

## Background

- Soccer is characterized by fast and powerful explosive running and jumping movements required of all players, regardless of the specific position that one plays<sup>1</sup>
- Recovery of soccer players is imperative to the performance of these athletes due to the diverse and highly explosive movements that occur in games<sup>2,3</sup>
- Insufficient time allotted to recovery of elite players can increase the risk of illness, injury and overtraining<sup>4</sup>
- Changes in salivary testosterone and cortisol have been evaluated as physiological markers of the physical demands of a competitive event<sup>2</sup>
- Testosterone to cortisol ratio (T:C) has been used as an indicator of anabolic-catabolic imbalances, where anabolic states refers to molecular building and catabolic states refers to molecular breakdown
- A high T:C represents a positive anabolic state, whereas a decline in T:C serves as a marker of overtraining

## Purpose

The purpose of this study was to evaluate changes in salivary testosterone and cortisol immediately prior to pre-season training (PS), before (PreGame) and after (PostGame) a competitive game and at 12 (Recovery12hr) and 36 (Recovery36hr) following the competitive game in Division I men's soccer athletes.

## Methods

### Participants:

- 19 players on the Elon University men's soccer team roster during the fall 2019 season were recruited to participate in this study.
- Age:  $18 \pm 1$  yrs.; body fat:  $11.0 \pm 3.1\%$

### Study design:

- Pre- and Post-season testing days: participants signed up for designated testing appointments and arrived in a fasted state for DXA scans and were expected to return within a week for a graded exercise test
- Pre-season practice testing day: participants arrived at practice and a saliva sample was collected within 60 minutes prior to practice, and within 15 minutes after the practice ended
- Saliva collection pre- and post-game: saliva was also collected within 60 minutes before the start of the game and within 15 minutes of the completion of the game
- Two morning practices following Game 1: saliva was collected within the 30 minutes prior to the beginning practice
- Statistical analyses were conducted using analysis of variances (ANOVAs) with significance accepted at  $p < 0.05$ .

Figure 1. In-Season Testing Timeline

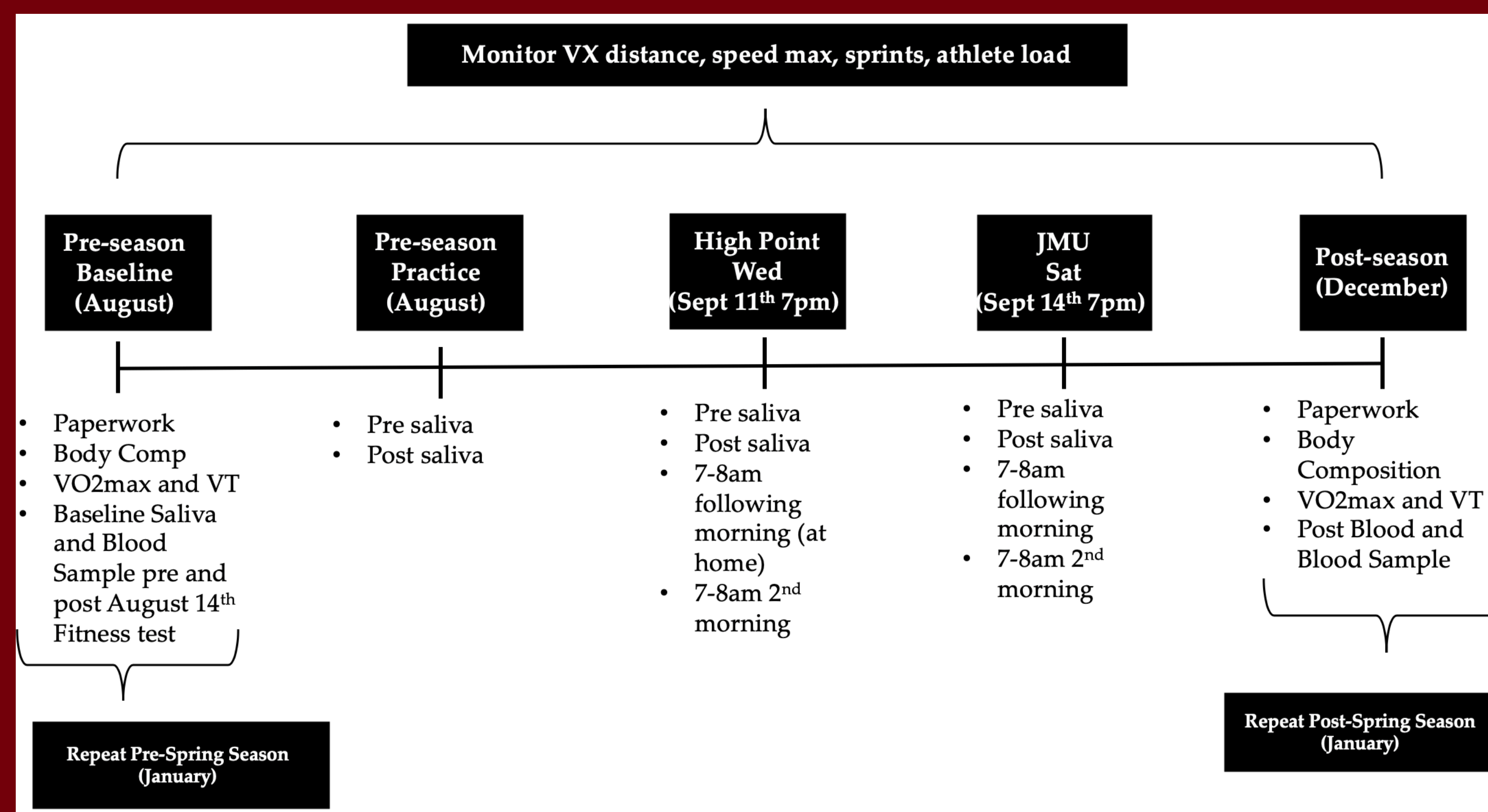
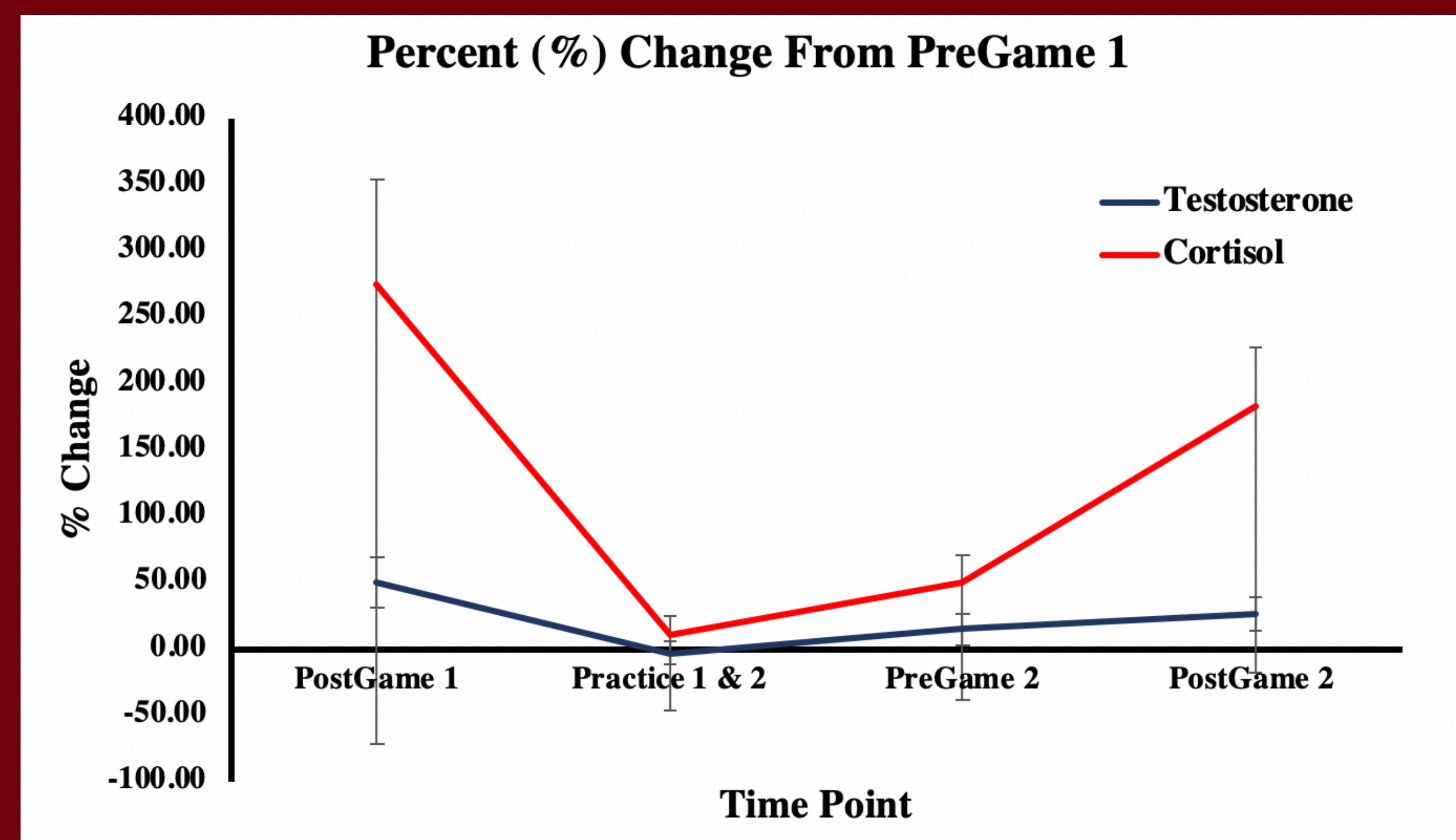


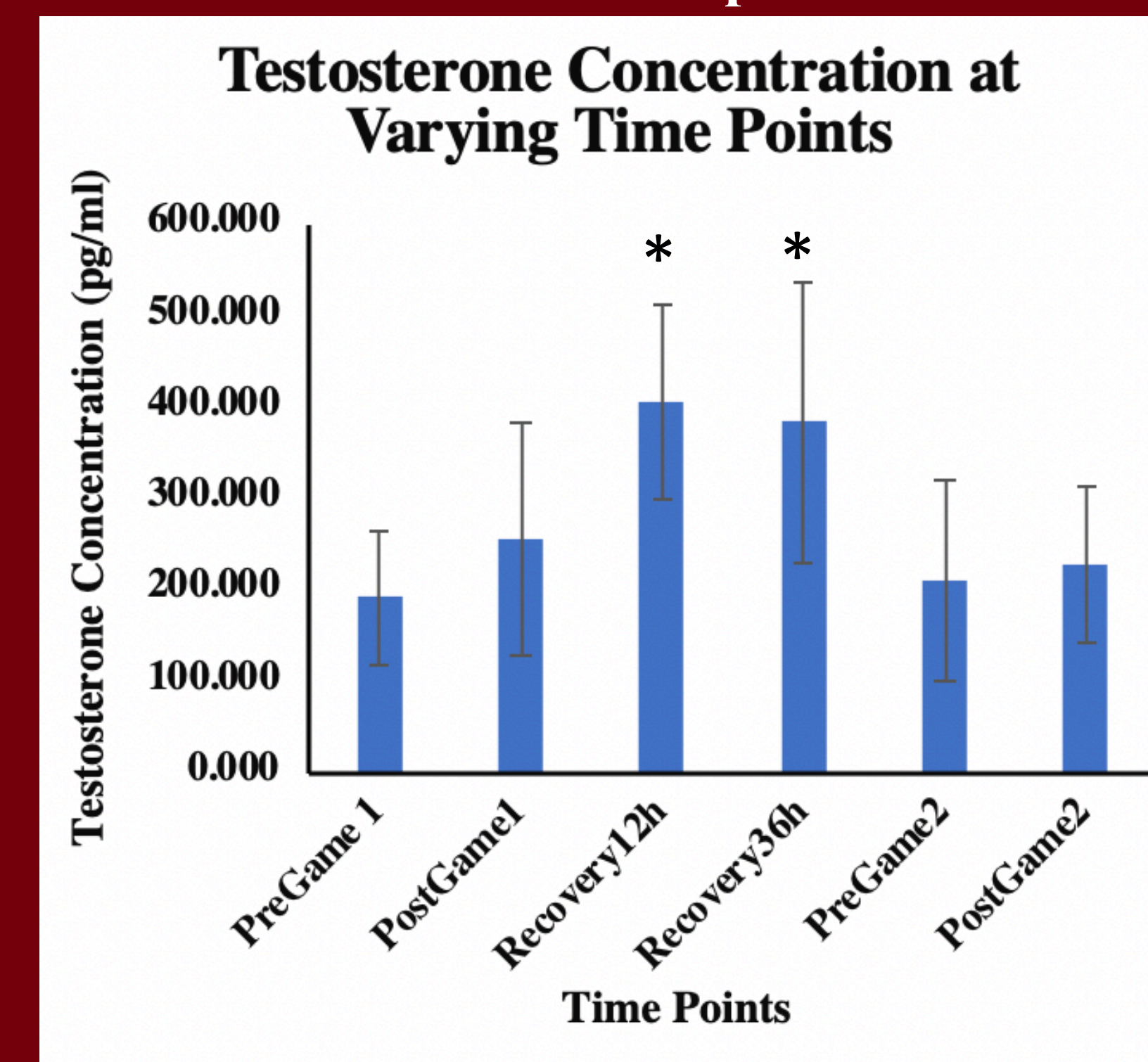
Figure 2. Percent change (%) in testosterone and cortisol from PreGame 1 to multiple timepoints



**Author: Madeleine August**  
**Mentor: Dr. Titch Madzima, Ph.D.**  
**Department: Exercise Science**  
**Contact: [maugust@elon.edu](mailto:maugust@elon.edu), [tmadzima@elon.edu](mailto:tmadzima@elon.edu)**

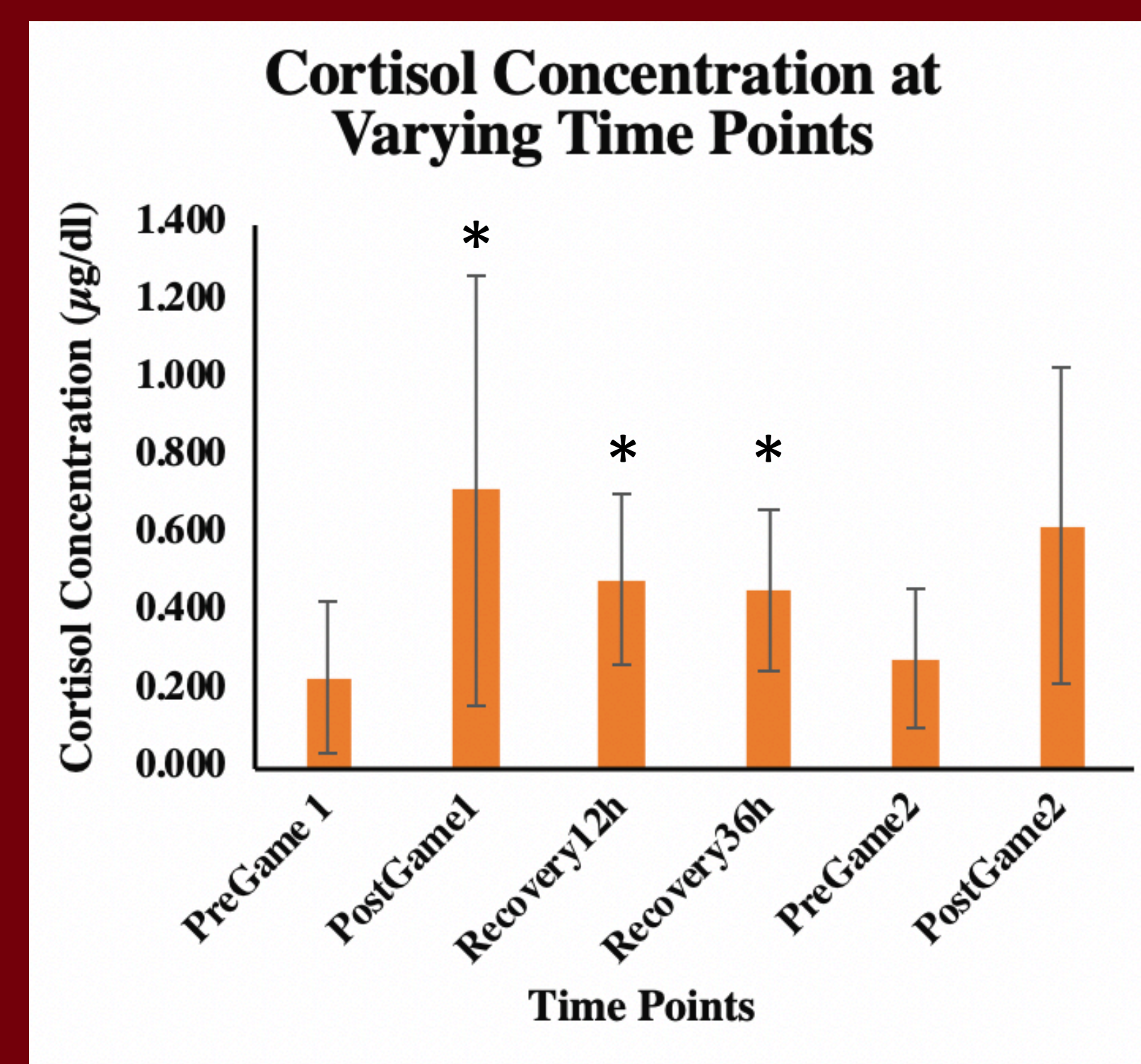


Figure 3. Levels of testosterone at various time points



\* ,  $p < 0.05$ , significantly different from PreGame

Figure 4. Levels of cortisol at various time points



\* ,  $p < 0.05$ , significantly different from PreGame

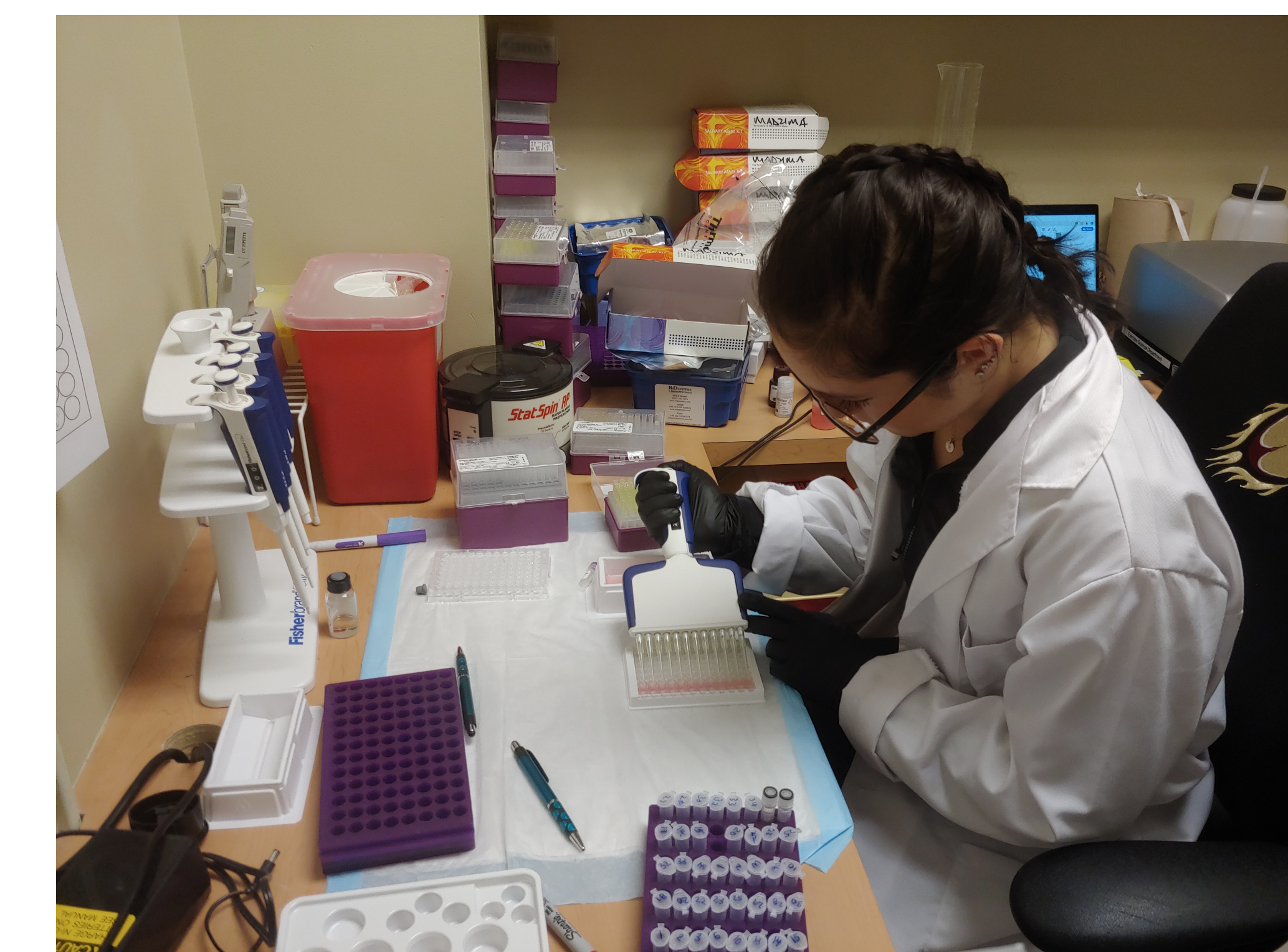
## Results

Postgame testosterone levels ( $244 \pm 108$  pg/mL) were similar to pregame levels ( $174 \pm 69$  pg/mL;  $p = 0.056$ ). Recovery12h ( $410 \pm 92$  pg/mL) and Recovery36h ( $398 \pm 147$  pg/mL) were both significantly greater than PreGame ( $174 \pm 69$  pg/mL) and PostGame ( $244 \pm 108$  pg/mL) levels ( $p < 0.001$ ). When compared to PreGame levels ( $0.204 \pm 0.10$  µg/dL), cortisol was significantly greater at PostGame ( $0.704 \pm 0.51$  µg/dL), Recovery12h ( $0.510 \pm 0.21$  µg/dL), and Recovery36hr ( $0.484 \pm 0.21$  µg/dL) ( $p < 0.05$ ). There were no differences in cortisol levels between PostGame, Recovery12h, and Recovery36hr. The T:C was significantly lower at PS than all other timepoints ( $p < 0.001$ ). T:C significantly declined from PreGame to PostGame ( $-501 \pm 140$ ;  $p = 0.028$ ), but returned to PreGame levels at Recovery12h, and Recovery36hr.

## Discussion

The testosterone to cortisol ratio (T:C) significantly declined from PreGame to PostGame, signaling that the athletes were in a catabolic state after the soccer match. The T:C returned to PreGame levels at both the 12- and 36-hour PostGame time points. This return to PreGame levels indicated that the athletes had adequately recovered to PreGame T:C levels within the 12-hours immediately following the soccer game. Within the specific time period of the study, the athletes had adequately recovered and were not in an over trained state.

Figure 5. Analyzing saliva samples in the lab



## Citations

- Drust, B., Atkinson, G., & Reilly, T. (2007). Future Perspectives in the Evaluation of the Physiological Demands of Soccer. *Sports Medicine*, 37(9), 783-805.
- Lee, E. C., Fragala, M. S., Kavouras, S. A., Queen, R. M., Pryor, J. L., & Casa, D. J. (2017). Biomarkers in Sports and Exercise: Tracking Health, Performance, and Recovery in Athletes. *Journal of Strength and Conditioning Research*, 31(10), 2920-2937.
- Silvestre, R., Kraemer, W. J., West, C., Judelson, D. A., Spiering, B. A., Vingren, J. L., . . . Maresh, C. M. (2006). Body Composition and Physical Performance During a National Collegiate Athletic Association Division I Men's Soccer Season. *Journal of Strength and Conditioning Research*, 20(4), 962-970.
- Doeven, S. H., Brink, M. S., Kosse, S. J., & Lemmink, K. A. (2018). Post match recovery of physical performance and biochemical markers in team ball sports: a systematic review. *BMJ Open Sport & Exercise Medicine*.

**Changes in salivary testosterone and cortisol indicate optimal recovery was achieved in NCAA Division I men's soccer athletes between matches 72 hours apart**

