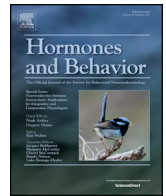




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## Competition-related testosterone, cortisol, and perceived personal success in recreational women athletes

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## ABSTRACT

Thirty-five women participating in one or more intramural flag-football games provided saliva samples before, immediately after, and 10 min after competition and completed an after-competition questionnaire appraising their own performance during the game. As seen in other studies of elite athletes, these recreational athletes, on average, showed significant elevations in testosterone (T) and cortisol (C) across the competition period – the “competition effect”. In winners and losers, T levels at all time points measured were positively related to athletes’ appraisals of their own individual performance. Results from this study show that the competition effect for T and C is evident in recreational women athletes and provide preliminary evidence about the relationship between cognitive appraisal and competition-related T levels.

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### 1. Introduction

Athletic competition is a formal contest for status and an ideal real-world setting for the study of the neuroendocrinology of social competition (Casto and Edwards, 2016a). For serious athletes, personal performance and competition outcome (win/lose) have a significant bearing on self-concept, morale, prestige, and status with teammates. Athletic competition, in a variety of sports, is associated with a substantial increase in both testosterone (T) and cortisol (C) levels in men and women (e.g., Bateup et al., 2002; Casto et al., 2014; Casto and Edwards, 2016b; Edwards et al., 2006; Edwards and Kurlander, 2010; Filaire et al., 2009; González-Bono et al., 1999; Hamilton et al., 2009; Suay et al., 1999). This effect could be due to the psychological experience of competition, the physical exertion inherent in sport, or some combination of the two (for review, Casto and Edwards, 2016a). Efforts to quantify physical exertion in studies of the T response to athletic competition (e.g., blood lactate, number of minutes played, self-reported physical exertion, observer-rated physical exertion) have not found any significant correlations between these metrics of exertion and T (Aguilar et al., 2013; Casto and Edwards, 2016b; Oliveira et al., 2009; Suay et al., 1999). However, C response may demonstrate greater connection with physical exertion in these contexts (for review, Gatti and De Palo, 2011; Viru and Viru, 2004). Whatever the cause, competition-related increases in T and C will elevate the concentration of these hormones at target tissues in the brain and body – a result that could have

important effects on psychological states relevant to status-motivation and competitive behavior.

According to the biosocial model of status (Mazur, 1985; Mazur and Booth, 1998), winning a contest for status should increase T levels whereas losing should decrease T levels. This reciprocal model proposes that an increase in T following a win reflects dominance and motivates future competitive or aggressive encounters that could be advantageous for social status. Likewise, a decrease in T following a loss reflects deference and reduces competitive motivation. However, only a few studies of the hormonal response to athletic competition have shown a differential T response based on competition outcome (e.g., Aguilar et al., 2013; Jiménez et al., 2012; Oliveira et al., 2009; for recent meta-analysis, Geniole et al., in this issue), and only when post-competition saliva samples are taken at least 15 min after the end of play (Casto and Edwards, 2016a). Although many researchers operate under the assumption that there is a 15-minute delay between the psychological experience of winning or losing and changes in salivary hormonal levels, the precise timing of these effects has not been clearly established (Riad-Fahmy et al., 1987; Mehta and Josephs, 2006; Schultheiss et al., 2005; Wirth et al., 2006). In any case, the effects of competition on levels of T and C should be considered separate from the effects of winning/losing on these same hormones given the psychological and temporal differences in these experiences. At least for athletic contexts, competition-related increases in salivary T and C probably occur before the winner and loser have been decided (e.g., we have unpublished data that demonstrates a significant increase in T and C levels at half-time of a competition; also see Casto and Edwards, 2016a for a discussion of this point). Thus, if there is a winner/loser effect for T and C, as predicted by the biosocial model of status, it should be most evident in the period following

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the end of competition, when the winner and loser have been formally decided and the experience of victory or defeat are most keenly felt.

The formal designation of winner and loser in sport may not always be congruent with an individual's appraisal of his/her own performance or social status gained or lost as a result of competition. For example, the overall outcome of a soccer match could be a loss, but one or more individuals on the team may feel that they performed well (e.g. scored a goal, successfully defended the other team's best player). Similarly, even though a contest ends in victory, some individuals can feel they performed poorly. How an individual performs can influence feelings of social status, mood, and potentially, after-competition hormone levels and fluctuations. In studies with professional men's basketball players, post-match T levels were negatively related to performance self-appraisal (measured by a single item) for members of a losing team (González-Bono et al., 1999), but not for members of a winning team (González-Bono et al., 1999, 2000). That is, for men who lost, the higher their post-match T, the more negatively they viewed their personal performance in the match. That the relationship between T and self-appraisal appeared only for losers, perhaps owes to greater inter-individual variability in self-appraisal in contests that are lost relative to those that end in victory (González-Bono et al., 2000). In a study of Tsimane men (in the Bolivian Amazon) competing in tournament style cross-community soccer matches, T change associated with competition was positively related with post-competition self-ratings of personal match performance (Trumble et al., 2012). While not all studies have found a relationship between T and post-contest self-appraisal of personal performance (Suay et al., 1999), updated reformulations of the biosocial model have proposed that cognitive variables, including performance appraisal, likely influence the androgen response to competition (Oliveira and Oliveira, 2014; Salvador, 2005; Salvador and Costa, 2009).

This study was designed to explore relationships between T and C and individual differences in how women athletes perceive their personal performance in an athletic competition. Based on updated models of the biosocial model (Salvador, 2005; Salvador and Costa, 2009), we hypothesize that competition-related changes in T levels will be positively related to self-perceptions of personal performance in that competition.

Nearly all of the published studies of the "competition effect" for T and C in sport contests have been conducted with elite or well-trained athletes. But, the hormonal effects of competing are thought to be basic biological responses to contests for social status regardless of formal training or preparation (e.g., Mazur and Booth, 1998). If so, provided individuals are sufficiently motivated to compete, the competition effect for T and C should also be evident in recreational athletes who enter the competition with substantially less sport-specific training and competition-related interaction with teammates and who compete in a lower-stakes atmosphere than elite-level athletes. The present study extends previous research on the hormone response to athletic competition in elite women athletes to novice athletes. Specifically, we hypothesize that for novice women athletes, T and C will significantly increase over the course of recreational athletic competition.

## 2. Methods

### 2.1. Participants

Thirty-five Emory University women undergraduate ( $N = 13$ ) and graduate ( $N = 22$ ) students participating in intramural flag-football tournament for either the 2013 or 2014 season were recruited for the study. This research was approved by the university's Institutional Review Board and participants gave written informed consent prior to participation. As part of the consent procedure women were asked to respond "yes" or "no" to the question "Are you currently using an oral contraceptive?" and to one other: "Are you currently using any injected, implanted, or patch-delivered hormone contraceptive?" – answering

yes to either one of these questions was coded "1" for hormone contraceptive (HC) user and "0" for non-user. Participants were from a variety of teams organized by university departments/club affiliations which, for reasons of confidentiality, were de-identified for this report.

### 2.2. Measures

#### 2.2.1. Perceived personal success (PPS)

To determine how participants appraised their personal performance in the match separate from overall team outcome, participants completed a 6-item survey after the competition ended. Absent an existing validated survey that measures perceived personal success in athletic competitions, we wrote the items for the survey based on our own experiences. Survey items are shown in Table 1. Responses were on a 5-point Likert scale with a value of 1 indicating "strongly disagree" and a value of 5 indicating "strongly agree." A preliminary principal component analysis (PCA) was conducted on the six items with oblique rotation (oblimin). The Kaiser-Meyer-Olkin measure determined that the sampling adequacy for the analysis,  $KMO = 0.75$ , was above the bare minimum of 0.5, but considered mediocre (PCA results should be interpreted cautiously). Bartlett's test of sphericity  $\chi^2(15) = 118.08$ ,  $p < 0.001$ , indicated that correlations between items were sufficiently large for PCA. Eigenvalues revealed two components within the data (with a Kaiser's criteria of 1) that combined to explain 78.64% of the variance. After rotation, the items that clustered on Factor 1 were PPS1, PPS2, PPS4, and PPS6 and the items that clustered on Factor 2 were PPS3 and PPS5. As shown in Table 1, Factor 2 is comprised of the reverse-scored items. Although these items were properly reverse-scored (Mean for Factor 1 = 3.52, Factor 2 = 3.40), Factor 2 items did not correlate as strongly with the four other items in the scale. Indeed, Cronbach's alpha for the scale including these Factor 2 items is 0.76 and excluding these items is 0.82. Thus, survey items 3 and 5 were not included in the mean PPS score used in subsequent analyses (overall results were not different in terms of significance, direction, or approximate magnitude of effects when including these items). In Supplement 1, we provide analysis of the relationship between these two items (interpreted as a negative affect or threat appraisal) and T levels, C levels, and competition-related changes in T and C.

### 2.3. Procedure

#### 2.3.1. Competition

Competitions were intramural flag-football playoff games arranged by the University recreation center as the culmination of the intramural flag-football program. Matches took place in late October, outdoors on campus recreational athletic fields. Because all participants were university students, the match was technically a "home" game for all teams. There were few, if any, spectators present. All the games took place in the evening between 7 and 9:30 PM and were comprised of the semi-final and final tournament matches of the 2013 season and the final match of the 2014 season. All matches were comprised of two 20-minute halves with a 5-minute halftime. Each team was allowed seven players on the field at a time, but not all the members of each team participated in the study (they either opted out or showed up

**Table 1**  
Items designed to measure perceived personal success.

Please rate your agreement with the following statements based on your opinions about <b>how you played in today's game personally, despite the overall outcome</b> (i.e., how your team played as a whole or whether you won or lost). (R) denotes items that are reverse-scored.
1. I personally played well in the match.
2. I'm happy with my personal performance in the game.
3. I feel personally defeated by my mistakes during the game. (R)
4. I personally contributed greatly to the overall team outcome.
5. I feel down on myself for the way I played today. (R)
6. Today's game was a personal success for me.

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