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CONFLICT OF INTEREST STATEMENT

I currently have, or I have had in the past 2 years an affiliation or financial interest with the Department of Defense, USMC, USSOCOM, and LabSavvy around this presentation, including:

- Research funding
- Consulting
- Honoraria
- Advisory Board

From the Lab to the Field: Using Biomarkers to Enhance Training and Nutrition Programming

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BIOMARKERS

- bi·o·mark·er (/ˈbīōˌmärkər)
  - *Noun*; biological marker; a measurable substance in an organism whose presence is indicative of some phenomenon such as disease, infection, or environmental exposure; a characteristic that is objectively measured and evaluated as an indicator of normal biological processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention

- So…where's the "health" and the "optimal" part of this???
  - Normal ranges: Sufficient or optimal?

Potentially Critical Areas of Application

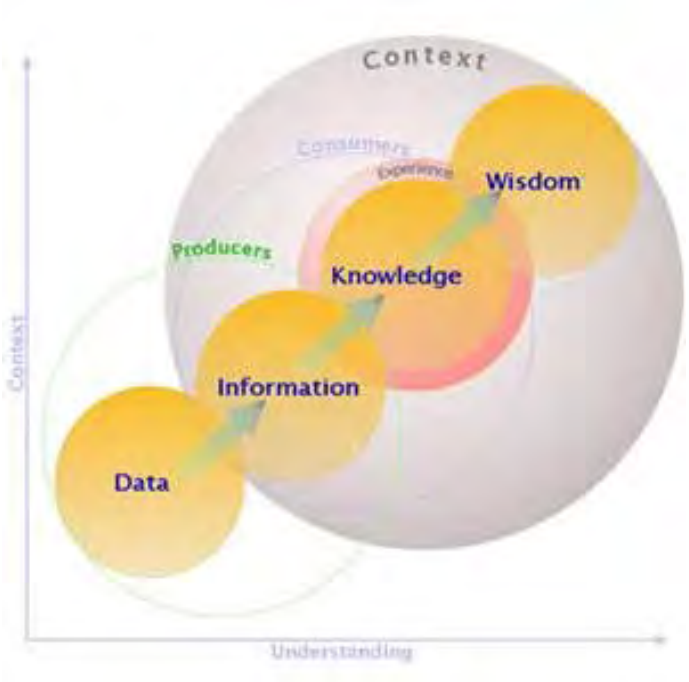
- ***Endocrine***
  - Acute vs Chronic stress; Assessment of adaptation; Repair and recovery; Homeostasis; Fuel metabolism
    - Cortisol (total & free); ACTH; Testosterone (total & free); GH; IGF-1; Glucagon; Insulin; TSH, T3, T4; Estradiol; E/NE
- ***Biochemical***
  - Muscle Damage; Fuel metabolism; Bioenergetics; Hydration; Oxidative Stress; Inflammation
    - CK; amino acids; TG; Glucose; Hemoglobin/Hematocrit; electrolytes; free radicals; cytokines (IL-6, CRP)
- ***Nutritional Markers***
  - HbA1c; TC/HDL/LDL; B_{12}; Iron; Omega 3; Vit D; SOD

Assessment Considerations

- Evidence for scientific “meaningfulness” when it comes to performance
- Timing
  - Understanding of time-course
  - Proximity to training or deployment
  - Assessed in a way to influence preparation

- Frequency
  - Too infrequently for many markers = useless; Too frequently = burdensome
- Acute vs Chronic
  - Some markers have very different “meanings” in terms of their acute vs chronic elevation or change
  - Some are more important acutely, others chronically

- **Performance Management Cycle**
  - **Plan**
  - **Monitor**
  - **Report**
  - **evaluate**



Context is Critical

…and the problem with lab-based studies

Military Research

- Tanskanen et al. (2011)
  - 8-week Finnish military basic training
  - 33% (of 57) classified as “overreached”
    - Higher SHBG (pre, 4, & 7 weeks); higher basal serum CORT (post) despite overall decrease; no increase in TEST:CORT; decreased IGF-1
  - Less fit and those w/ lower TEST:CORT at pre had more reported “sick” absences
- Nindl et al. (2007)
  - Army Ranger training course (N=50)
  - 1000 kcal/d deficit on average
  - Decreases in power, strength, body mass, FFM, and FM
  - TEST & IGF-1 decreased; CORT increased
    - IGF-1 & CORT associated w/ loss of mass

Military Research

- Friedl et al. (2000)
  - 8-wk Army Ranger course (2 different cohorts) (N=97)
  - 1200 kcal v 1000 kcal deficits
    - Group 1: T3 below normal; TEST almost non-existent; IGF-1 decreased by ½; TSH high; Refeeding after caused recovery of all (some took 1 full month)
    - Group 2: attenuated T3 decline; less FFM decline; less IGF-1 decline; similar decline in TEST and increase in TSH; mid-course refeed temporarily restored IGF-1 & T3
    - Across both groups, CORT increased (delayed in Group 2) and GH increased; cholesterol also increased
  - Energy deficit *may* be even more important than sleep deprivation
  - Refeeds have been shown to help minimize effects of repeated jungle patrols (Rai et al., 1983)

An Inherent Need for Redundancy

- While there are many markers ASSOCIATED with overreaching and overtraining, there is no real agreed-upon set of markers
  - Individual variability
  - Degree of overtraining
  - Sympathetic vs Parasympathetic
  - Dietary influences

- Because of this, it is important to have a broad enough array of markers to capture changes, but not so broad as to get diluted and lose interpretability
- By the time some of these markers change, overtraining may have already occurred
  - Prediction vs Confirmation

Risk vs Reward: Relaying the Information

- Paralysis through analysis
- Psychological impacts – what, when, & how
  - The ostrich approach
- The fear of monitoring
  - Who gets the info and how is it used? It's a Catch-22
- Who deciphers the information? One potential limitation: physicians don't typically deal in performance

The Ideal Situation

- For biomarkers to have “context”, it’s important that they be tied to other “measurables”
  - Performance testing or outcomes
  - Load monitoring and physiological responses
- Ultimately, the most useful biomarkers are the ones that will be most easily modified through training, diet, and sleep
  - If they’re hard to change, how useful can they be from a practicality standpoint? But if they’re TOO EASILY changed, they may be spurious

The Two Key Questions

- So What?
- Now what do I do with it?

- **SEE. SAY. DO.**

- For anything to be appealing to athletes or operators, it has to have impact
- "Health" vs "Performance"
- It also has to be easy enough to understand and important enough to impact ***preparation***
- In many cases, the most critical influence on biomarkers is typically not under individual control – ***training***
    - This means buy-in at multiple levels

Original Research

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Biomarker Response to a Competitive Season in Division I Female Soccer Players

Alan J. Walker,[1] Bridget A. McFadden,[1] David J. Sanders,[1] Meaghan M. Rabideau,[1] Morgan L. Hofacker,[1] and Shawn M. Arent[1,2]

[1]IFNH Center for Health and Human Performance, Rutgers University, New Brunswick, New Jersey; and [2]Department of Kinesiology and Health, Rutgers University, New Brunswick, New Jersey

- Significant declines in V̇O2max, VJ, weight, and %BF with no significant differences in FFM
- Training load and EEE significantly decreased from T1–T3
- Significant increases were seen in CORTT, CORTF, PRL, T3, IL-6, CK, and TIBC throughout the season
- Significant decreases were seen in n-3FA, Fe, Fer, %Sat, and Hct throughout the season
- Female athletes experience significant physiological changes following high TL and EEE associated with preseason and appear to be further exacerbated by the cumulative effects of the season
- Unique insights provided by biomarkers enable athletes and coaches to be cognizant of the physiological changes that are occurring throughout the season

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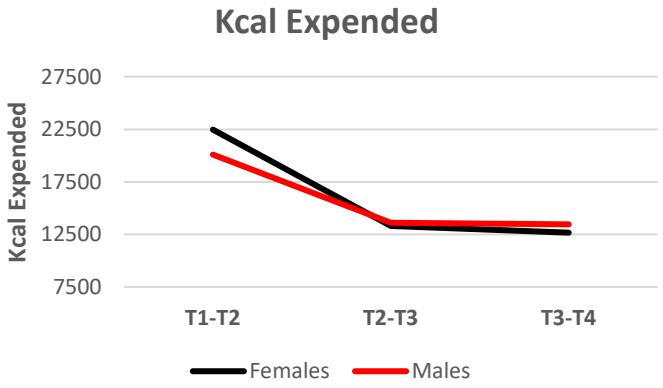
Comparison of Internal and External Training Loads in Male and Female Collegiate Soccer Players During Practices vs. Games

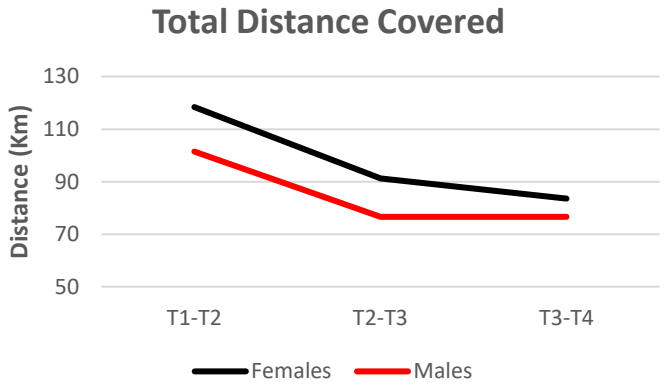
Bridget A. McFadden,[1] Alan J. Walker,[2] Brittany N. Bozzini,[1] David J. Sanders,[3] and Shawn M. Arent[1,3]

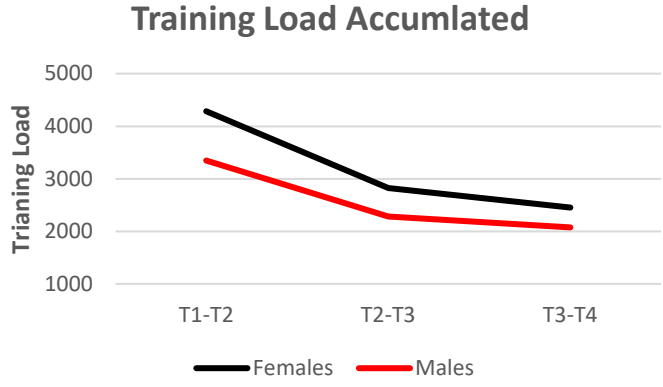
and women for TL, Kcal·kg^{-1}, HR_{Z1-Z5}, SPD_{AVG}, DIS, DIS_{Z1}, DIS_{Z3}, and DIS_{Z4}. However, men accumulated a significantly greater number of sprints and DIS_{Z5} ($p < 0.05$) during games, whereas women accumulated a greater DIS_{Z2} ($p < 0.05$). During practice, no differences were observed for TL, DIS, sprints, Kcal·kg^{-1}, DIS_{Z2}, DIS_{Z3}, HR_{Z1-Z5}, but men exhibited higher SPD_{AVG}, ($p < 0.05$), DIS_{Z1} ($p < 0.05$), DIS_{Z4} ($p < 0.05$), and DIS_{Z5} ($p < 0.05$). The parallels in Kcal·kg^{-1}, total DIS, HR, and TL indicate a similar relative workload between men and women. However, distance covered in higher speed zones was found to be greater in men than women across practice and games likely reflecting inherent sex differences in the ability to achieve those speeds. Monitoring techniques that track relative player workloads throughout practices and games may enhance player health and performance during the season. An individualized approach to tracking high-intensity running may improve workload prescriptions on a per player basis.

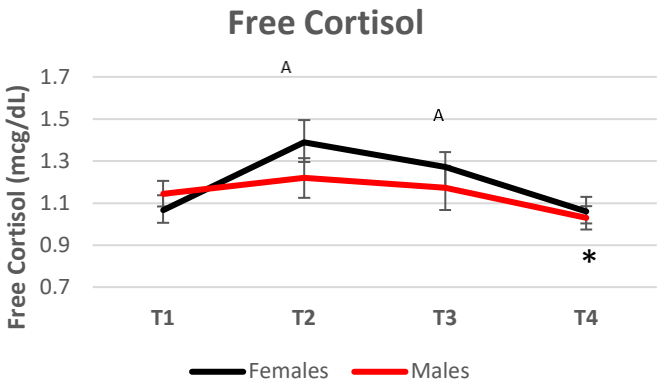
In-Season Performance

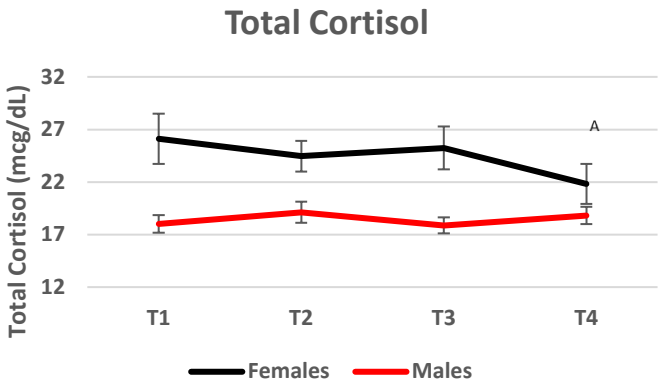
- Pre-Season training elicits the highest energy expenditure and workload
- Decrease in workload as season progresses

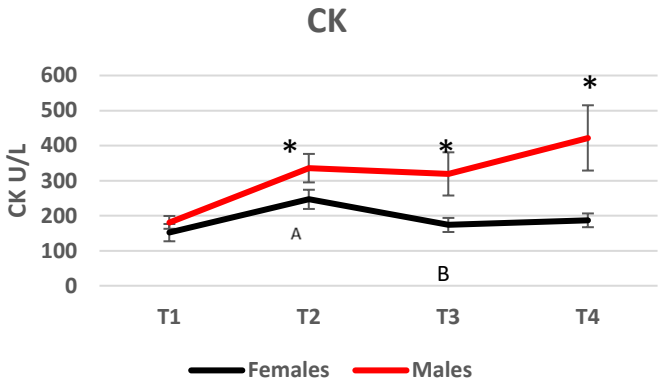




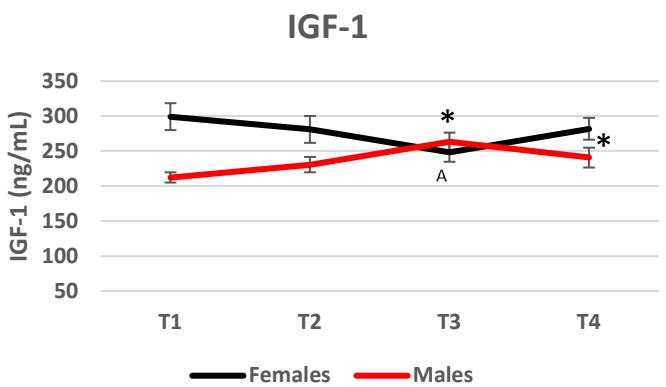


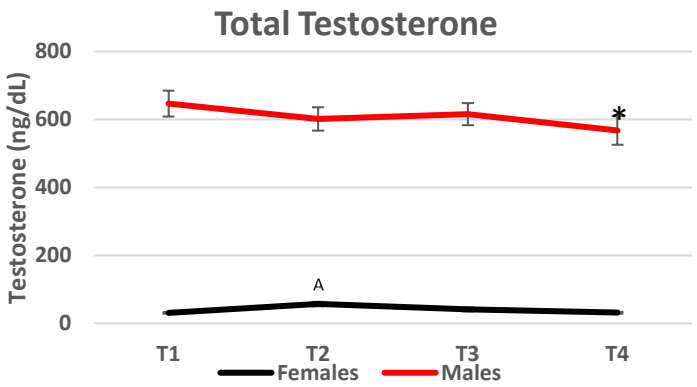

Free Cortisol
Free Cortisol (mcg/dL)
1.7
1.5
1.3
1.1
0.9
0.7
A
A
*
T1
T2
T3
T4
Females
Males

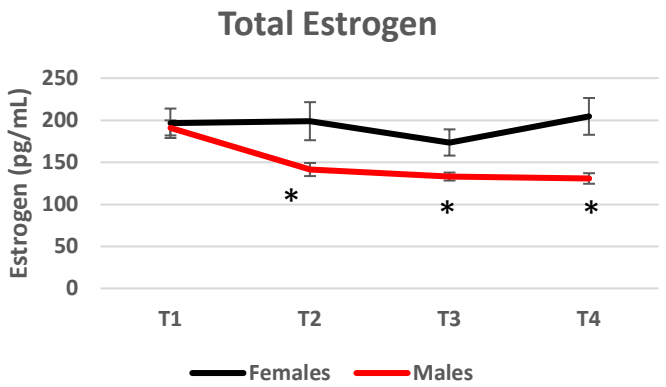

Total Cortisol
Total Cortisol (mcg/dL)
32
27
22
17
12
A
T1
T2
T3
T4
Females
Males

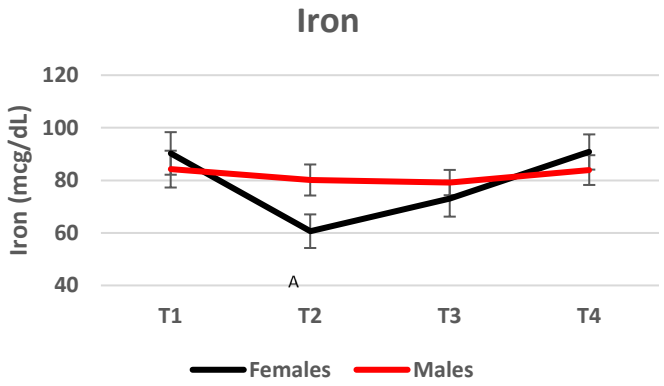

CK
CK U/L
600
500
400
300
200
100
0
*
*
*
A
B
T1
T2
T3
T4
Females
Males

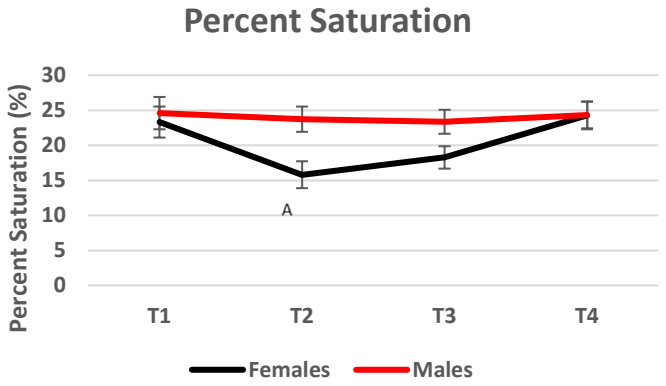

Growth Hormone
GH (ng/mL)
6
5
4
3
2
1
0
A
A
A
T1
T2
T3
T4
Females
Males

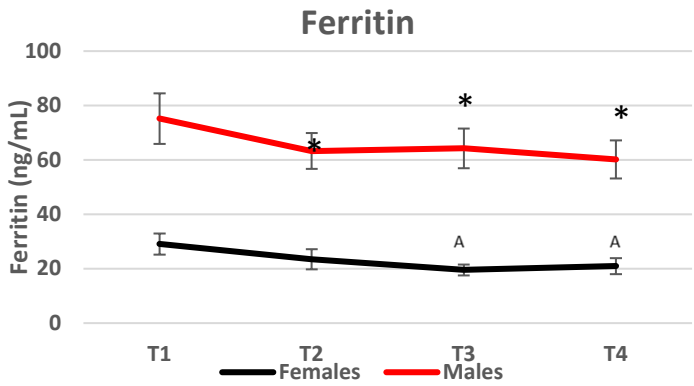

IGF-1
IGF-1 (ng/mL)
350
300
250
200
150
100
50
*
*
A
T1
T2
T3
T4
Females
Males


Total Testosterone
Testosterone (ng/dL)
800
600
400
200
0
*
A
T1
T2
T3
T4
Females
Males


Total Estrogen
Estrogen (pg/mL)
250
200
150
100
50
0
*
*
*
T1
T2
T3
T4
Females
Males


Iron
Iron (mcg/dL)
120
100
80
60
40
A
T1
T2
T3
T4
Females
Males


Percent Saturation
Percent Saturation (%)
30
25
20
15
10
5
0
A
T1
T2
T3
T4
Females
Males


Ferritin
Ferritin (ng/mL)
100
80
60
40
20
0
*
*
*
A
A
T1
T2
T3
T4
Females
Males

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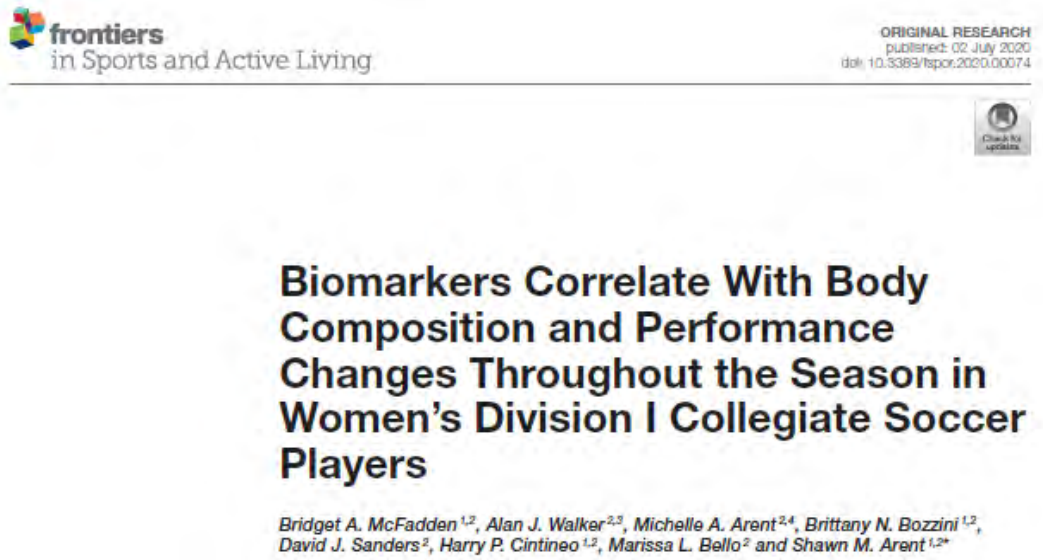
Early Season Hormonal and Biochemical Changes in Division I Field Hockey Players: Is Fitness Protective?

Alan J. Walker,[1] Bridget A. McFadden,[2] David J. Sanders,[3] Brittany N. Bozzini,[3] Sean P. Conway,[3] and Shawn M. Arent[2,3]

FIT ATHLETE PARADOX

- Players with increased fitness coming into preseason (higher VO_2 and lower %BF) experienced more notable changes in hormonal biomarkers that are associated with overreaching (TCORT, FCORT, T3, SHBG, Fe)
- The more fit athletes are capable of performing more work compared to the less fit athletes and appear to "make up" for the less fit players
- The ability to perform more work coupled with the high volume and short recovery time of preseason training puts the more fit athletes at greater risk of overreaching

What's Moving the Needle?


frontiers in Sports and Active Living

ORIGINAL RESEARCH
published: 02 July 2020
doi: 10.3389/fspor.2020.00074

Biomarkers Correlate With Body Composition and Performance Changes Throughout the Season in Women's Division I Collegiate Soccer Players

Bridget A. McFadden[1,2], Alan J. Walker[2,3], Michelle A. Arent[2,4], Brittany N. Bozzini[1,2], David J. Sanders[2], Harry P. Cintineo[1,2], Marissa L. Bello[2] and Shawn M. Arent[1,2]

- TCORT neg correlated with FFM (r = -0.48); pos correlated with VO2max (r = 0.47), %BF (r = 0.39)
- IGF-1 & GH pos correlated with deadlift (r = 0.57 & r = 0.59, respectively)
- IL-6 neg correlated with bench press (r = -0.53)

american physiological society | JOURNAL OF APPLIED PHYSIOLOGY.

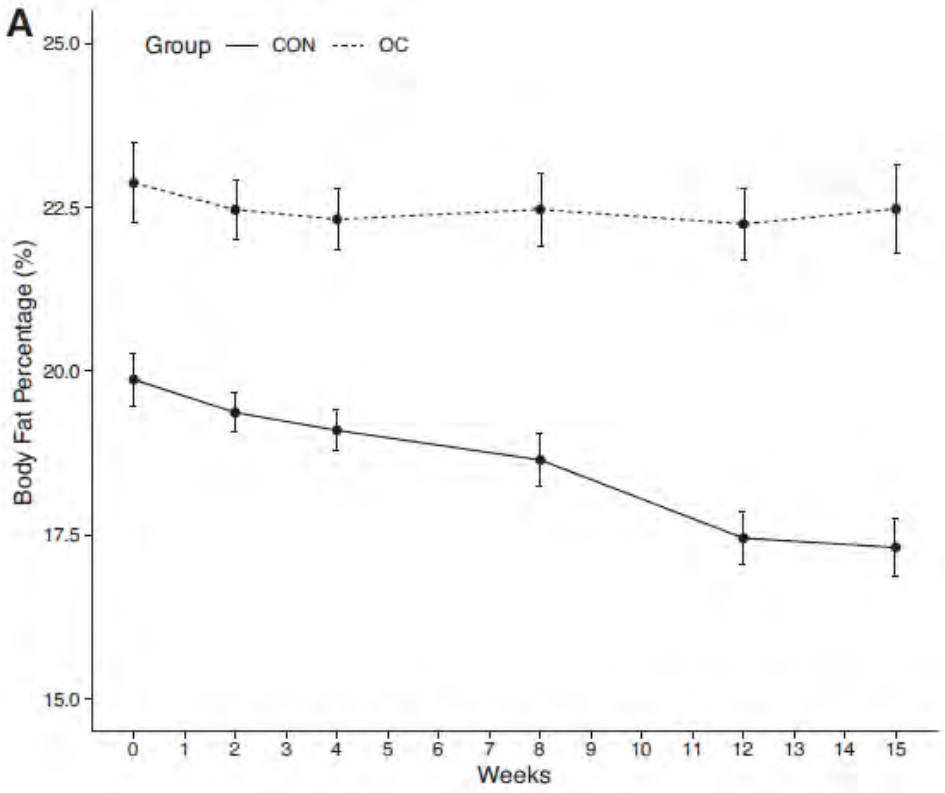
J Appl Physiol 130: 1971–1982, 2021.
First published May 6, 2021; doi:10.1152/japplphysiol.00818.2020

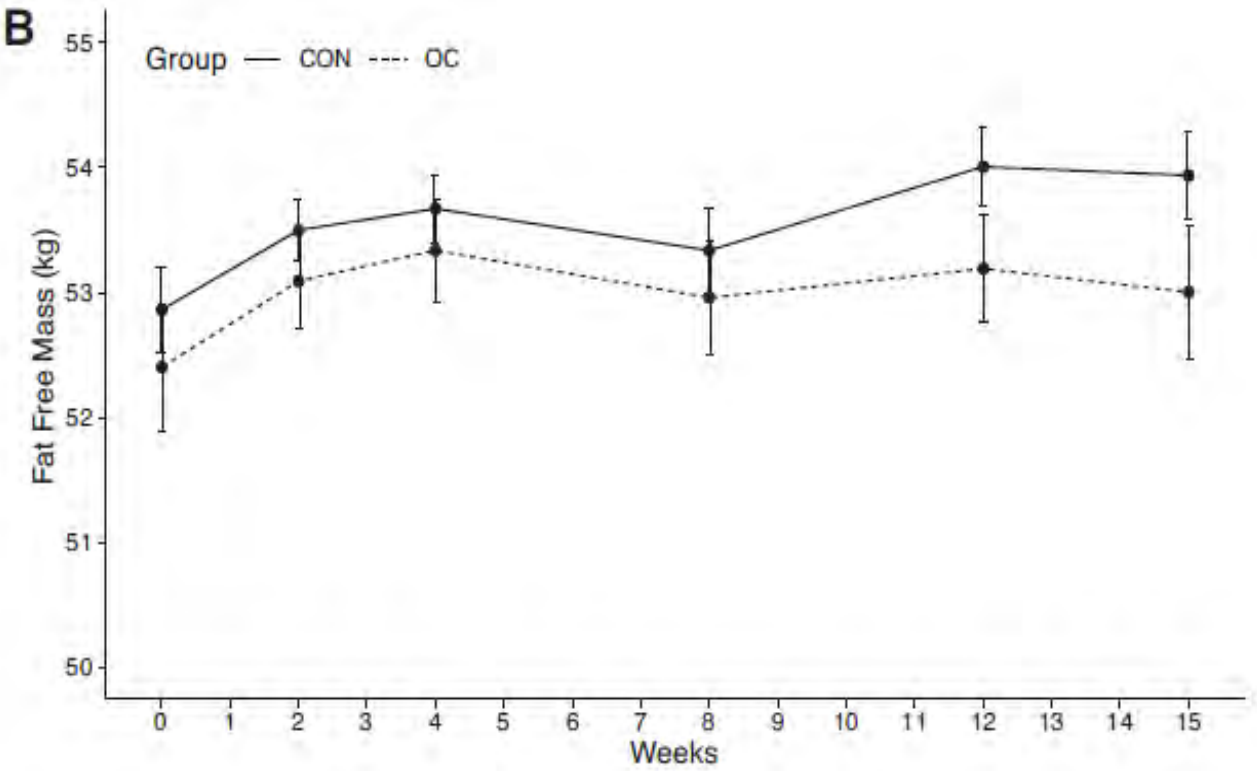
RESEARCH ARTICLE

Evaluating the effects of oral contraceptive use on biomarkers and body composition during a competitive season in collegiate female soccer players

Brittany N. Bozzini,[1,2] Bridget A. McFadden,[1,2] Kirsty J. Elliott-Sale,[3] Paul A. Swinton,[4] and Shawn M. Arent[1,2]

- OC group exposed to substantially higher levels of SHBG, **CORT, CRP**, leptin, & GH
- OC group exposed to substantially lower levels of E2, progesterone, $TEST_F$, FSH, & CK
- Both groups increased FFM, but CON had greater magnitude of increase and a decrease in %BF
- Similar training loads!


A
Group — CON ---- OC
Body Fat Percentage (%)
25.0
22.5
20.0
17.5
15.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Weeks


B
Group — CON ---- OC
Fat Free Mass (kg)
55
54
53
52
51
50
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Weeks

The Chicken or the Egg…

Original Research

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Psychological and Physiological Changes in Response to the Cumulative Demands of a Women's Division I Collegiate Soccer Season

Bridget A. McFadden,[1,2] Alan J. Walker,[3] Brittany N. Bozzini,[1] Morgan Hofacker,[2] Mark Russell,[4] and Shawn M. Arent[1,2,4]

[1]Department of Exercise Science, the University of South Carolina, Columbia, South Carolina; [2]Institute for Food, Nutrition, and Health (IFNH), Rutgers, the State University of New Jersey, New Brunswick, New Jersey; [3]Department of Exercise Science, Lebanon Valley College, Annville, Pennsylvania; and [4]School of Social and Health Sciences, Leeds Trinity University, Leeds, United Kingdom

KNOWLEDGE – Providing CONTEXT to Information

- When is the greatest stress incurred? Why?
  - The more you sweat in training, the less you bleed in battle
- What can the INDIVIDUAL control? What can be done at the organizational level?
- Accounting for OVERALL stress – the missing piece of the puzzle
  - For the athlete, it's not just about what's happening in training & games
- Individual factors – Fitness? Injury history? Nutrition? Sleep?

THANK YOU!

- Bridget McFadden, PhD, CSCS*D
- Alan Walker, PhD, CSCS*D
- Brittany Bozzini, PhD, CSCS*D
- Michelle Arent, MPH, CSCS*D
- Dave Sanders, PhD, CSCS*D
- Harry Cintineo, MS, CSCS
- Kirsty Elliott-Sale, PhD
- Mark Russell, PhD
- Paul Swinton, PhD

- Rutgers Men's & Women's Soccer
- Quest Diagnostics

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