for certain if the number of males and females was matched between groups, as a difference in these numbers could skew results.

What the paper does provide in terms of subject data is body mass and 20-sec power output for the short-distance and long-distance cyclists (76.5 ± 7.5 kg, 67.8 ± 6.6 kg; 1077.0 ± 102.0 W, 907.6 ± 99.7 W; respectively). Significant differences between groups were found for both these measures. However, a back of the napkin calculation demonstrates the W/kg for the short versus long groups was 14.1 W/kg and 13.4 W/kg, respectively. To me, that does not seem like a large difference considering the cohorts. Therefore, I wish they would have also provided a between group analysis for the W/kg metric.

## Jason's Comments

"Admittedly, I have been a bit critical of this paper, but I'm of the opinion the issues I have noted above could have been amended prior to this paper being published had it been submitted to a "more appropriate" journal (i.e. a sport science or applied physiology journal). As it stands, this journal was published in Nature Scientific Reports (i.e. not a sport science journal), and I think it is worth questioning whether this paper was reviewed by the appropriate reviewers. I am guessing a reviewer with an expertise in applied sport science relevant to cycling performance would have noted these absences and requested amendments in the review process- resulting in a stronger paper for the authors. So, I think the take home message here is, when consuming cycling science/performance papers from a non-sport science/non-applied physiology journal- consumer beware.

My remaining comments are in regards to the study design the authors utilized. But to be fair, these are not criticisms leveled at the researchers or the paper specifically. It is always easy to criticize what the researchers did not include in their study design in hindsight without knowing the limiters they may have faced. However, as the authors pointed out in their discussion, it would have been great if they could have analyzed additional athlete (especially weight lifters) and non-athlete groups for comparison (i.e. controls) with the cyclists. Additionally, an aerobic test (e.g. 20-minute power output, graded exercise test) would have been a nice addition to compare muscle architectural characteristics with aerobic power in these cyclist groups."

Abstract

# Exercise in the heat blunts improvements in aerobic power

**OBJECTIVE**

The purpose of this study was to determine if the blunting effect heat stress during exercise has on peroxisome proliferator-activated receptor gamma coactivator 1-alpha (PGC-1a), a master regulator of mitochondrial biogenesis, results in reduced aerobic ability after combined heat acclimation and exercise training.

**WHAT THEY DID**

Twenty-one untrained college aged males were randomly assigned to 3 weeks (16 sessions) of aerobic exercise training in either 33°C or 20°C. Pre and post the training intervention participants performed a graded exercise test in temperate conditions (20°C) to determine peak oxygen consumption (VO2peak) and peak power output (PPO). Additionally, the first and last exercise sessions were performed in the given intervention temperature at a set exercise intensity to evaluate changes in fitness relative to temperature (i.e. test for heat acclimation). During these sessions muscle biopsies were taken 4 hours after training to evaluate PGC-1a response, and markers of mitochondrial content after exercise in 33°C or 20°C. Exercise intensity for the remaining sessions (i.e. 2-15) was determined by individual rate of perceived exertion. Heart rate (HR) and power output (PO) during these training sessions were recorded.

**WHAT THEY FOUND**

Heart rate and PO during the 20°C and 33°C training interventions were not significantly different.

The group that trained in 20°C increased their VO2peak from 37.8 ± 9.9 mL/kg/min to 42.6 ± 8.7 mL/kg/min (~13%), while the 33°C training group did not observe a significant change in VO2peak (37.5 ± 5.4 mL/kg/min to 38.8 ± 6.5 mL/kg/min; 3.5%). However, contrary to VO2peak results, increases in PPO were similar between the 33°C and 20°C groups. PGC-1a levels were lower after training session #1 in 33°C compared to 22°C, but levels of PGC-1a declined in both groups by the final training session with no difference in levels between groups. Markers for mitochondrial content did not change pre and post intervention.

## **Practical** Takeaways

When it comes to practical takeaways, it is important to point out some of the major differences between this study and what an athlete and/or coach might face in real life. Firstly, these were untrained individuals (i.e. not endurance athletes), and this comes with a plethora of confounding factors (e.g. lower fitness & ability to recover, higher body mass & percent body fat) that potentially affect this study's findings. Additionally, the heat acclimation/training intervention utilized in this study is atypical for endurance athletes. Conventional heat acclimation protocols for this cohort are typically 14 days or less and involve training sessions outside of a hot environment. Any or all of these factors could have provoked a state of nonfunctional overreach in this study's untrained population, resulting in the findings observed by the researchers for the 33°C group. Indeed, even endurance athletes can experience a decline in performance due to overreaching after only 5 consecutive days of high-intensity exercise in the heat1,2.

The fact that the PO was the same between the two temperature conditions when RPE and HR were also the same is a bit odd. Typically, a matched RPE and/or HR between a hot and cool condition would mean a lower PO, and the authors of this study did indeed note that. In the case of reduced workload during training in the heat, one could potentially expect reductions in peripheral stimulation- which could also explain the results from this study.

Generally speaking, VO2max increases during training in untrained individuals is initially caused predominantly by increasing plasma and blood volume. One could potentially hypothesize, given the similar HR between training conditions, similar central adaptations would be stimulated by the training intervention resulting in similar increases in VO2peak between the 22°C and 33°C training groups. However, this was not the case for this study.

## Jason's Comments

"I reviewed this study with the intention of presenting it as an example of why it is important to look closely at the details of a scientific study prior to considering how it will impact your athletes (if you're a coach) or training (if you're an athlete).

Despite the title and select results of this study indicating the potential that exercising in the heat can attenuate endurance performance, I can think of three pieces of evidence that demonstrate this is a lower risk than one might initially think. Firstly, the amount of evidence for the benefits of heat acclimation when preparing to compete in a hot environment is massive. So if your intention is to acclimate for competing in the heat you should not be discouraged by this study. Secondly, the PPO for both training groups increased similarly post intervention. And I think in the applied world, this result of an actual PO should hold more weight than the lack of increase in a physiological parameter related to performance. Lastly, despite the decrease of PGC-1a after training in 33°C, the metric this was supposed to affect (mitochondrial content) did not change between pre and post intervention for either temperature conditions."

# Technology & Profiling

This month's top research on technology and profiling

### Ramp vs. step tests: valid alternatives to determine the maximal lactate steady-state intensity?

Caen, K., et al. European Journal of Applied Physiology. 2021.

### Assessing the Accuracy of Popular Commercial Technologies That Measure Resting Heart Rate and Heart Rate Variability

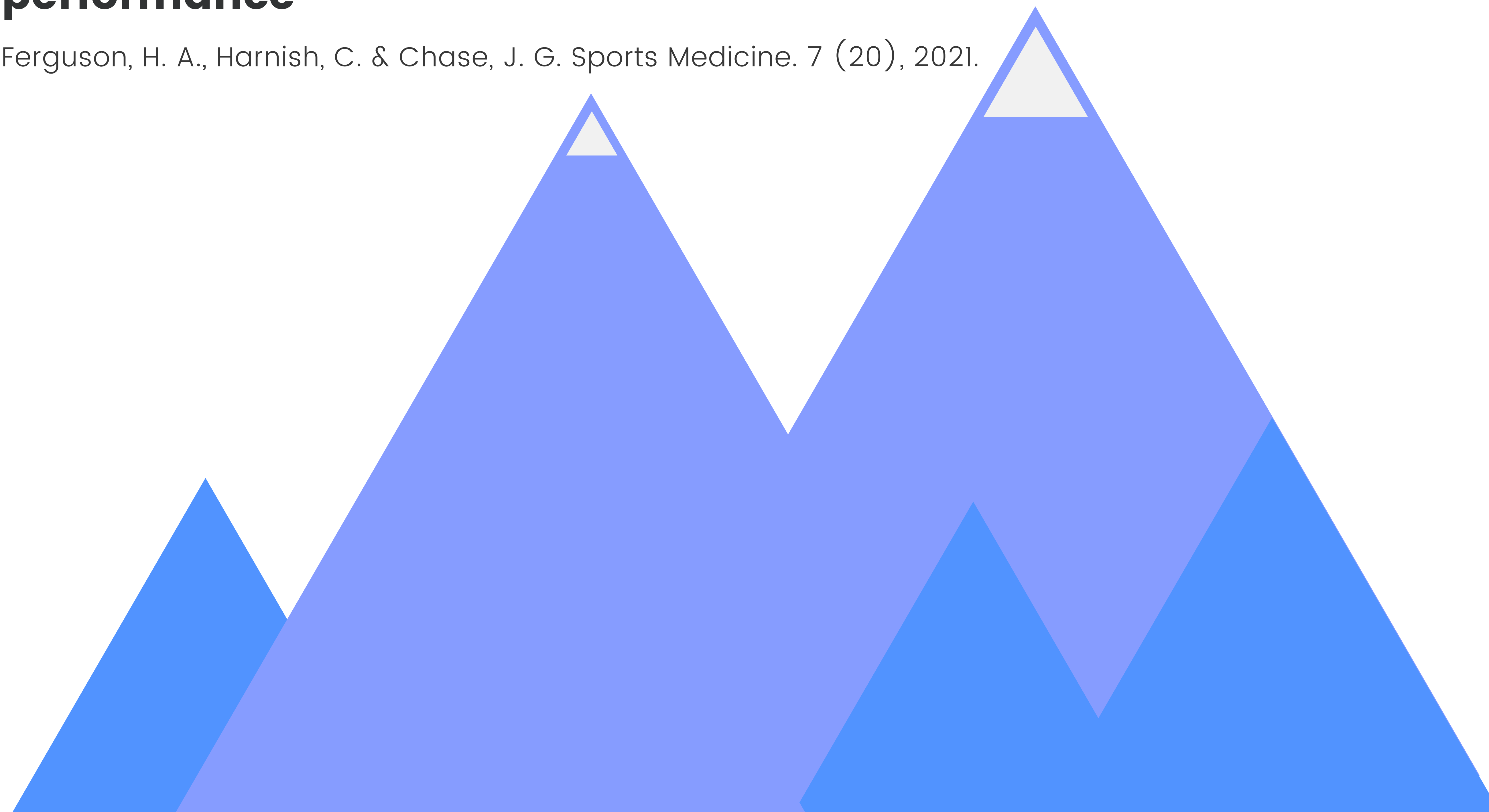
Stone, J., et al. Frontiers in Sports and Active Living. 3, 2021.

### Demands of the Tour de France: A case study of a world-class sprinter (Part I)

Erp, T., et al. International Journal of Sport Physiology 1 (8), 2020.

### Using field based data to model sprint track cycling performance

Ferguson, H. A., Harnish, C. & Chase, J. G. Sports Medicine. 7 (20), 2021.



Abstract

# Ramp vs. step tests: valid alternatives to determine the maximal lactate steady-state intensity?


**OBJECTIVE**

Ramp incremental (RI) exercise tests are commonly used to assess physical fitness levels and to design exercise and training programs in a wide variety of populations. The main advantage of these protocols relates to the possibility of evaluating both maximal and submaximal parameters of aerobic performance in a time-efficient way.

Due to the non-steady-state circumstances during RI exercise, the measured $\dot{V}O_2$ will lag behind the true metabolic needs for any given intensity above the gas exchange threshold (GET), even when the mean response time (MRT) of the $\dot{V}O_2$ kinetics is accounted for. This leads to a situation in which the ramp-identified power output (PO) at respiratory compensation point (RCP) will in reality elicit a metabolic intensity that exceeds 'maximal metabolic steady state' (MMSS).

The aims of this study were to examine whether the correction strategy for RCP as proposed by Caen et al. (2020) is a valid procedure to estimate MLSS.

**WHAT THEY DID**

RI test: This test consisted of 4 min of baseline cycling at 50 W, followed by a linear and continuous increase in PO of 30 W·min-1.
SI test: The protocol consisted of 3-min stages and was designed to obtain a minimum of six steps, starting at 30 W (for women) or 40 W (for men) with stepwise increments of 30 W (for women) or 40 W (for men).

MLSS tests: Participants performed two or more constant workrate (CWR) trials to determine MLSS. Each test started with 4 min cycling at 50 W, immediately followed by an abrupt increase to the appropriate PO at which the subjects had to cycle for 30 min. Every 5 min, a capillary blood sample was taken to measure [La-]. The PO for the first test corresponded to the corrected PO at RCP (RCPcorr-1). The PO for the subsequent tests was increased or decreased by 10 W dependent on the blood La- response.

**WHAT THEY FOUND**

- In general, time to exhaustion (TTE) was longer for the SI test ($P<0.001$), and POpeak and RERpeak were higher for the RI test ($P<0.001$). On the contrary, no differences in $\dot{V}O_2$peak ($P=0.859$) and HRpeak ($P=0.679$) were found.

  RCP, as derived from a standard RI test, can be accurately translated into the PO associated with MLSS. Furthermore, they found that the SI test was suitable to estimate the MLSS intensity when LT2 was determined by experts (i.e., LT2-expert), but not when the threshold determination was based on a predefined model.


## **Practical** Takeaways

- Together, these results suggest that both RI and SI tests can be successfully used to determine the PO at MLSS, but also highlight that the selection of an appropriate threshold methodology and the expertise of the exercise physiologist are essential.

- Due to the complexity of $\dot{V}O_2$ kinetics at higher intensities, coaches and physiotherapists who prescribe exercise on the basis of a RI test are often lost in translation and impose a higher then intended training load. The present study validated a novel correction strategy to overcome this problem by demonstrating that both the PO and HR at MLSS can be accurately derived from a standard RI test. By providing an appropriate correction strategy for RCP, RI tests can be easily used to define PO zones for training purposes and increases the overall utility of RI tests in the lab and the field.

  The correction strategy for translating PO at RCP can be found in the link below.

## Cyrus' Comments

""Unfortunately, this study did not use well-trained participants and the authors noted that the VO2 kinetics pivotal to their correction method may vary in those with more prior endurance training.
If a similar correction strategy is found to be applicable to trained athletes in future it could shift the preference of coaches toward ramp tests over step tests for defining athlete training zones. As a rider, I like the idea of this; a ramp test involves a significantly shorter time period to complete - less time in pain to give a similar insight into metabolic thresholds.

The authors also highlight the importance of a knowledgeable physiologist to apply test results to real-world training no matter the test protocol is used. Given the differing energy system interplay between athletes with contrasting physiological characteristics, it's important to keep in mind that one number from a test result should never define the intensity for every type of training session."

Abstract

# Assessing the Accuracy of Popular Commercial Technologies That Measure Resting Heart Rate and Heart Rate Variability

### OBJECTIVE

The proliferating market for consumer off-the-shelf (COTS) wearables has created an opportunity for consumers to systematically monitor their own health on a regular basis.

Shortcomings in the extant literature pertaining to heart rate variability (HRV) commercial technologies are concerning as data derived from these sources may be incorporated into daily decision making by clinicians, researchers, practitioners, or consumers.

The purpose of this study was to perform resting-state validations of HR and root Mean Square of Successive Differences (rMSSD; a HRV metric), collected via COTS devices, against a commercially available multi-lead electrocardiogram (mECG). A secondary objective was to determine whether or not there were differences in accuracy for measuring rMSSD when comparing commercial ECG and photoplethysmography (PPG) devices.

### WHAT THEY DID

The various COTS devices and applications implemented for direct comparisons to mECG included three tangible devices and three third-party applications. Of the devices examined, the 2nd generation Oura smart ring (OURA) was a finger-based ring whereas both the Polar H10 and Firstbeat Textile strap (FSTBT) were commercial chest-based ECG straps (cECG). Data from OURA and FSTBT were obtained via Bluetooth synchronizing to the companies' smartphone application on an iPhone 8. The Polar H10 strap was connected via Bluetooth to the third-party smartphone applications HRV4Training (HRV4TR/ECG) and EliteHRV (ELT/ECG). Additionally, PPG comparisons were conducted for the following third-party applications: HRV4Training (HRV4TR/PPG), EliteHRV (ELT/PPG), and CameraHRV (CAMHRV). An iPhone 8 camera was utilized for HRV4TR/PPG, ELT/PPG, and CAMHRV such that all three were fingertip-based PPG (fPPG) assessments.

Subjects were asked to sit still for a 3-5 minute period and data from mECG and all COTS devices were timestamped for statistical analyses.

### WHAT THEY FOUND

| Metric: HR<br>Device: | MAPE (%) |
|---|---|
| Firstbeat | 0 |
| PolarH10+EliteHRV | 0.69 |
| Camera+EliteHRV | 1.22 |
| PolarH10+HRV4Training | 2.07 |
| Camera+HRV4Training | 2.34 |
| CamHRV | 17.26 |

| Metric: HRV<br>Device: | MAPE (%) |
|---|---|
| PolarH10+HRV4Training | 4.10 |
| Oura | 6.84 |
| PolarH10+EliteHRV | 7.66 |
| Camera+EliteHRV | 8.71 |
| Camera+HRV4Training | 9.43 |
| Firstbeat | 11.27 |
| CamHRV | 112.36 |

## Practical Takeaways

- Similar to previous studies, devices performed with varying degrees of accuracy with MAPE ranging from 4 to 112%. The greatest degrees of confidence are extended to HRV4TR/ECG and OURA, as this data suggests they can most accurately report rMSSD as both possessed MAPEs below 7% and concordance correlation coefficients (CCCs) above 0.90. Contrarily, CAMHRV was the worst performer with a MAPE of 112% and CCC of 0.04%. Further, cECG based devices generally outperformed PPGs, although there were a couple of exceptions. The Oura smart ring (PPG) exhibited better accuracy than all cECGs except for HRV4TR/ECG and the FSTBT (cECG) lacked in rMSSD accuracy.
- Ultimately, a decision regarding purchase and usage of any of these COTS is to be made as to what degree of accuracy is necessary for the intent of the device, which may vary across populations.

## Cyrus' Comments

""Independent, third-party evaluations such as this one are imperative as they hold brands accountable to claims made about the accuracy of their product. Given the increasing use of data from wearables to influence recovery and training strategies, it is important for athletes and coaches to ensure the device used is providing reliable data before any pivotal decisions are made regarding training.

This particular study may even have been a little too generous to the companies' claims behind the devices used; only resting data was collected. Greater errors could be expected with movement and HR fluctuations associated with exercise.

A take home message I like to give to my own athletes and peers is that you shouldn't rely entirely on a watch or device to tell you whether you're tired or not. Your body does a pretty great job of this."

Abstract

# Demands of the Tour de France: A case study of a world-class sprinter (Part I)

### OBJECTIVE

The purpose of this case study was to describe intensity, load, and performance characteristics of a world-class sprinter competing in the Tour de France (TdF). Road sprinters who compete in grand tour cycling events can be classified as outliers among outliers, with noteworthy physiological and anatomical differences between them and their contemporaries in the peloton. For example, unlike the role of a climber (which requires a high watts/kg), a the role of a sprinter requires the ability to produce high explosive power output (PO). This ability is linked with an increased muscle mass. However, this increase in muscle mass hampers a cyclist ability to climb. Consequently, the results of sprinters (and other cycling specialists) are heavily determined by the topography of the course.

Comparisons in this study were made across different types of TdF stages for the individual sprinter. To the author's knowledge, this was the first study to present the average daily load and intensity demands for this level of sprinter competing in the TdF (i.e. one of the most demanding races in cycling). Additionally, this paper presented differences between sprinter and general classification (GC) contenders.

### WHAT THEY DID

Power output data was collected from professional road cycling sprinter Marcel Kittel for the 2013, 2014, 2016, and 2017 editions of the TdF. Training load (e.g. training stress score; TSS), intensity distribution (using Coggan's zones), and maximal mean PO (MMP) were quantified. TdF stages were categorized as flat (FLAT), semi-mountainous (SMT), mountain (MT) and time-trials (TT). Additionally, mountain passes were classified by their location in the stage as BEGINNING, MIDDLE, or END. TSS was calculated in part using functional threshold power (FTP). FTP for each TdF was calculated as 95% of the highest 20-minute MMP from that season.

### WHAT THEY FOUND

- Load, intensity, and performance characteristics were not significantly different across the four editions of the TdF, but the researchers did find the difference between average daily kilojoules (kJ) spent in 2013 versus 2014 were 16% higher in the latter.

  TT stages were higher in intensity, but lower in load than FLAT, SMT, and MT stages.

- Load during MT stages were higher than FLAT and SMT stages. FLAT stages had higher short duration (< 1min) MMP, while MT stages had higher long duration (>20 min) MMP.

  It was also observed that mountain passes at the BEGINNING of the stage were performed with higher PO, cadence, and speed mountain passes at the END of a stage.

## Practical Takeaways

- This study highlighted the differences between TdF editions; FLAT, SMT, and MT TdF stages for a high-level road sprinter; and also gave insight into how the TdF differs for a sprinting specialist vs. a GC specialist.

  The presence of the 16% higher kJs performed during the 2014 TdF versus the 2013 TdF coincided with Kittel finding it substantially more difficult to finish stages in 2014. Compared to GC specialist data across multiple grand tours, the largest difference in daily kJ expenditure was only 7%. This demonstrates the load the sprinters experience is influenced more by the course than their GC specialist colleagues.

  Marcel Kittel is at one extreme of the TdF competitor population. Highly successful in the sprints he contended in, having won 16%-22% of the mass start races he participated in during his most successful seasons. These wins are due in a large part to his ability to produce a high explosive power output- approaching that of a track cyclist. This high PO for short durations is due to his large muscle mass. However, this additional mass leaves him ~20 kg heavier than a GC contender, while his FTP is comparatively similar. This results in a W/kg reduction of ~20% compared to other competitors. Consequently, in contrast to his prominent sprint wins, he finished in the last 5% the GC. And while this he finished in the bottom 5% of the GC, his overall TSS score in a GT is ~750 AU higher than that of a GC contender. This again demonstrates the difficulty the TdF poses for a for a heavier sprinting specialist, but it also highlights the tactics utilized by this cohort of riders (i.e. taking it easy on stages they are not in contention for the sprint).

- Lastly, the authors of this paper noted that Kittel's relative FTP of 4.9 W/kg might be approaching the minimum needed to finish the TdF in the given time allowed.

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## Jason's Comments

""There are two general rules in science (more specifically human subject research) this study 'breaks'. First, it's best to avoid publishing papers with only one, or a few, number of participants, as these studies are highly susceptible to having their results skewed. After all, what is the difference between an "n of 1" and an anecdote? Secondly, it's not good practice to allow for your study participants to be identified. However, as they say, for every rule there is an exception, and in this case there are plenty of reasons why this paper gets a free pass on those typical standards.

Firstly, to be fair, this study never actually came out and stated it was Marcel Kittel's data. But when your study is looking at one world-class sprinter in the TdF and the second author of the paper happens to be a former world-class sprinter who competed in the TdF, it's pretty safe to say where the data came from. So big kudos to Marcel for sharing his data and being a part of the sport science process. The field is better off because of it.

To address the issue with the "n of 1", yes, typically scientific experiments involve multiple participants under conditions that are controlled for as best as can be expected. However, in this case when you are examining a minute subset of athletes (e.g. world-class TdF sprinters) within an already tiny population (e.g. athletes who compete in the TdF) the best we can expect sometimes is retrospective description of what an n= 1 did over the course of a handful of races. Some knowledge is better than nothing. So again, good on Marcel for allowing us to take a peek at what was going on during his races."

Abstract

# Using field based data to model sprint track cycling performance

### OBJECTIVE

This review discusses the current state of modeling in sprint track cycling performance. The authors note that several models currently exist that enhance the understanding of performance in road cycling and track endurance. However, similar models do not currently exist for sprint cycling. Instead practitioners rely on peak-power, speed, and strength to assess performance and guide training. Unfortunately, these methods of assessing performance do not adequately explain the demands of actual competition in events between 15-60 sec. Additionally, these methods fail to the represent the real-world demands of repeated maximal sprints over the course of a track competition, and concurrently, the full scope of bioenergetic demands sprint cyclists must cope with.

### WHAT THEY DID

In the absence of descriptive studies for track sprint cycling events this review utilized data from physiological interventions using track cycling and repeated sprint exercise from other sports in an attempt to interpret the demands that track sprint cyclists would experience during competition.

### WHAT THEY FOUND

- The primary test of sprint performance is a one off power test of 4-30 sec. Subsequently, the model for sprinting is focused on neuromuscular power and phosphagen bioenergetic pathways. However this approach to testing track sprinter performance is overly reductionist in nature as it does not take into account other contributing bioenergetic systems and the nature of sprint competition. Indeed, physiology research has demonstrated clear contributions from the glycolytic and oxidative systems for ATP production during sprints as short as 10 sec.

- Additionally, all track cycling events involve repeated sprint efforts, yet the current research suggests that sprinters with high type IIx fibers recover slower from maximal efforts. Consequently, this cohort of cyclists would potentially see greater decreases in performance than fellow competitors with better aerobic capacity over the course of a competition.

## **Practical** Takeaways

- A greater consideration and continued research on improving sprint track cycling performance models is needed. A better understanding of the areas covered in this review would help to close the gap of knowledge in the practice of sprint track cycling training. Moving forward, the authors of this review propose utilizing models based on field testing during sprint competition. Importantly, these models should take into consideration the repeated sprint nature of track cycling competition. Additionally, the authors proposed a shift in sprint-cyclist training. Whereby, instead of training for just peak power, they encourage a more comprehensive approach that considers the bioenergetic and ecological demands of actual competitive sprint events.

## Jason's Comments

""Hamish Ferguson, the first author of this paper is one of those few individuals who dwells in both the practitioner/coaching side and researcher side of cycling sport. As a coach he has lead riders to 84 National titles and 19 UCI World Championship Medals, and has twice won the Cycling New Zealand Coach of the Year for Road and Track Coaching. Currently, he is studying towards a PhD in Bioengineering at the University of Cantebury. This review reflects the keen insight of these professional and academic roles combined into one individual. I'll be looking forward to seeing more papers from him as he progresses through his academic career.

Additionally, I really like the fact that this review really hammers the point home that contributions from bioenergetic systems are never mutually exclusive from one another. I.e., you always have all of the different systems for ATP production contributing at any given time. What changes is the percentage and quantity they contribute to the overall system's ability to do work."

# Nutrition

This month's top research on nutrition

### The Cardiac Effects of Performance-Enhancing Medications: Caffeine vs. Anabolic Androgenic Steroids

Sivalokanathan, S., Malek, L., Malhotra, A.. Diagnostics. 11 (2), 2021.

### Menthol Mouth Rinsing and Cycling Performance in Females Under Heat Stress

Gavel, Erica., et al. International Journal of Sports Physiology and Performance. Ahead of Print, 2021.

Abstract

# The Cardiac Effects of Performance-Enhancing Medications: Caffeine vs. Anabolic Androgenic Steroids

**OBJECTIVE**

The removal of caffeine from the World Anti-Doping Agency (WADA) list of banned substances, in 2004, has naturally led to an exponential rise in its use amongst athletes. Whilst the evidence for a link between caffeine and increased cardiovascular risk may be equivocal, the ability of an athlete to train longer or at a greater power output cannot be overlooked. Furthermore, its impact on the myocardium remains unanswered.

In contrast, anabolic androgenic steroids (AASs) are recognised PEDs that improve athletic performance, increase muscle growth and suppress fatigue. Their use, however, comes at a cost, afflicting the individual with several side effects, including those that are detrimental to the cardiovascular system.

This review addresses the effects of the two most common PEDs, one legal, the other prohibited, and their respective effects on the heart, as well as the challenge in defining its long-term implications.

**WHAT THEY DID**

The authors performed a comprehensive search on Pubmed, and Scopus focusing on the effects of caffeine and/or AASs to exercise and its subsequent effects on the myocardium. Reviews, meta-analyses, prospective, retrospective, interventional and observational studies were included in our search. The review of AASs was limited to findings after the year of 1986, as widespread testing became available in Europe and the United States at the end of 1986. Key search terms included: “caffeine”, “caffeinated”, “CAF”, “tea”, “energy drinks”, “anabolic androgenic steroids” in combination with “exercise”, “athlete”, “myocardium”, “cardiac”, and “heart”.

**WHAT THEY FOUND**

Caffeine may conversely attenuate the physiological response to exercise, such that there may be reduced coronary blood flow or response of the endothelial cell in mediating the vascular tone during exercise, which signifies a potential risk to an athlete with silent coronary disease.

Other impacts of caffeine include a delayed return of the parasympathetic nervous system, and with a state of sustained sympathetic activity, this may confer an increased risk of life-threatening arrhythmias.

The findings suggest that whilst caffeine does not have noticeable structural changes on the myocardium, AASs have several. Imaging and histopathological samples have demonstrated left ventricular hypertrophy, cardiomegaly and interstitial fibrosis, respectively. Such remodelling has ramifications on the CVS, not only immediately but in the long-term as well. Substantial cardiovascular changes include increase in vascular tone and elevation in blood pressure, alterations in lipid profile and direct myocardial toxicity, resulting in reduced left ventricular function, cardiac hypertrophy and arterial and venous thrombosis. In contrast, there is a lack of compelling evidence to suggest that caffeine has lasting morphological changes to the myocardium.

## **Practical** Takeaways

When examining the literature to date, caffeine may not necessarily give an athlete the essential edge. However, its use may not disadvantage them either, especially since the majority have consumed such a supplement prior their sporting event. The findings listed above relating to caffeine are likely only applicable to those with pre-existing heart conditions and at significantly higher risk than the general population. This supports recent implementation from the UCI of mandated regular cardiovascular health assessments for all professional cyclists.

In contrast, AASs have documented improvement in athletic proficiency. However, it does not negate the several adverse cardiovascular effects that are associated with their use. With the continued use of both caffeine and AASs, regular assessment, that includes evaluating the electrical activity and morphology of the myocardium, using non-invasive imaging and functional methods would be important in identifying those who are at an increased risk of cardiovascular disease or an acute cardiac event.

## Cyrus' Comments

"This open-access review is a great ‘go-to’ to bookmark for information on caffeine and well worth a read for those currently using caffeine as a legal PED or planning to. Whilst the general conclusion of literature to date supports WADA’s stance on caffeine’s safety in sport it is important, as with any substance, to be aware of recommended dosages, possible risk factors, substances which compliment its influence and side effects to watch for.

It’s also a good reminder to those pushing their bodies to their physiological limits, with or without the aid of pharmaceuticals, to regularly have their cardiac health assessed. There’s likely to be a study near you where you can volunteer as a participant and get this done for free!

If anyone subscribed to this digest is using AASs or had considered it and all the obvious reasons (see integrity of sport) weren’t enough to deter you already - hopefully the likelihood of various future cardiovascular complications is enough to tip you over the line..."

Abstract

# Menthol Mouth Rinsing and Cycling Performance in Females Under Heat Stress

### OBJECTIVE

The primary purpose of this study was to characterise the effect of a methonol mouth rinse (MEN MR) on the performance of a 30-km cycling independent TT (ITT) in female cyclists while simultaneously measuring power output, core tempuratue (Tc), heart rate (HR), sweat loss, and perceptions of the environment and exertion.

They hypothesized that the MEN MR will improve ITT, isometric, and exercise performance and decrease the perceptual responses for a given workload.

### WHAT THEY DID

Nine females participated in the study. They were members of cycling clubs from across the Greater Toronto Area, trained at least 5 days per week in the summer, and participated in winter training.

Each participant performed three 30-km ITTs in an environmental chamber (30°C [0.6°C], 70% [1%] relative humidity, 12 [1] km/h wind speed). Each trial was separated by 7 days.

The time trials included a full familiarization trial and a total of 2 randomized experimental trials separated by 7 days took place.

The experimental trials involved either a placebo or a menthol mouth rinse. The mouth rinse occurred a total of 7 times, before the second handgrip strength and 5-second maximal sprint, 5, 10, 15, 20, 25, and 30 km.

### WHAT THEY FOUND

The ITT performance significantly improved with MEN MR by 2.3% (2.7%) relative to the placebo (62.6 [5.7] vs 64.0 [4.9] min P = .034; d = 0.85; 95% confidence interval, 0.14 to 2.8 min).

The average power output was significantly higher in the MEN trial (P = .031; d = 0.87; 95% confidence interval, 0.9 to 15.0 W). No significant interaction of time and MR for handgrip (P = .581, $\eta^2$ = .04) or sprint was observed (P = .365, $\eta^2$ = .103).

Core temperature, heart rate, ratings of perceived exertion, and thermal sensation did not significantly differ between trials at set distances (P > .05).

Pleasantness significantly differed between the placebo and MEN only at 5 km, with no differences at other TT distances.

These results suggest that a nonthermal cooling agent can improve 30-km ITT performance in female cyclists, although the improved performance with MEN MR is not due to altered thermal perception.

## **Practical** Takeaways

In this study, a 25 mL solution was used and the participants were asked to swill the solution around the mouth for 5 seconds before spitting it out into a container without swallowing the solution.

It is definitely not a 'rinse when you feel like it' kind of thing. In order to reproduce the findings from the study, a methonal solution needs to be rinsed in regular periods of 5 to 10 min, which may not be practical in a lot of contexts.

As mentioned in the methods section this was done 7 times during the ~60 minute time trial. This is also seaprate to any fuelling or hydration needs. So sqeezing them in and breaking an aero position, or finding time to use in a CX or XCO race might be even harder.

Outside of these contexts, it might better to look at alternative delivery methods like sprays. Another very recent study into menthol used it to combat heat(linked below). The researchers found that using a menthol spray after 20 minutes and again after 40 minutes significantly lowered thermal discomfort (although the perceived benefits were less later on during exercise).

The participants' jersey was sprayed evenly with 100 mL of either the CONTROL-SPRAY or the MENTHOL-SPRAY, while the participants continued to exercise. But again spraying would be difficult to repeat under competitive conditions as it took approximately 3 minutes to complete.

**Want to learn more?**
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## Damian's Comments

"The evidence for the benefits of menthol use in hot conditions is very persuasive. By reducing the sensation of thermal discomfort, the same workload performed in hot conditions is likely to feel easier in hot conditions. If the duration of exercise is longer, it may also help improve performance by delaying the onset of fatigue. Both menthol mouth rinses and sprays containing menthol are likely to be effective.

Confirming the benefits of menthol in the heat, a meta-analysis concluded that 'exercise performance can be improved by the application of non-thermally cooling menthol, which also reduces perceptual measures of thermal sensation (linked below).

However, as mentioned in the practical takeaways, these applications are both impractical and difficult to replicate in real race scenarios."

# 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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