

The Female Endurance Athlete (FENDURA): Exploring missing links in exercise physiology

Øyvind Sandbakk

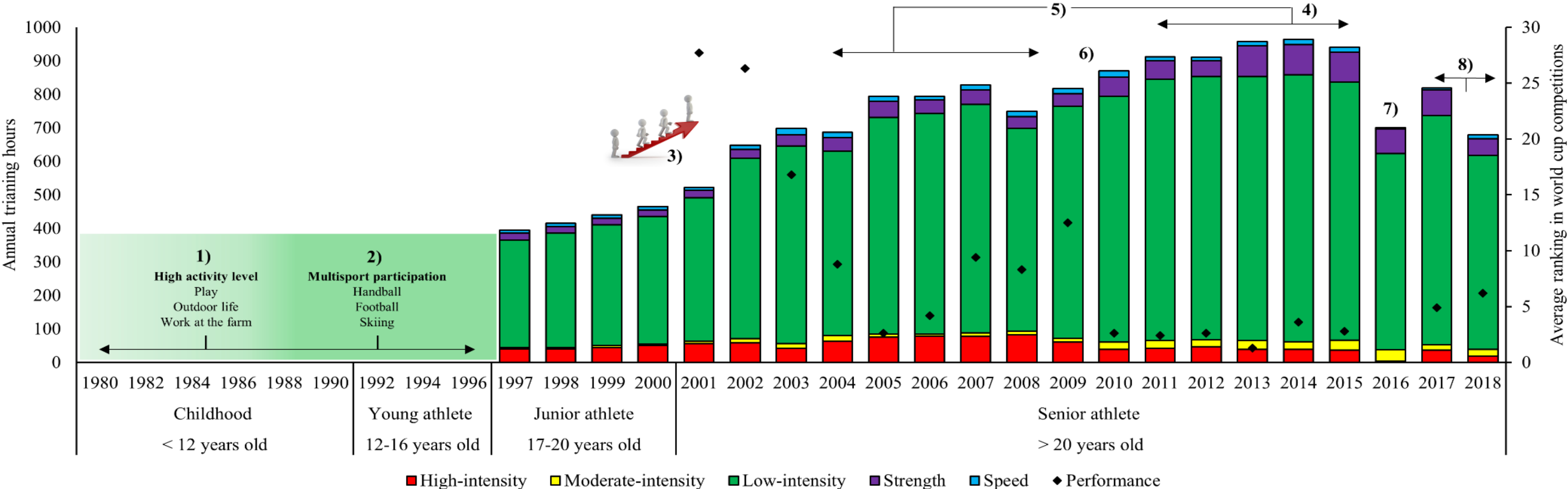
Professor Norwegian University of Science and Technology

Professor II School of Sport Sciences, UiT

Director for the Centre for Elite Sports Research

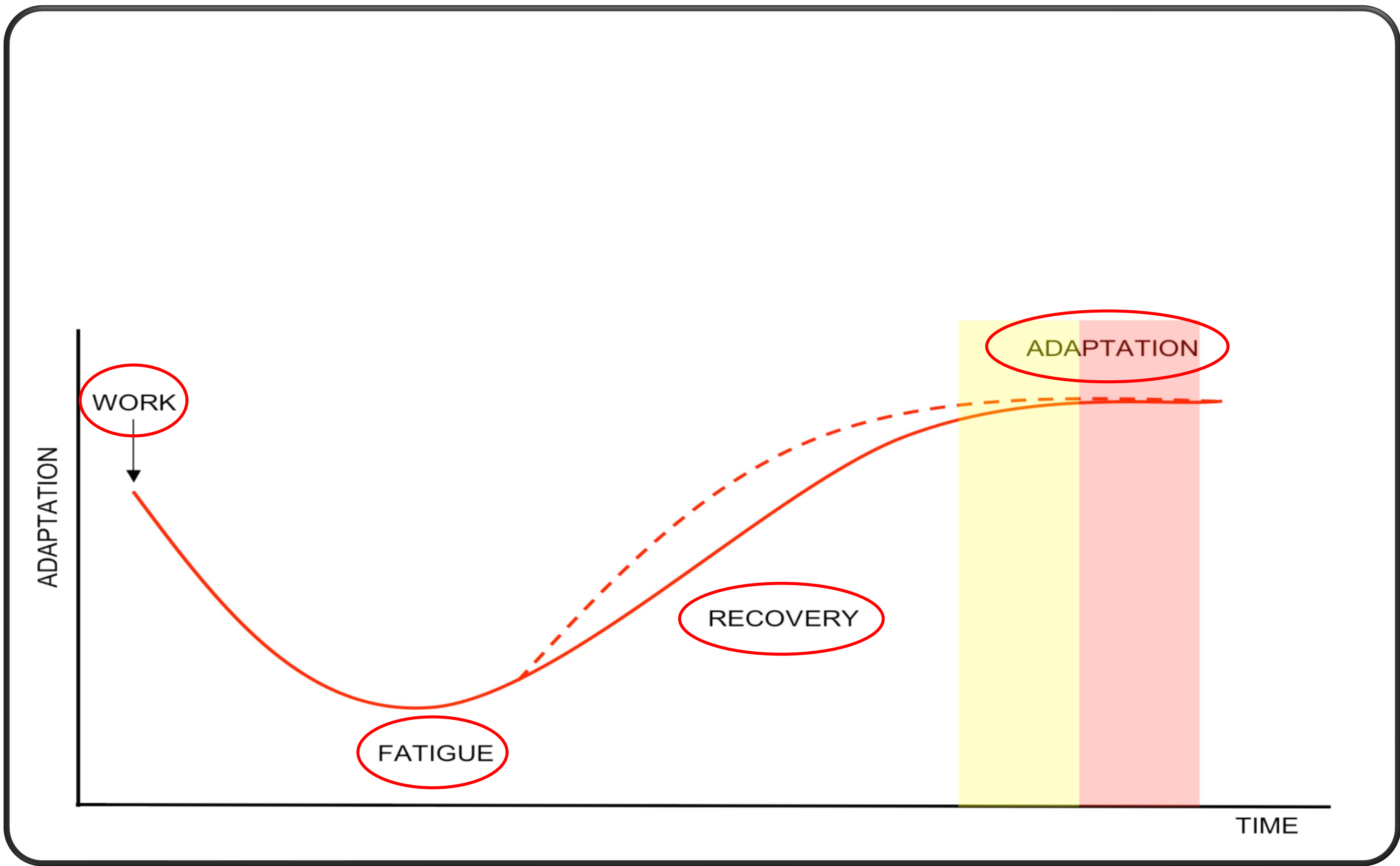
Editor in Chief International Journal of Sports Physiology and Performance

First, some repetition....



The Training Characteristics of the World's Most Successful Female Cross-Country Skier

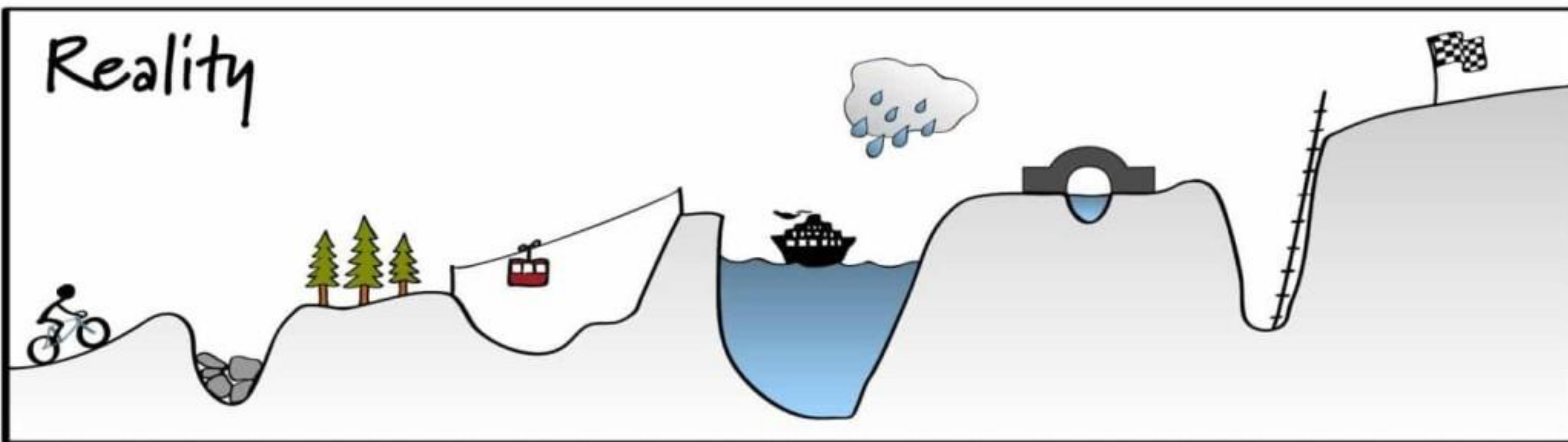
Guro S. Solli¹, Espen Tønnessen² and Øyvind Sandbakk^{3*}

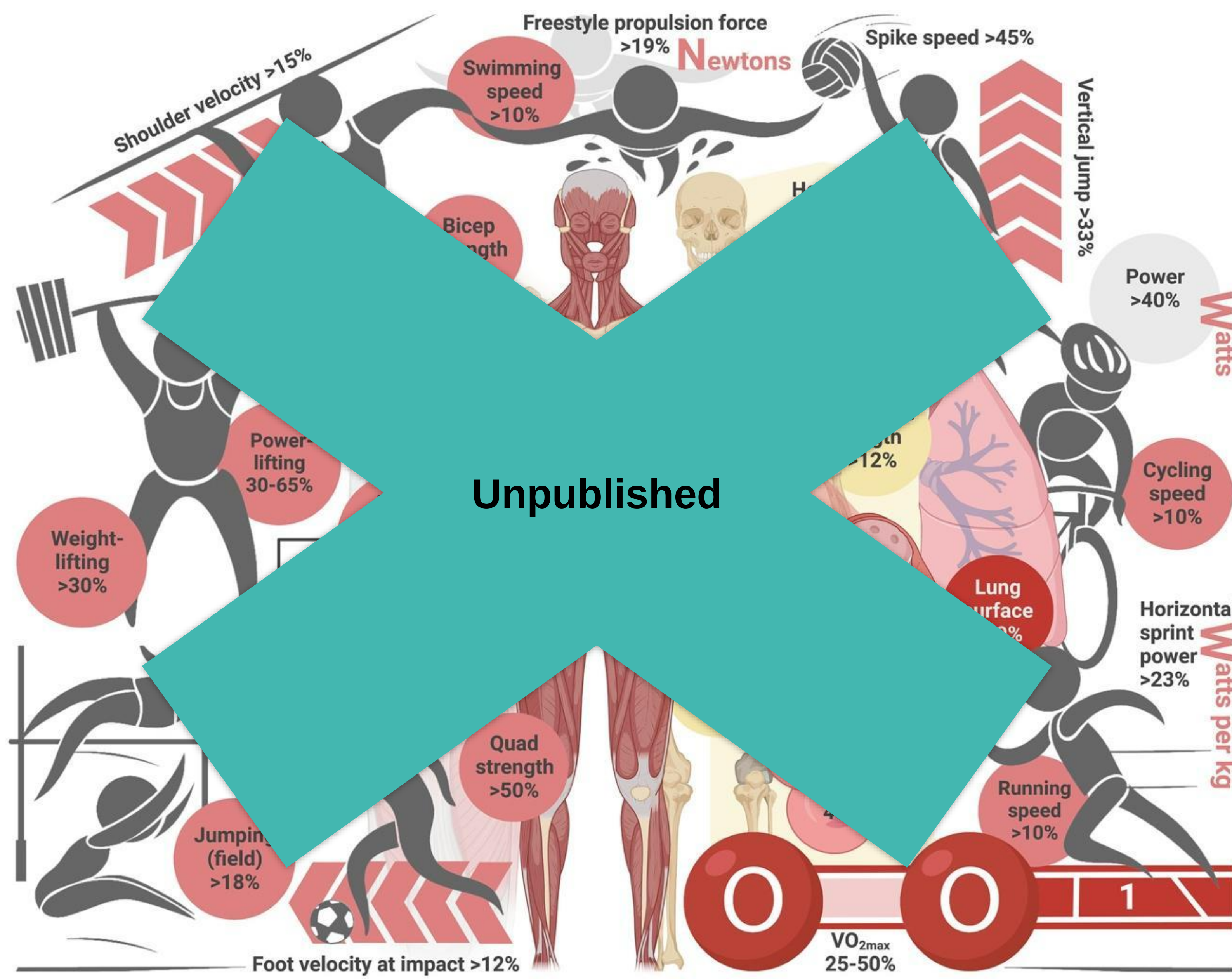


Your Plan



Reality





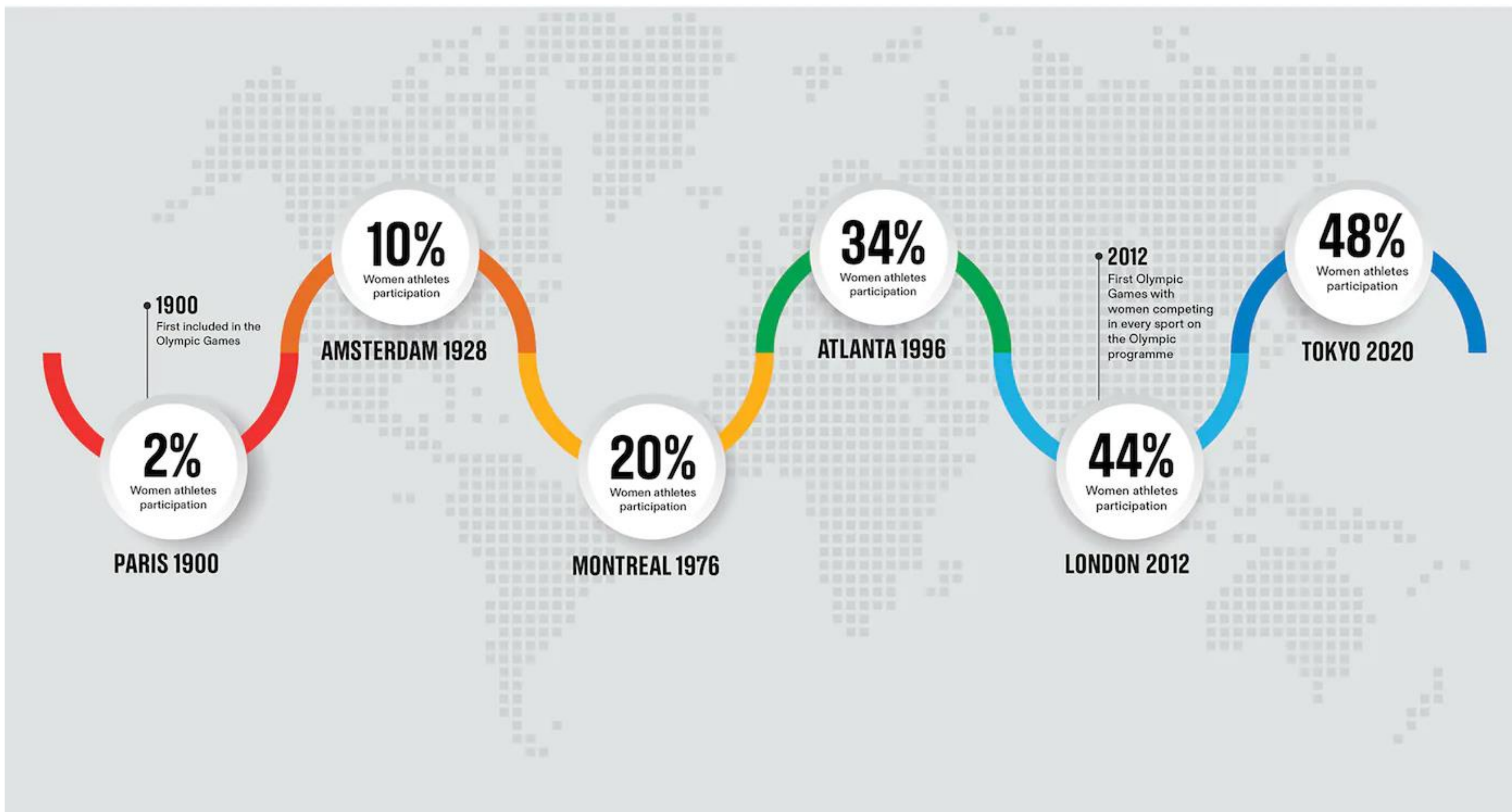
Emma Hilton



Tommy Lundberg



Ross Tucker



Women in Sport and Physical Activity Journal, (Ahead of Print)

<https://doi.org/10.1123/wspaj.2021-0028>

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“Invisible Sportswomen”: The Sex Data Gap in Sport and Exercise Science Research

Emma S. Cowley,¹ Alyssa A. Olenick,² Kelly L. McNulty,³ and Emma Z. Ross⁴

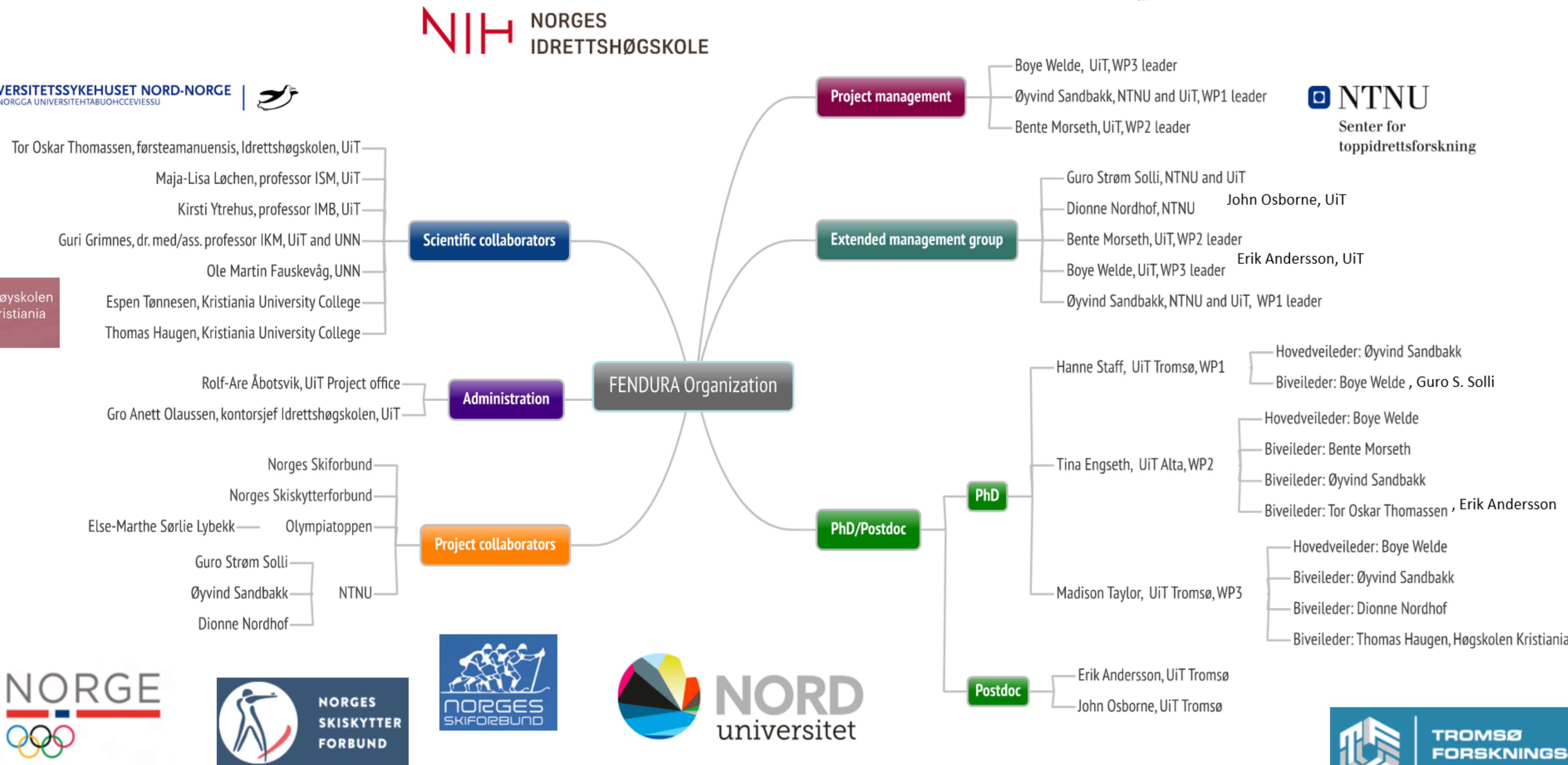
¹Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, United Kingdom;

²Integrative Cardiovascular Physiology Laboratory, Department of Kinesiology, University of Georgia, Athens, GA, USA;

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- Puberty
- Menstrual cycle
- Hormonal contraceptives
- Bone health
- Urine leakage
- Injury risks
- Strength training
- Endurance training
- Technique training
- Recovery
- Overtraining
- Pregnancy and post partum
- Nutrition
- LEA/eating disorders
- Psychology



“Training philosophies in endurance sports”

- 12 Norwegian coaches with a total of 378 Olympic, World- and European championship medals in female and male athletes
 - XC-skiing, biathlon, running, swimming, cycling, speedskating, rowing, triathlon
- Training data analyses and in-depth interviews
 - Quantitative and qualitative analyses
- Aims
 - Investigate best-practice in training content, coaching practice and **gender-differences** among successful coaches



S.B. Sandbakk



T. Haugen



E. Tønnessen



S. Seiler



T. Losnegard

Bucher Sandbakk S¹, Tønnessen E², Haugen T², Sandbakk Ø^{3,4}

Training and Coaching of Female vs. Male Endurance Athletes on their Road to Gold. Perceptions among Successful Elite Athlete Coaches

Training und Coaching von weiblichen vs. männlichen Athleten auf ihrem Weg zu Gold? Einschätzungen erfolgreicher Trainer von Eliteathleten

SHORT REPORT

ACCEPTED: October 2022

PUBLISHED ONLINE: November 2022

Bucher Sandbakk S, Tønnessen E, Haugen T, Sandbakk Ø. Training and coaching of female vs. male endurance athletes on their road to gold. Perceptions among successful elite athlete coaches.. Dtsch Z Sportmed. 2022; 73: xx-xx. doi:

- **Should women and men train differently?**
- **Should women and men be coached differently?**

Bucher Sandbakk S¹, Tønnessen E², Haugen T², Sandbakk Ø^{3,4}

Training and Coaching of Female vs. Male Endurance Athletes on their Road to Gold. Perceptions among Successful Elite Athlete Coaches

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All coaches described how training and coaching of female athletes differs from that of men

- Male athletes considered as the reference group, and male physiology and psychology considered as the norm

Societal factors (e.g. male-dominant sports culture) and underlying gender stereotypes might amplify gender differences

Coach 9 (Biathlon)

«The big challenge is that female athletes are often treated differently than male athletes. I have experienced this both among coaches and other staff. My experience is that there is greater acceptance for boys to be heard when they propose that training should be individualized, even when this individualization leads to deviation from the team's plan. If boys propose such changes, they are perceived as smart and innovative. If girls propose the same type of changes, they are perceived as "difficult".. [...] We have a long way to go in the way we treat women.»

All coaches adjusted their key training and coaching principles to the individual athlete, rather than gender

- A **coach-driven** and **athlete-centered individualization process** was essential to create trust, mutual understanding, and optimal training content

Coach 5 (Cross-country skiing)

- *«The individual process for doing the right priorities in the planning phase [...] leads to the content of the training - so the outcome can of course differ among athletes, and should there be any gender differences, e.g., adjusting training to the menstrual cycle, this is picked up through a thorough analysis and planning process.»*

Potential gender/sex differences

- **Sport-specific competition demands**
 - Fewer and shorter competitions in some sports
 - Differences in absolute performance
 - Larger muscular load at the same relative internal intensity in training and competition
- **Physiological**
 - Hormone-driven sex-differences typically lead to stagnation in performance during middle-to-late adolescence in girls, but not in boys
 - The menstrual cycle may have an impact on training and performance in some women
 - Earlier introduction to and more emphasis on strength training in women
 - Lower tolerance for monotonous muscle loads in women

Coach 10 (Middle- and long-distance running)

- *«This means that we must have considerably **more patience with female athletes**, and thus not rush the training progression. [...] the lack of progress is probably because much of the specific effect (e.g., high anaerobic training load and artificially low body weight) was maximized too early during their careers. [...] Internationally, **many medal winners are well beyond 30 y of age.**»*

- **Psychological**
 - Most coaches perceived larger differences between individuals than genders
 - Female athletes were perceived more emotional, more conscientious, and less resilient by some coaches
- **Interpersonal**
 - Coach-athlete relationship may be coloured by the gender of the coach
 - Communication style
 - Cautious to not negatively impact female athletes' self-confidence and self-esteem

Coach 9 (Biathlon):

“My experience is that it takes more time to create a good relationship and trust with female compared to male athletes. This means that I must spend more time coaching girls, and that I must listen more carefully.”

Overall aim: investigate the long-term development of training characteristics, physiological capacities, and performance in Norwegian world-class female endurance athletes



Hanne Staff

Sports Medicine
<https://doi.org/10.1007/s40279-023-01850-z>

SYSTEMATIC REVIEW



Long-Term Development of Training Characteristics and Performance-Determining Factors in Elite/International and World-Class Endurance Athletes: A Scoping Review

Hanne C. Staff¹  · Guro Strøm Solli^{1,2} · John O. Osborne¹  · Øyvind Sandbakk^{1,3}

Accepted: 31 March 2023
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Follow-up studies

- **Participants**
 - 18 female endurance athletes
 - Cross-country skiing
 - Biathlon
 - Orienteering
- **Data collection**
 - Training Diary
 - Weekly training data logged in specifically designed training diaries
 - Physiological test databases at the Norwegian Top Sport Training center
 - Qualitative interviews



Hanne Staff



Guro S. Solli



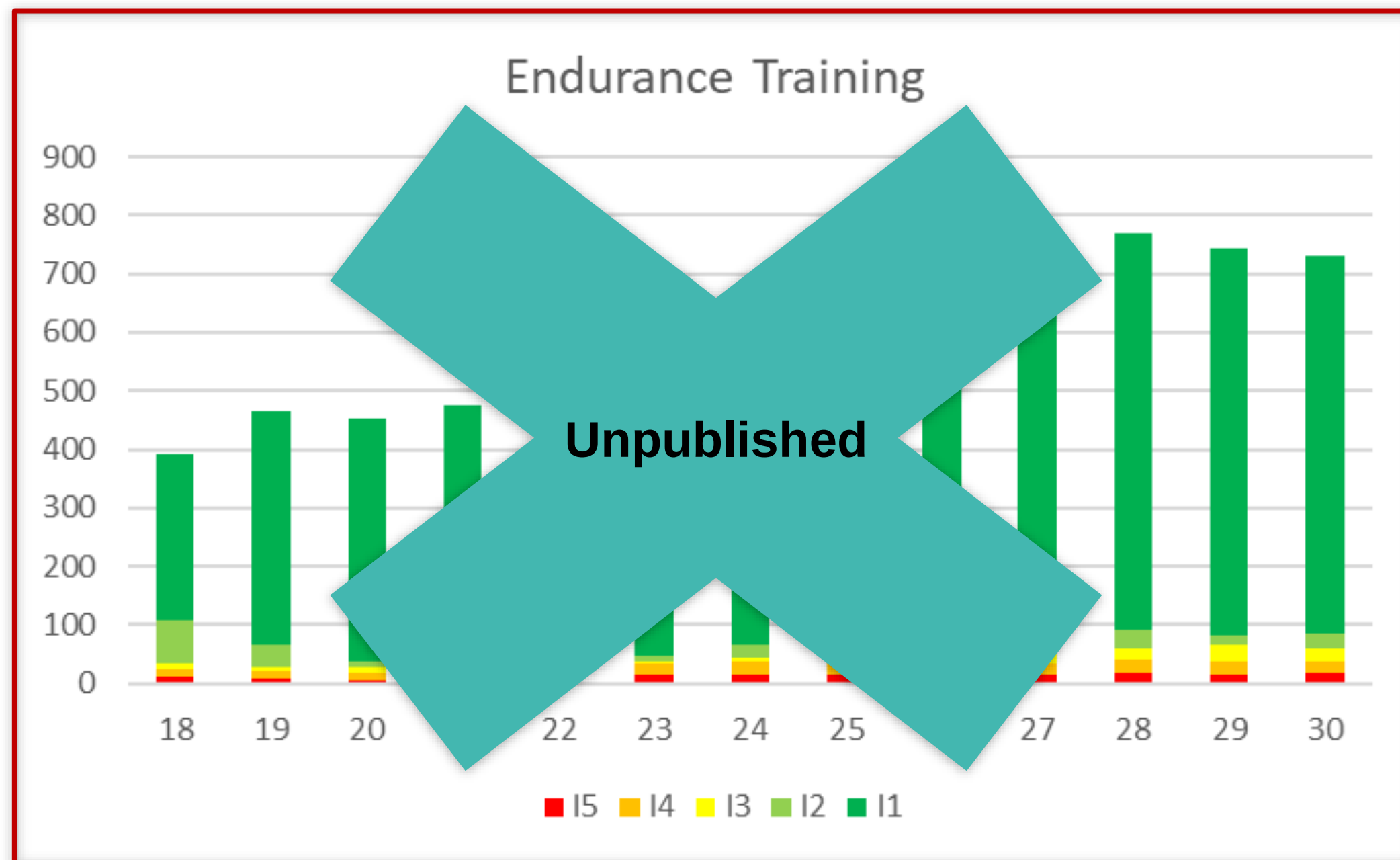
Boye Welde



John O. Osborne

The typical pattern...

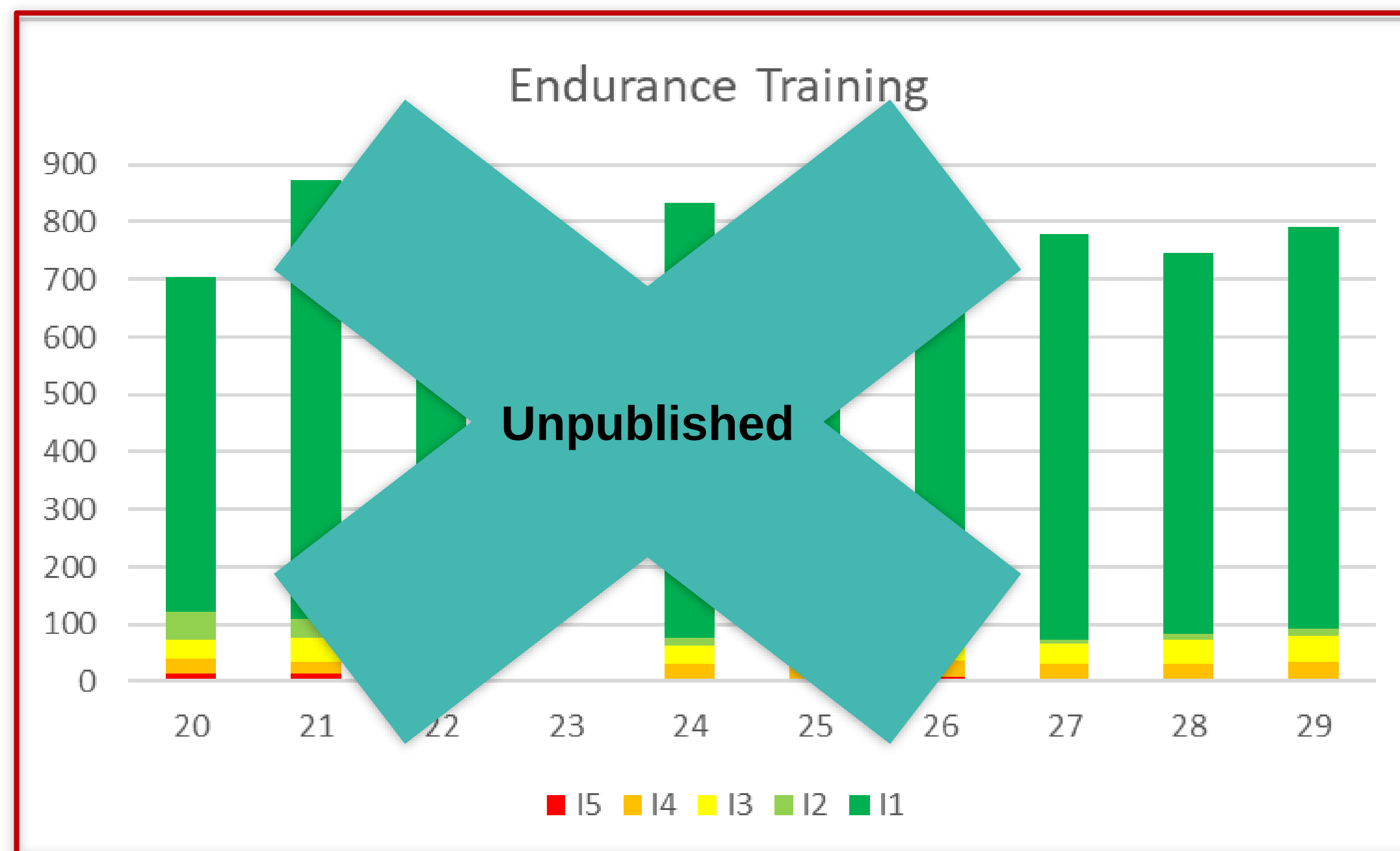
Endurance training - Athlete 2



- **Junior**
 - Silver and gold (relay) in Junior World Championship
- **Senior**
 - Gold medal in World Championship 26 yr
- **Gradual increase in TV until stabilize at 27 yr**
 - Low TV as junior

Fast-track to success...

Endurance Training – Athlete 5



- **Junior**
 - Gold senior World Championship 20 yr
- **Senior**
 - Silver in World Championship 28 yr
- **No systematic change in TV**
 - High TV as junior

Peak Age and Relative Performance Progression in International Cross-Country Skiers

Jacob Walther, Roy Mulder, Dionne A. Noordhof, Thomas A. Haugen, and Øyvind Sandbakk

Overall aim: investigate the long-term development of performance, training characteristics, physiological of XC skiers



Jacob Walther

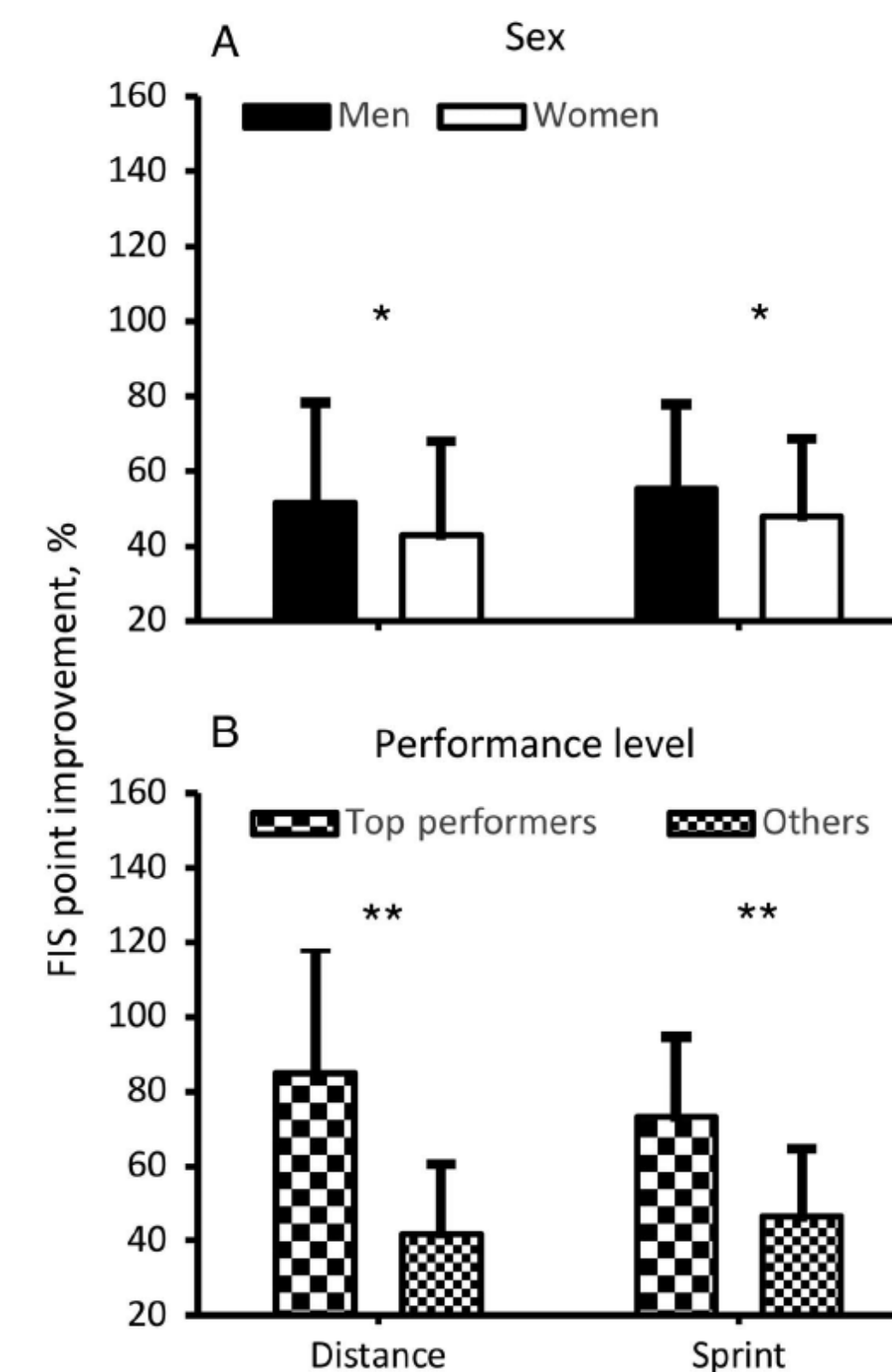
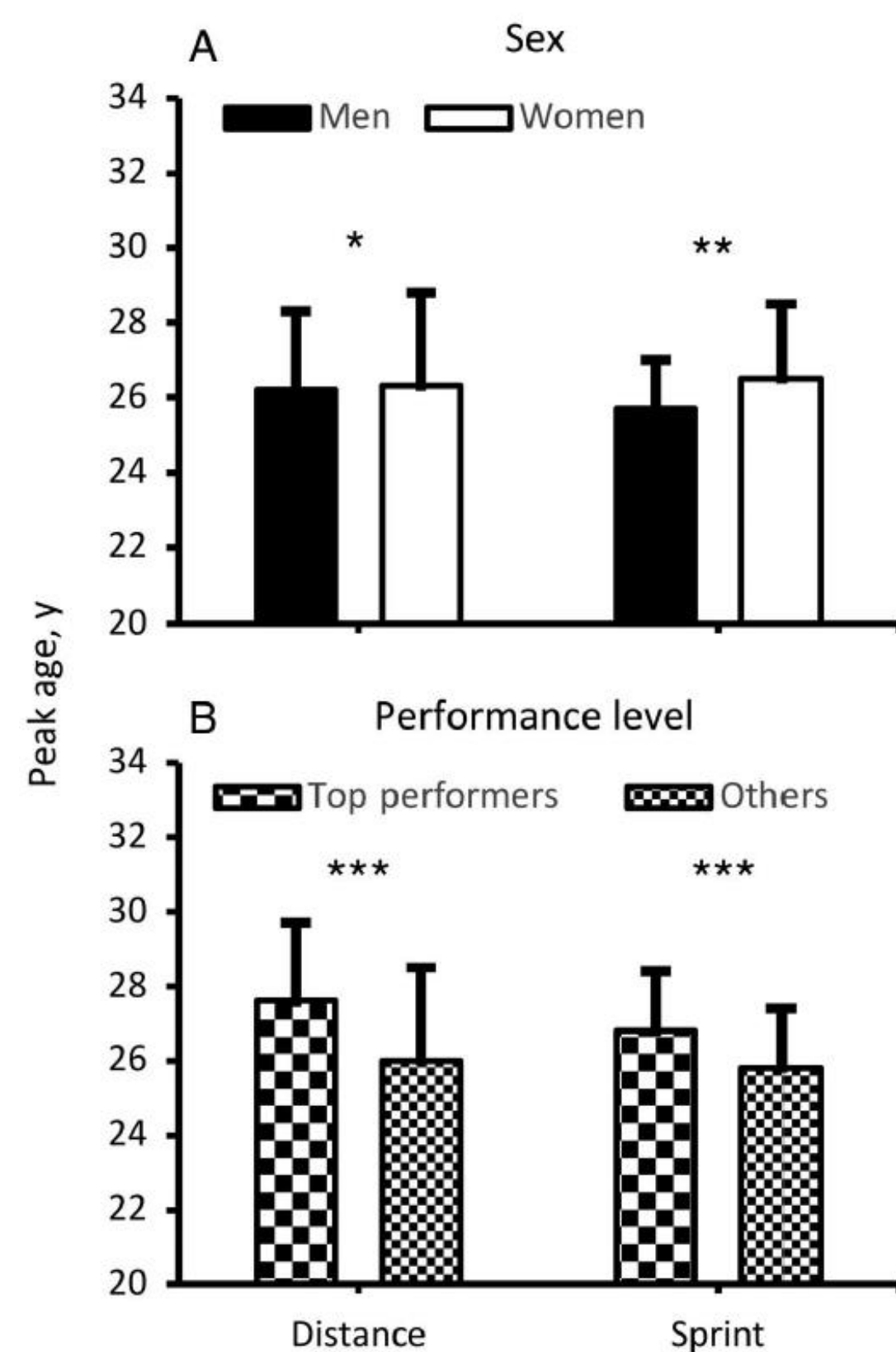


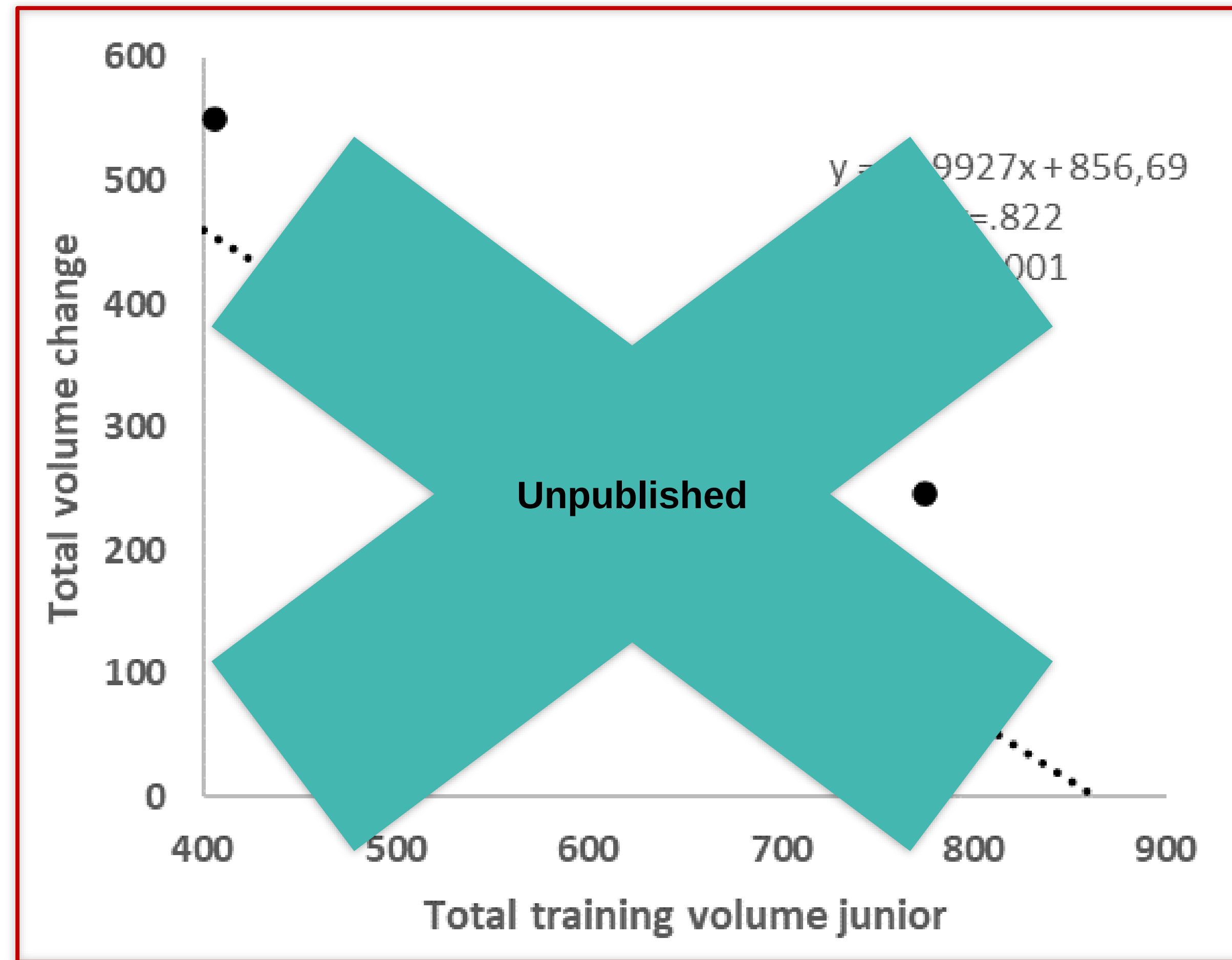
Table 1 – Annual training distribution (mean $\pm$ SD) during junior and senior season.

		Junior		overall	Senior	
		women	men		women	men
Training	End	587.5 $\pm$ 126.8	587.3 $\pm$ 80.0	781.4 $\pm$ 103.6	587.5 $\pm$ 126.8	587.3 $\pm$ 80.0
%		89.2 $\pm$ 2.5	89.2 $\pm$ 2.5	89.2 $\pm$ 2.5	89.2 $\pm$ 2.5	89.2 $\pm$ 2.5
		14.8 $\pm$ 1.1	14.8 $\pm$ 1.1	14.8 $\pm$ 1.1	14.8 $\pm$ 1.1	14.8 $\pm$ 1.1
% of total						
Speed (h)					15.6 $\pm$ 6.6	15.6 $\pm$ 6.6
% of total training					1.9 $\pm$ 0.8	1.9 $\pm$ 0.8
Other (h)		11.4 $\pm$ 5.6	11.4 $\pm$ 5.6	11.4 $\pm$ 5.6	11.4 $\pm$ 5.6	11.4 $\pm$ 5.6
% of total training		1.8 $\pm$ 0.7	1.8 $\pm$ 0.7	1.8 $\pm$ 0.7	1.8 $\pm$ 0.7	1.8 $\pm$ 0.7

Unpublished

Table 2

Subject	Mean $\pm$ SD (kg $^{-1}$ min $^{-1}$)	Body mass (kg)	Mean $\pm$ SD (kg $^{-1}$ min $^{-1}$)	Body mass (kg)
Mean	66.8	65.3	62.8	62.8
Mean	77.9	73.4	6.02	74.0



Does the menstrual cycle (MC) or hormonal contraception (HC) affect performance?

Curse or myth - do periods affect performance?

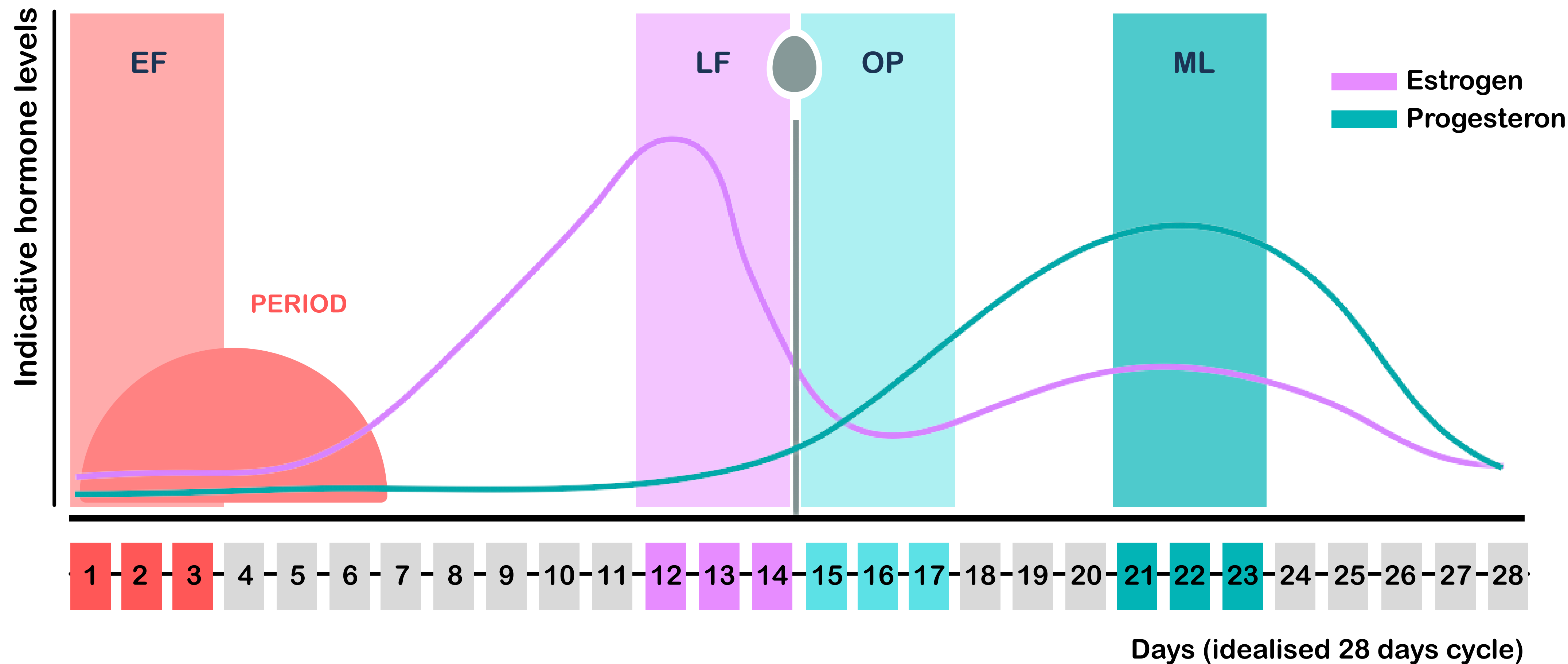
By Aimee Lewis
BBC Sport

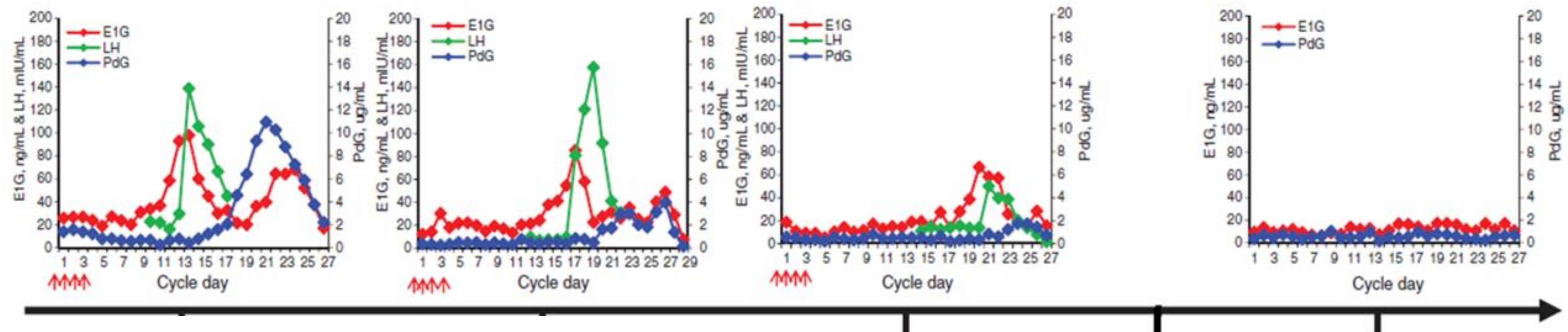
22 January 2015 | Sport

Share



Watson arrived at the Australian Open having won her second WTA title in Hobart last week



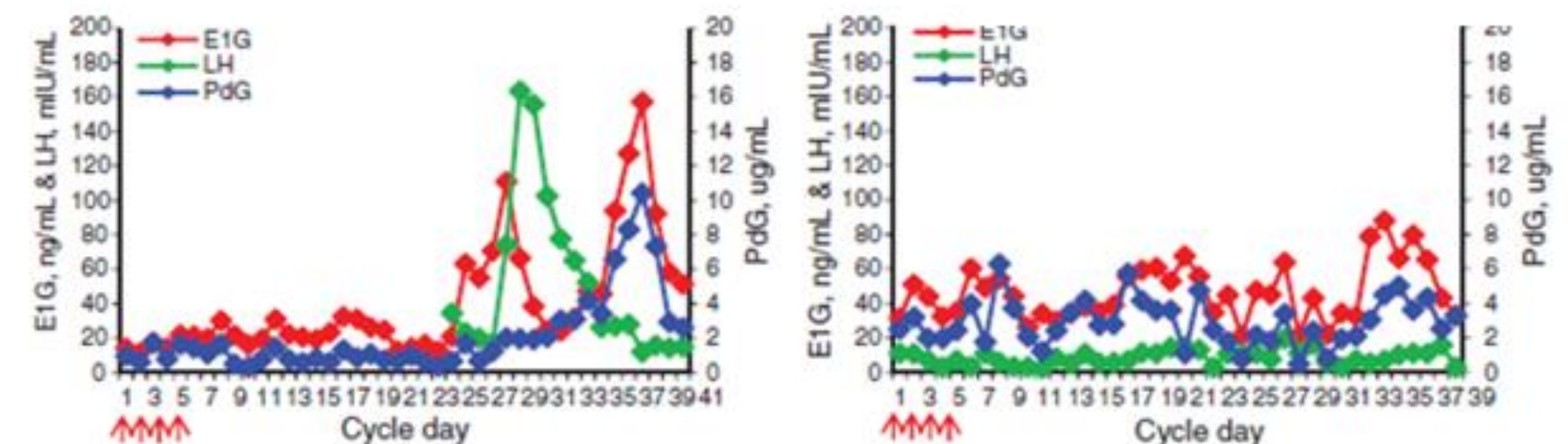


Normal menstruation

LPD

No ovulation

Amonere
No ovulation
No bleeding



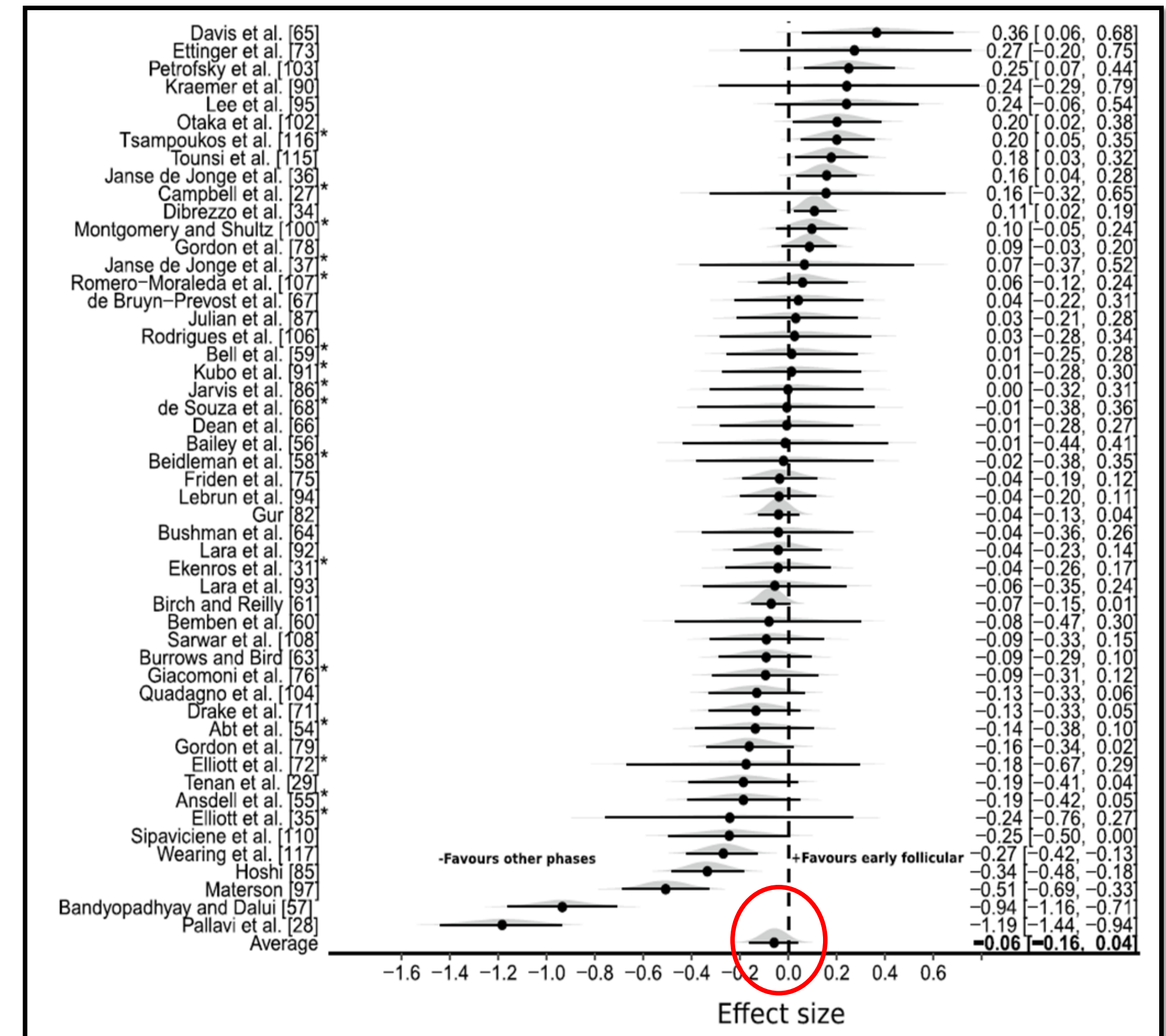
Oligomenore
cycles >35 days
with ovulation

Oligomenore
cycles >35 days
without ovulation

The Effects of Menstrual Cycle Phase on Exercise Performance in Eumenorrheic Women: A Systematic Review and Meta-Analysis

Kelly Lee McNulty¹  · Kirsty Jayne Elliott-Sale²  · Eimear Dolan³  · Paul Alan Swinton⁴  · Paul Ansdell¹  · Stuart Goodall¹  · Kevin Thomas¹  · Kirsty Marie Hicks¹ 

- Exercise performance may be ↓ in the early follicular phase compared to other MC phases
- Large variations between and within studies
 - Low quality
 - Methodological differences
- Individual approach

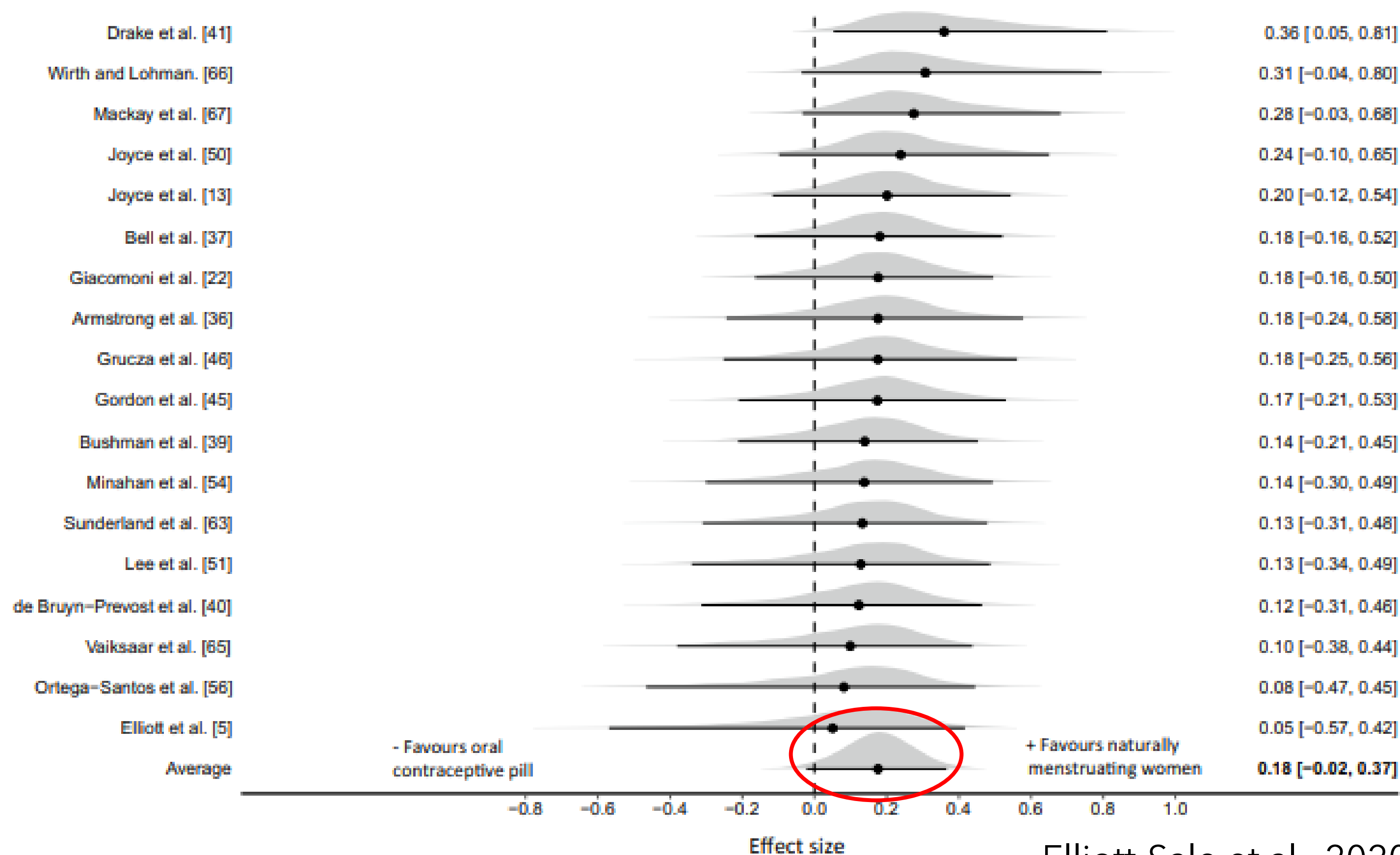




The Effects of Oral Contraceptives on Exercise Performance in Women: A Systematic Review and Meta-analysis

Kirsty J. Elliott-Sale¹  · Kelly L. McNulty²  · Paul Ansdell²  · Stuart Goodall²  · Kirsty M. Hicks²  · Kevin Thomas²  · Paul A. Swinton³  · Eimear Dolan⁴ 

- The oral contraceptive may ↓ performance compared to the natural MC
 - Consistent performance throughout the HC cycle
 - ↓ performance vs non-HC users?
- Individual approach
- Little research on progestin-only HC



Changes in Self-Reported Physical Fitness, Performance, and Side Effects Across the Phases of the Menstrual Cycle Among Competitive Endurance Athletes

Guro S. Solli, Silvana B. Sandbakk, Dionne A. Noordhof, Johanna K. Ihalainen, and Øyvind Sandbakk



Guro S. Solli

- 140 female cross-country skiers and biathletes
- 56% used hormonal contraceptives
- Only 7% of athletes planned their training according to their MC
- Only 27% of athletes communicated with their coach about the topic

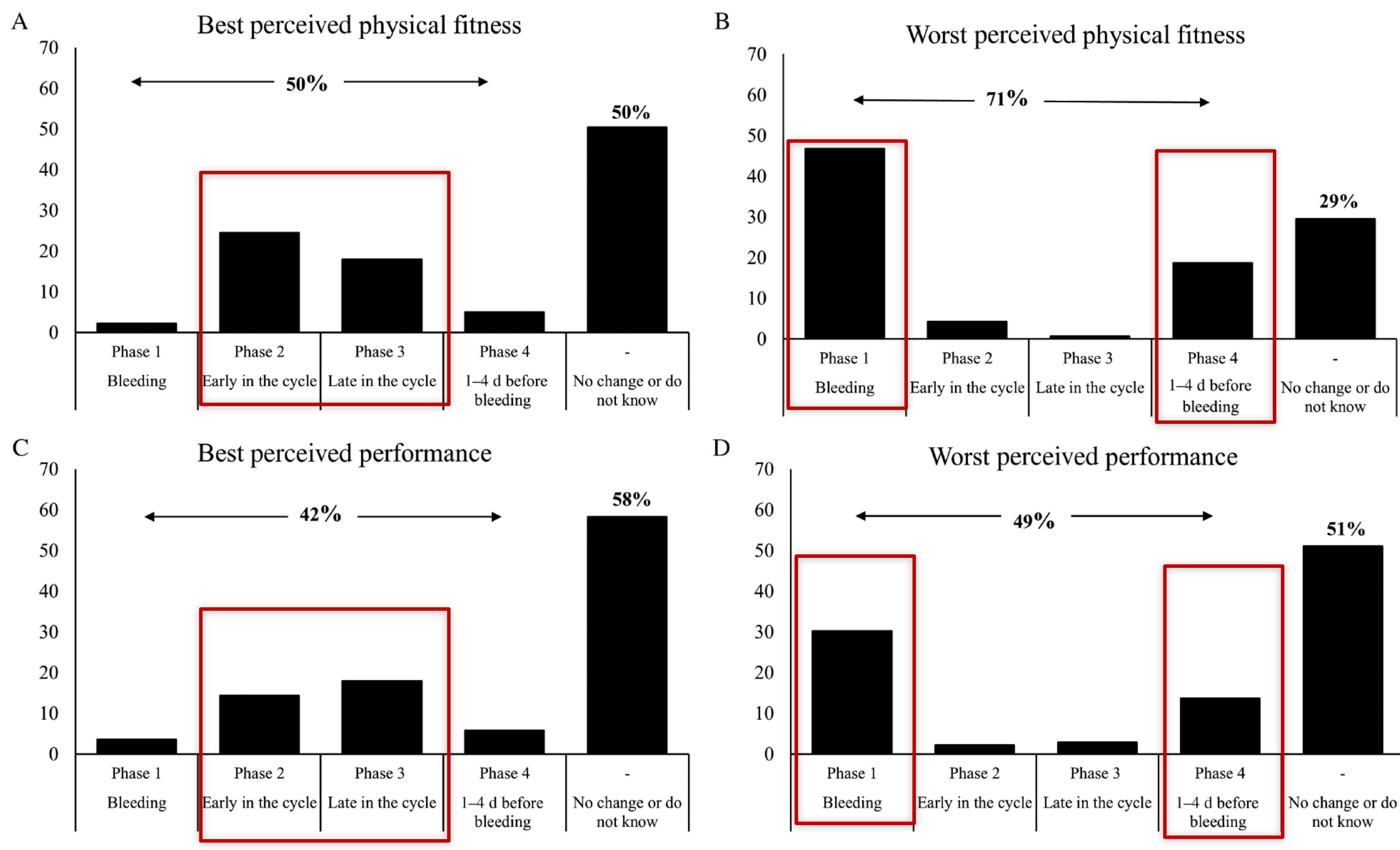


Figure 3 — The athletes' self-reported best (A) and worst (B) physical fitness and self-reported best (C) and worst (D) performance across the phases of the menstrual cycle.

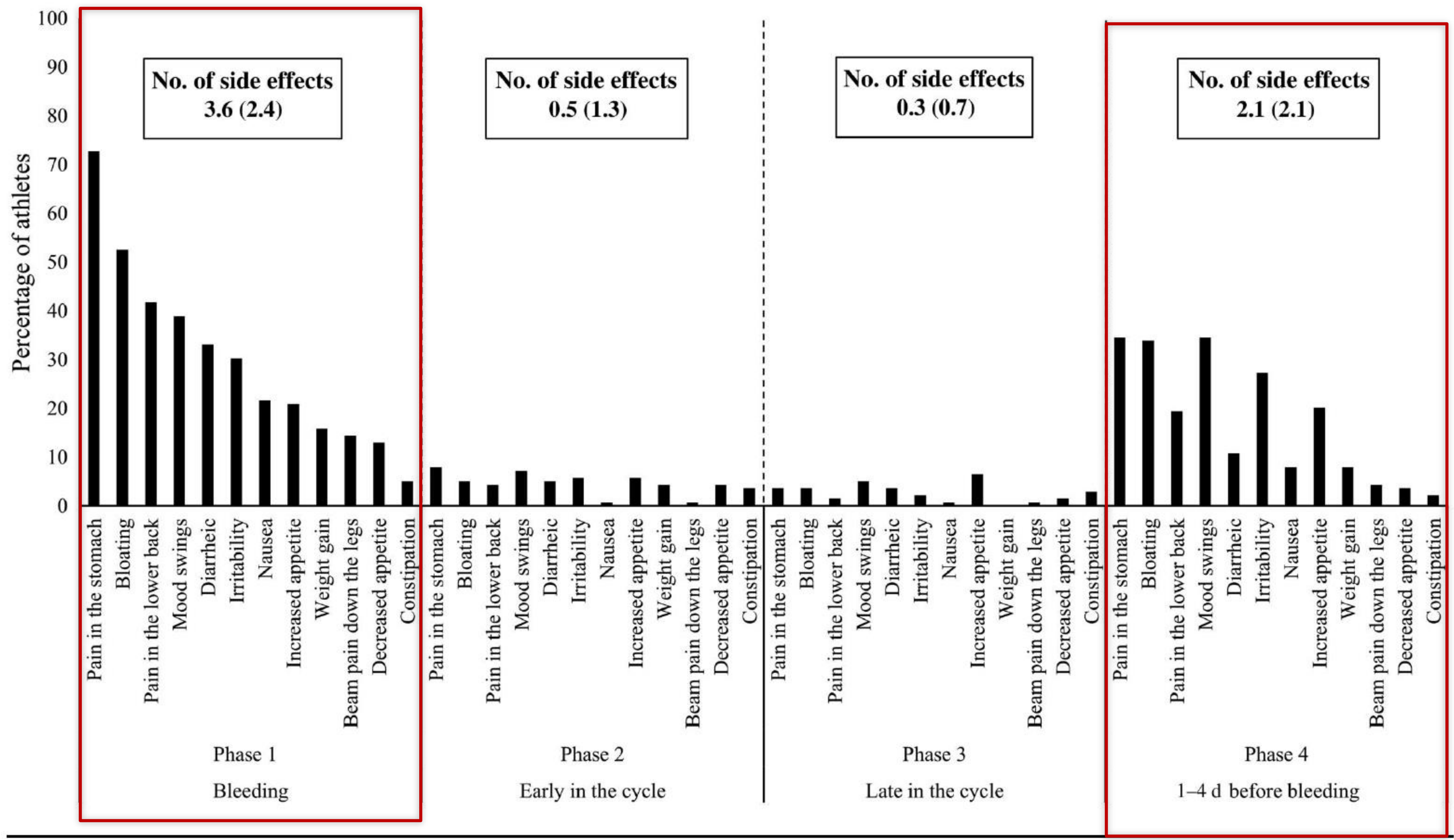


Figure 4 — The athletes' self-reported side effects across the phases of the menstrual cycle.

Practical Applications

- Systematic monitoring of the MC: Coaches should motivate their athletes to track their MC and MC-related symptoms and actively use this information in the evaluation of training quality, training adaptations, and performance.
- Conscious use of HC: Coaches should make the athletes aware that HCs could affect their training response, both positively and negatively, and ensure that the athletes communicate about this with the medical doctor, so the preparations prescribed are optimal for their individual situation. Athletes should also systematically monitor their training response when starting with a (new) HC.
- More communication: Because of the high interindividual variability in performance and side effects experienced by athletes during the MC, coach–athlete communication is important to safeguard the athlete’s health as well as to optimize training adaptations and performance. The same applies for the use of HC.
- Increased knowledge about the MC and HC: Coaches should consult experts to ensure that they have enough knowledge to have an evidence-based dialogue about this topic with their athletes.
- Education of athletes: Increased attention should be paid to educating female athletes and their support teams about the MC, HC, and athletic training.

Indian Endurance Athletes' Menstrual Cycle: Practices, Knowledge, Communication, Health, and Changes in Perceptions Across the Phases

Tanugatri Majumder,¹ Virginia De Martin Topranin,² Øyvind Sandbakk,^{2,3} and Dionne A. Noordhof²

¹Department of Sports Science and Yoga, Ramakrishna Mission Vivekananda Educational and Research Institute, Belur Math, Howrah, India;

²Center for Elite Sports Research, Department of Neuromedicine and Movement Science (INB), Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology, Trondheim, Norway; ³School of Sport Sciences, UiT the Arctic University of Norway, Tromsø, Norway

Perceived impact of the menstrual cycle and hormonal contraceptives on physical exercise and performance in 1,086 athletes from 57 sports

Linda Ekenros¹, Philip von Rosen¹, Guro Strøm Solli^{2,3}, Øyvind Sandbakk^{2,4}, Hans-Christer Holmberg^{5,6}, Angelica Lindén Hirschberg^{7,8} and Cecilia Fridén^{1,7*}

Offered Support and Knowledge about the Menstrual Cycle in the Athletic Community: A Cross-Sectional Study of 1086 Female Athletes

Philip von Rosen ¹, Linda Ekenros ¹, Guro Strøm Solli ^{2,3} , Øyvind Sandbakk ^{2,4}, Hans-Christer Holmberg ^{5,6}, Angelica Lindén Hirschberg ^{7,8} and Cecilia Fridén ^{1,7,*}

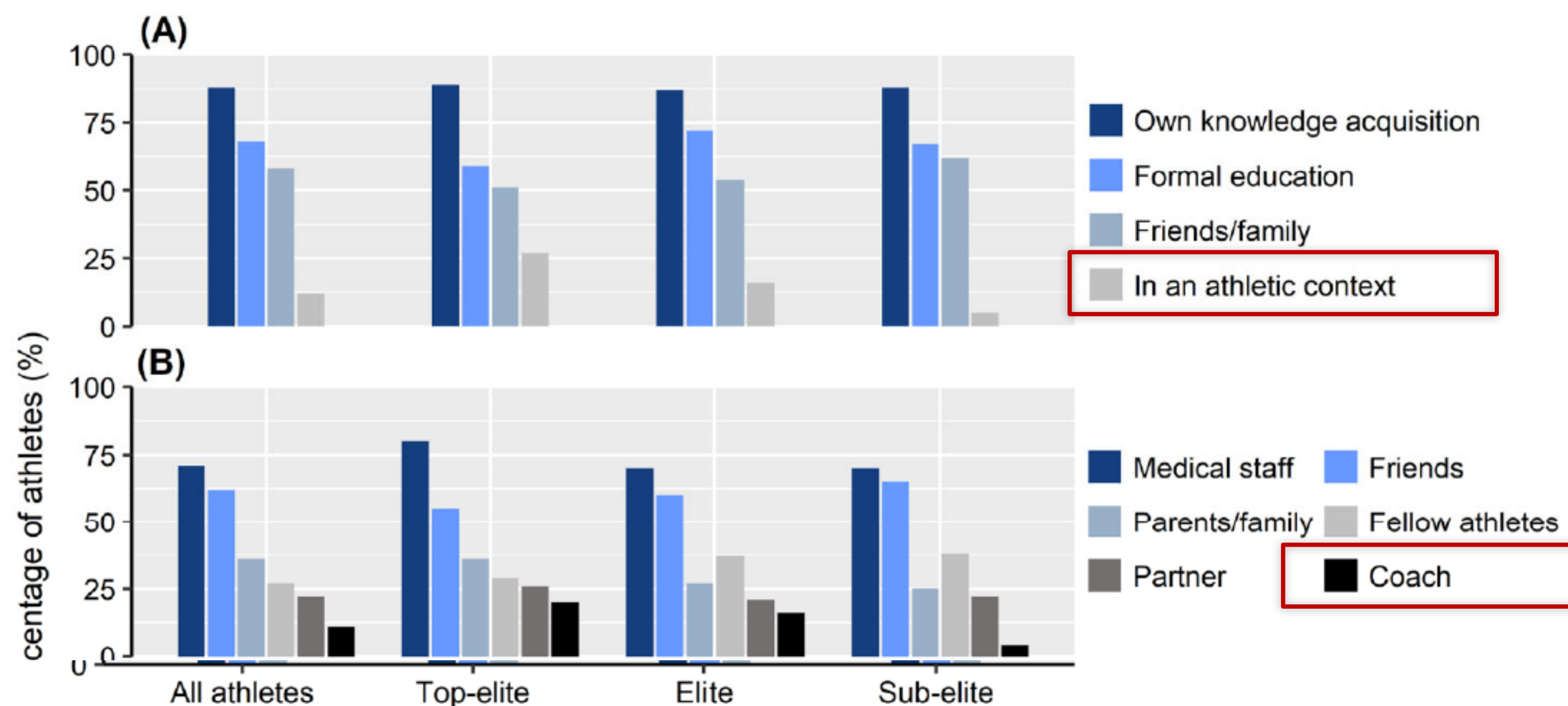


Figure 1. How knowledge about female athlete health was acquired (A), person to talk with about female athlete health (B) and opportunities to discuss amenorrhea, lasting > 3 months, in the athletic community (C).

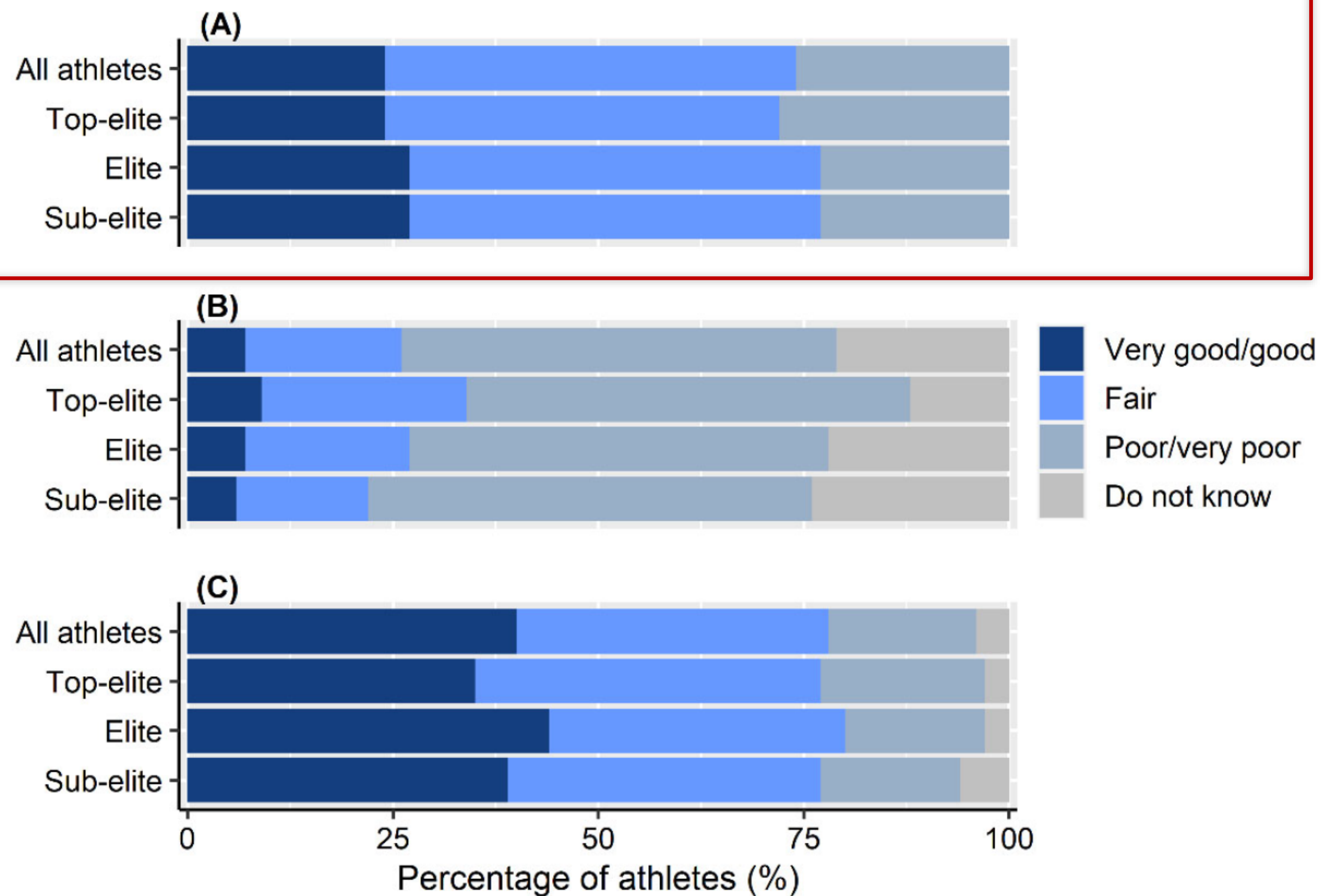


Figure 2. Athletes' own perceived knowledge about aspects of female athlete health that might influence athletic performance (A), their coach's knowledge in this area (B) and whether this subject was taboo in the athletic community (C) across athlete level. For "C", the ordinal scale "Strongly agree/agree", "Partly agree", "Disagree/strongly disagree", "Do not know" was used in descending order.

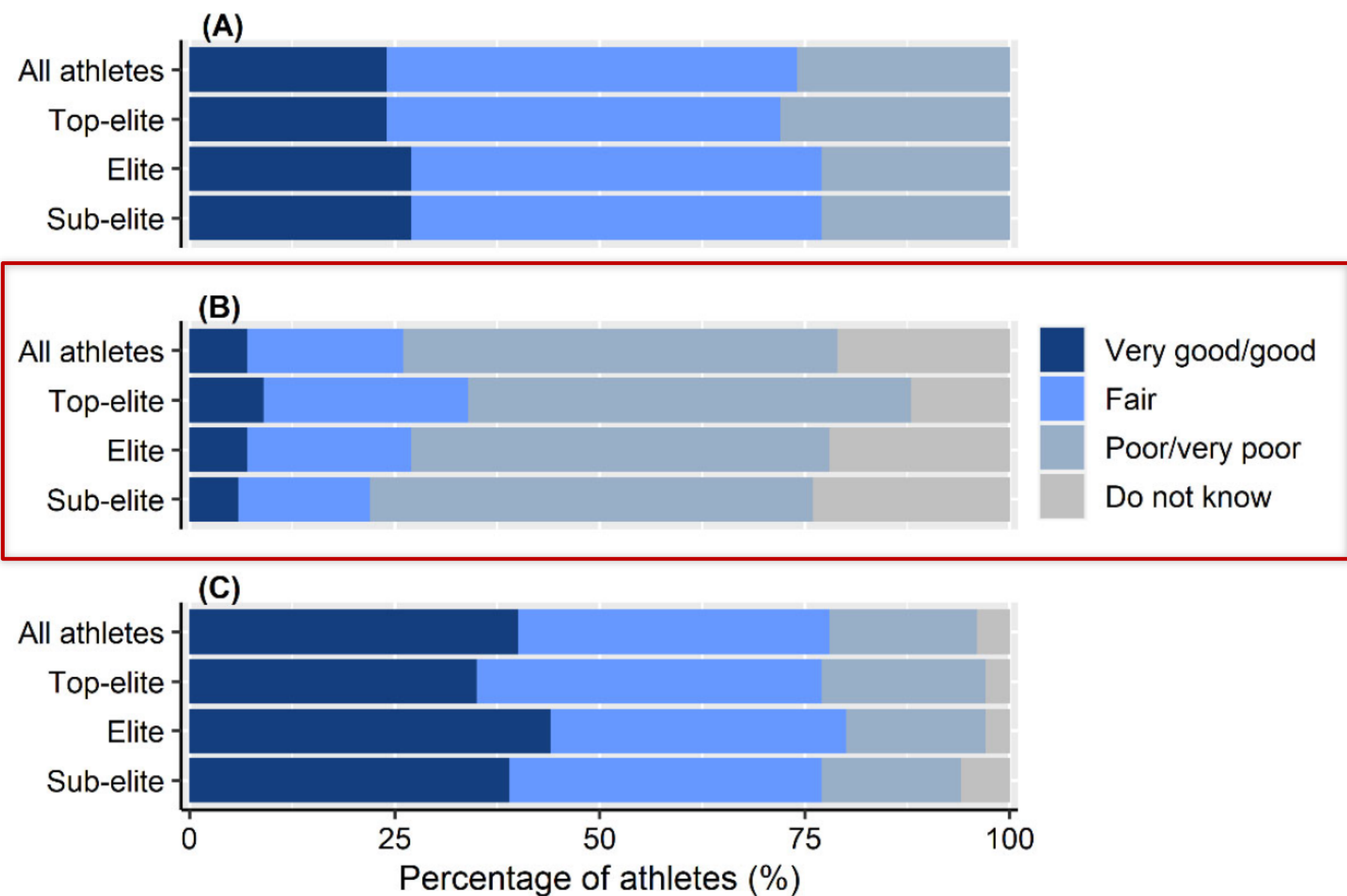


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Overall aim: Explore the prevalence and reasons for HC use among endurance athletes, as well as their perception of how HC and MC influence fitness and recovery markers



Tina Pettersen Engseth

Logging

Trening

Statistikk

DAGSPARAMETRE

22.10.2020

Husk å lagre

Syk

Skadet

Mensen

På reise

Høydedøgn

Fridag

Konkurranse

Hvilepuls

SØVN

READINESS TO TRAIN

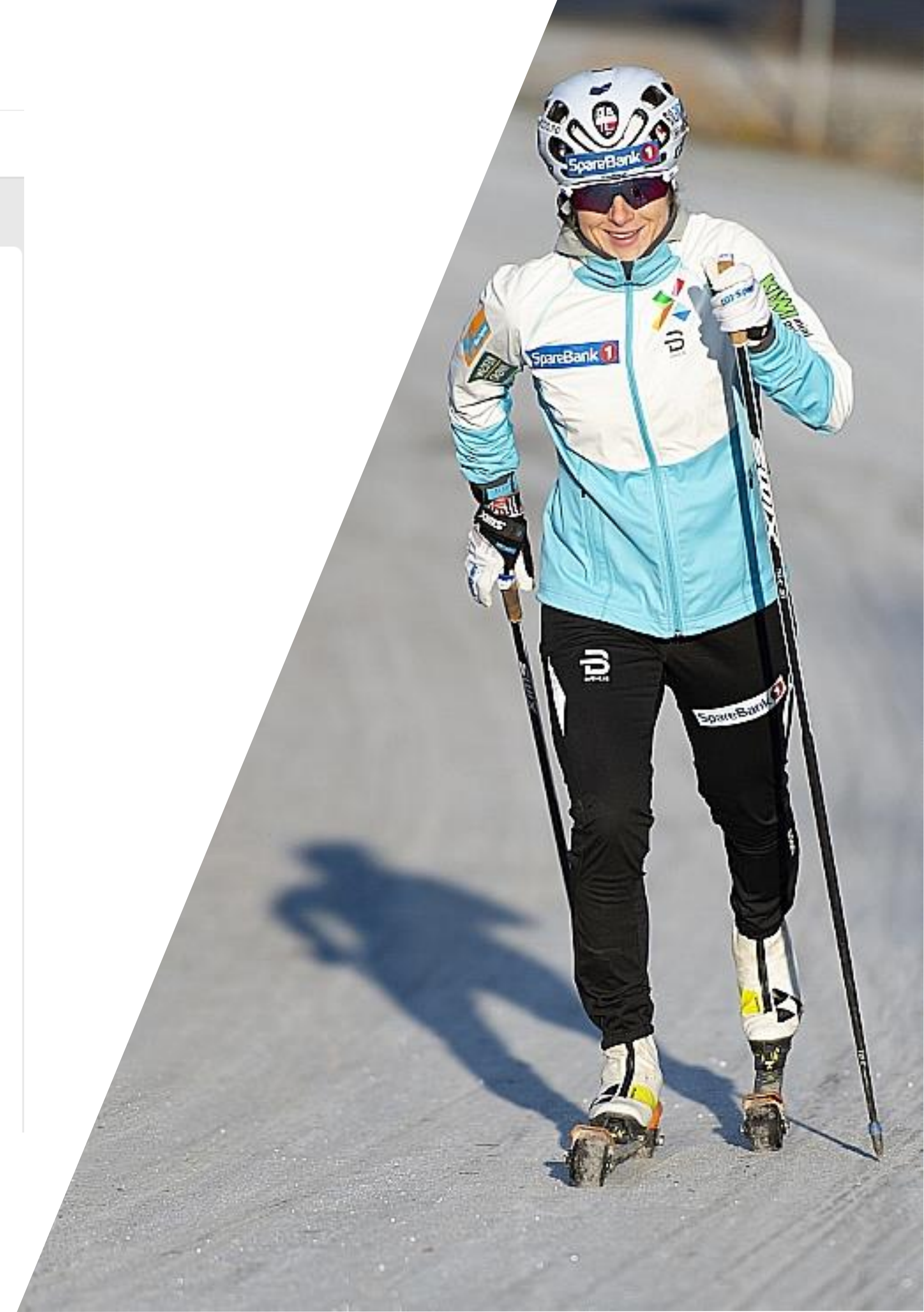
PLAGER TILKNYTTET
MENSTRUASJONSSYKLUS

Ingen plager

Store plager

1 2 3 4 5 6 7 8 9 10

KOMMENTAR TIL DAGEN





Main findings

- 68% use hormonal contraception (HC)
 - Of these, 64% use progestin-only
- 60% of the HC users reported to use HC for other reason than as birth control
 - Menstrual symptoms was the most reported reason
 - Although practical reasons were second most common, many athletes explained that they used HC to manipulate their MC
- Most HC users (80%) experienced a “solely positive” or no effect on training and/or performance by using HC
- Only 5% experienced a “solely negative” effect

Prevalence and Self-Perceived Experiences With the Use of Hormonal Contraceptives Among Competitive Female Cross-Country Skiers and Biathletes in Norway: The FENDURA Project

Tina P. Engseth^{1*}, Erik P. Andersson¹, Guro S. Solli^{1,2}, Bente Morseth¹,
Tor Oskar Thomassen¹, Dionne A. Noordhof³, Øyvind Sandbakk^{1,3} and Boye Welde¹

What about recovery?



V. De M. Topranin D. Noordhof

Methods

PARTICIPANTS

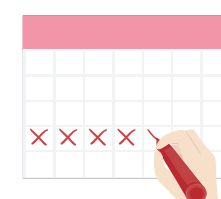


15 recreational to professional endurance athletes (18 - 39 years old)

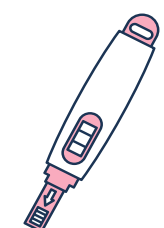


Naturally menstruating (on average 10 menstrual cycles in the previous 12 months)

MC PHASE IDENTIFICATION

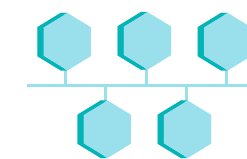


Calendar-based counting method



Urinary ovulation prediction test: start testing on day 8 until 

DATA COLLECTION



Timeline: January - March 2021



1-3 menstrual cycle/participant
Total 33 menstrual cycles



Daily log: training, discomfort (1-10 VAS), recovery variables



Tina Engseth

RECOVERY VARIABLES



Resting heart rate (night watch recording or morning procedure)



Subjective sleep quality (1-10 VAS)



Physical and mental readiness to train (1-10 VAS)

Conclusions

OBJECTIVE MEASURES



Resting heart rate
No effect of MC phase, when accounting for ovulation

SUBJECTIVE MEASURES



Subjective sleep quality
Lower subjective sleep quality during the ovulatory phase and mid-luteal phase.



Physical and mental readiness to train

- Lower physical and mental readiness to train during the mid-luteal phase.
- Effect of discomfort on mental readiness to train.

TAKE HOME MESSAGE

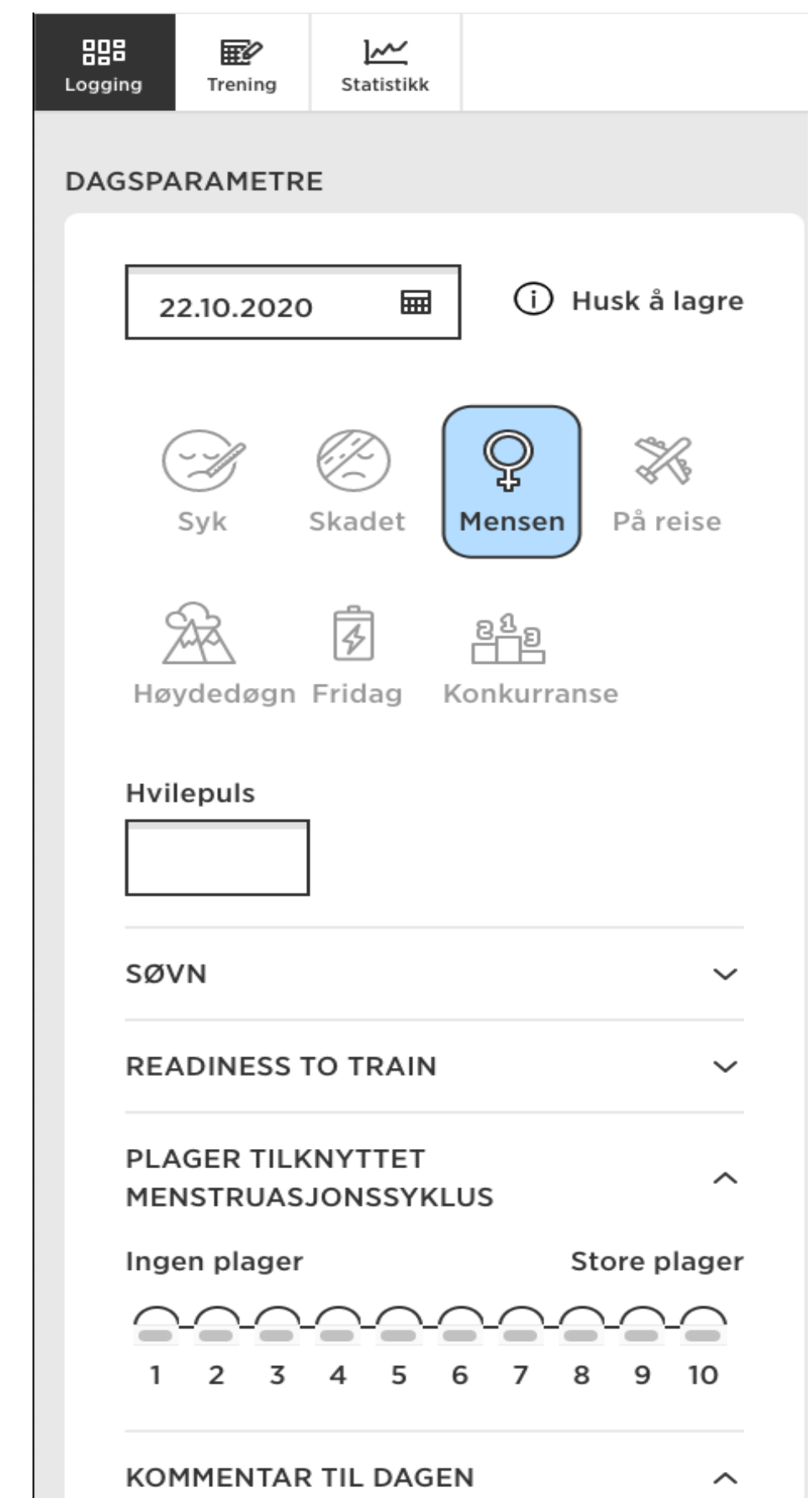
- It seems there is an effect of MC phase on subjective recovery measures.
- These measures seem to indicate that female endurance athletes recover less good during the ovulatory and/or mid-luteal phase

Perceived influence of bleeding and symptoms related to MC and HC cycle on daily fitness and recovery markers

- Description of bleeding patterns
- Does fitness and recovery markers differ between pre-bleeding, bleeding and non-bleeding days?
- Are there associations between severity of symptoms and the fitness and recovery markers?



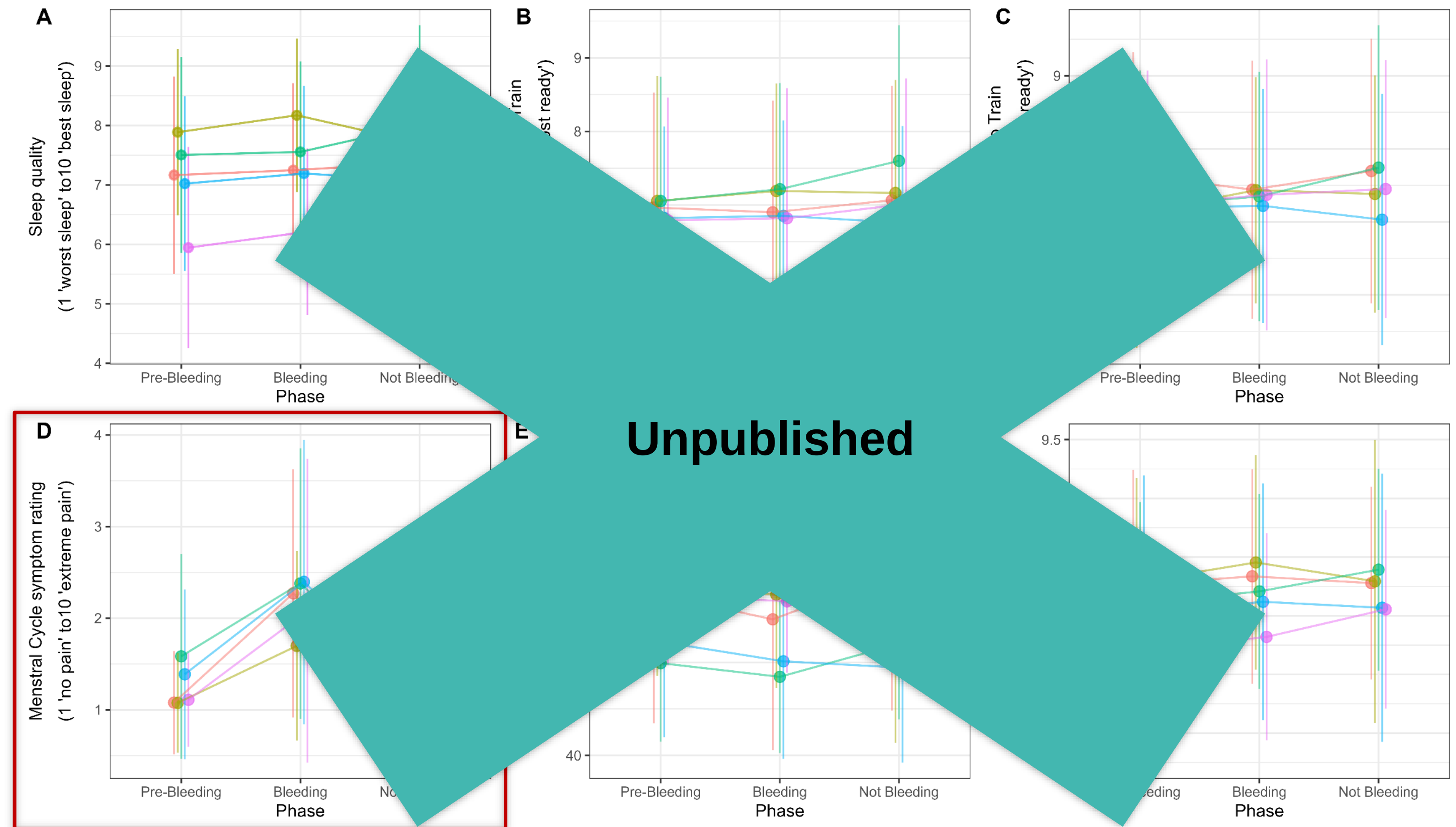
Tina Engseth



The screenshot shows a mobile application interface for tracking menstrual cycle and fitness markers. At the top, there are three tabs: 'Logging', 'Trening', and 'Statistikk'. Below the tabs is a header 'DAGSPARAMETRE'. The main content area includes a date selector '22.10.2020' and a button 'Husk å lagre'. There are several icons representing different states: 'Syk' (sick), 'Skadet' (injured), 'Mensen' (menstruating, highlighted with a blue border), and 'På reise' (on travel). Below these are icons for 'Høydedøgn' (altitude day), 'Fridag' (rest day), and 'Konkurranse' (competition). A section titled 'Hvilepuls' (resting pulse) has a text input field. Below that are expandable sections for 'SØVN' (sleep), 'READINESS TO TRAIN', and 'PLAGER TILKNYTTET MENSTRUASJONSSYKLUS' (discomforts related to menstrual cycle). The 'PLAGER TILKNYTTET MENSTRUASJONSSYKLUS' section shows a row of 10 circles representing the days of the cycle, with the first circle labeled '1' and the last labeled '10'. A button 'Store plager' is next to the circles. At the bottom is a section 'KOMMENTAR TIL DAGEN' (comment for the day) with an expandable arrow.

Preliminary findings

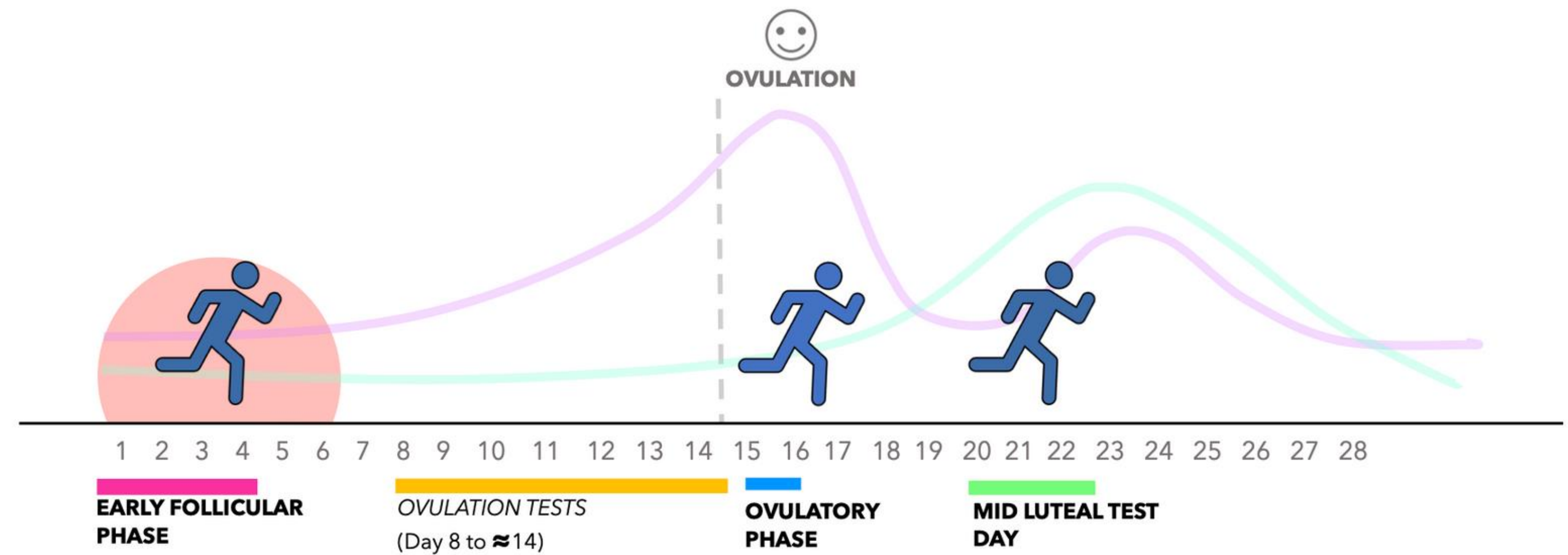
- Athletes with severe symptoms are more affected
- Severe symptoms is associated with reduced sleep quality, physical and mental readiness to train



**Overall aim:
Investigate the effect
of MC phase on
physical fitness, as
well as the acute
response to training
and recovery**



Madison Taylor



Does MC phase influence endurance performance-determining variables?

Participants:

Endurance trained female athletes (naturally menstruating)

Standardized Fitness Testing

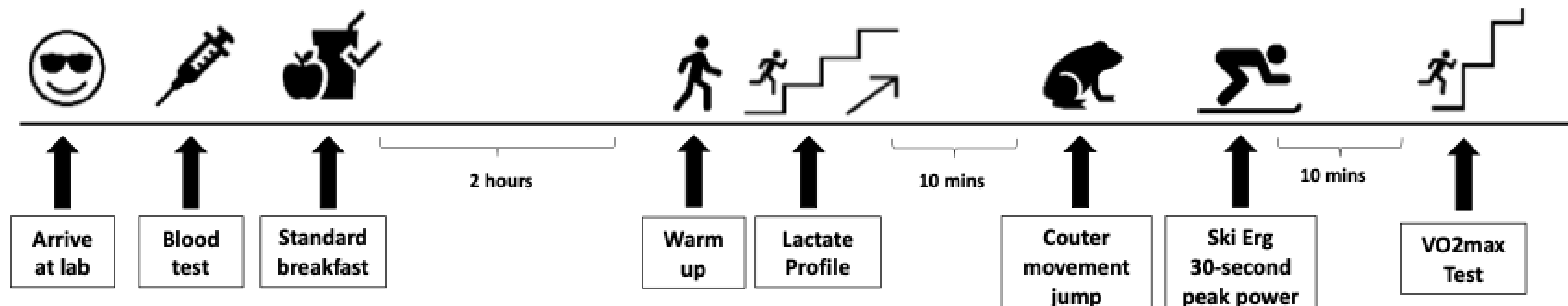
in three hormonally distinct phases of the MC (EF, O, ML)

Three Step MC Phase Verification

Calendar Counting
Ovulation Testing
Serum Hormone Analysis

Repeated for two menstrual cycles

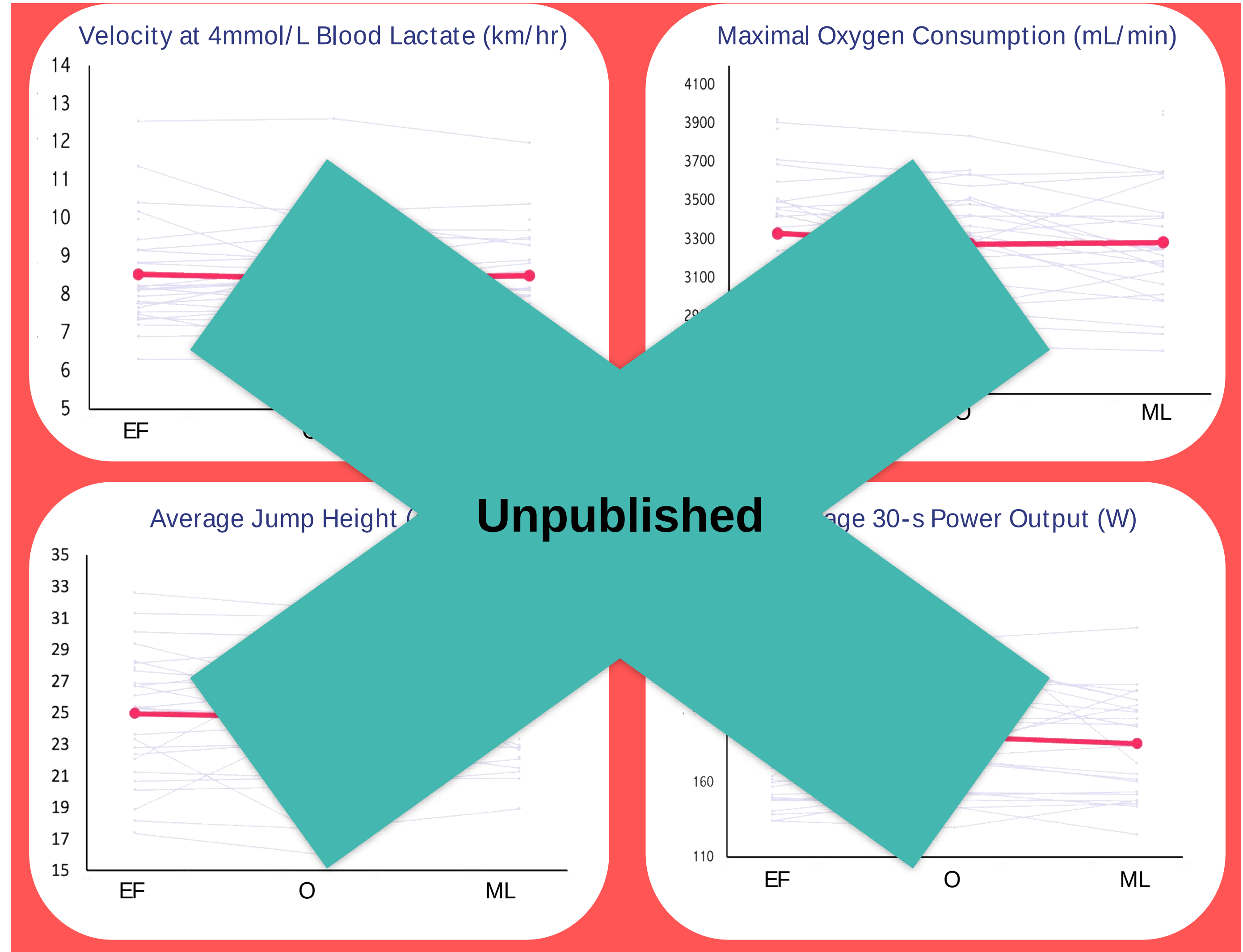
Test Day:



Preliminary findings

MC phase does not influence:

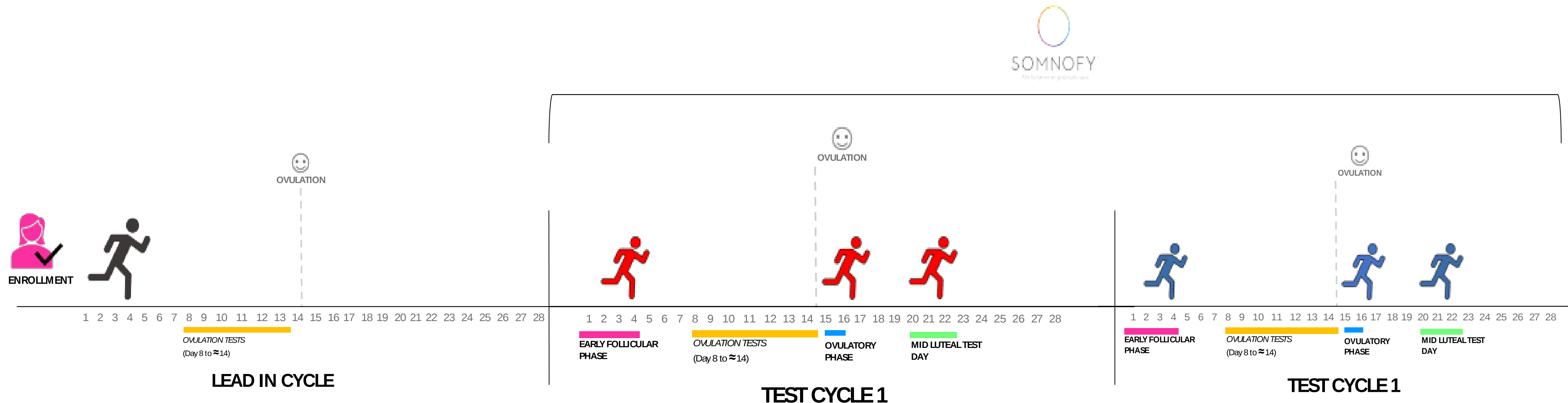
- $\text{VO}_{2\text{max}}$
- Speed at LT
- VO_2 at LT
- Jump height
- 30-sec WG

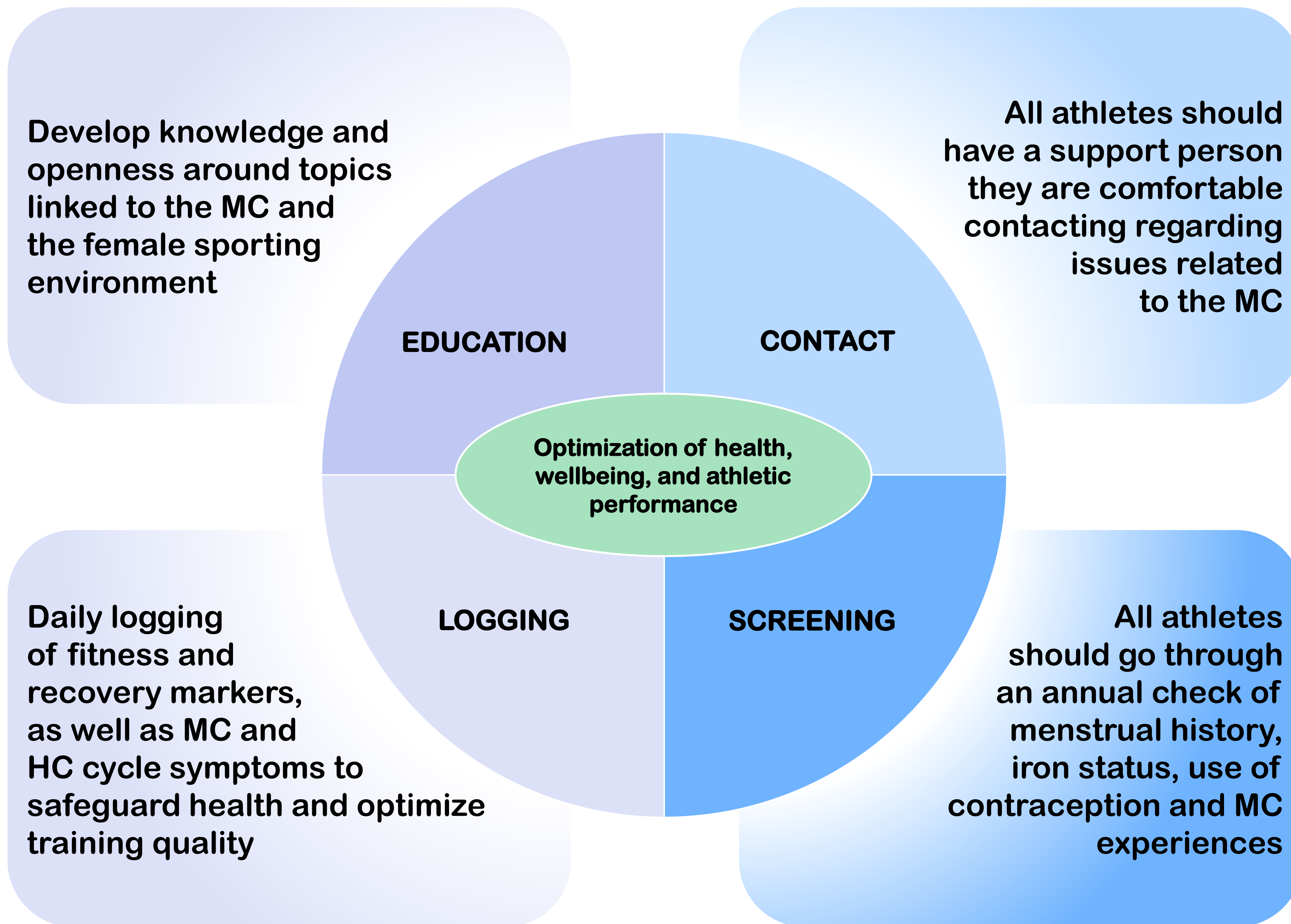


Follow-up study

Questions:

- Does the acute physiological response to standardized endurance sessions differ between the early follicular, ovulation, mid-luteal phases?
- Does MC phase affect subjective recovery and sleep after standardized exercise sessions?





A good coach can change a game

A great coach can change a life!

Good luck!