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SHORT COMMUNICATION

Watching a previous victory produces an increase in testosterone among elite hockey players

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Summary Previous research indicates that testosterone concentrations are highly responsive to human competitive interactions and that winners have elevated testosterone concentrations relative to losers. Also, there is some evidence that simply observing others compete can have a similar effect on the endocrine system. Here, in two studies, we examined the extent to which elite male hockey players would demonstrate an increase in testosterone concentrations after watching themselves engaged in a previous successful competitive interaction. Results indicated that watching a previous victory produced a significant increase in testosterone concentrations (42—44% increase), whereas watching a previous defeat or a neutral video did not produce a significant change in testosterone (17% and 6%, respectively). Given that natural fluctuations in testosterone have been shown to influence future competitive and aggressive behaviours, the current studies may have important practical implications for individuals involved in competitive sports.

1. Introduction

Testosterone concentrations are highly responsive to competitive interactions in a number of species (see Leshner, 1975; Mazur, 1985; Wingfield et al., 1990; Mazur and Booth, 1998; Oliveira, 2004; van Anders and Watson, 2006; Archer, 2006 for reviews). In humans, testosterone varies as a function of the outcome of the competition, with levels elevated after a victory relative to a defeat (see Archer, 2006 for meta-analysis). An interesting extension to this finding is that human spectators watching their favourite sports team win also experience a rise in testosterone, while spectators of the losing team experience a decrease (Bernhardt et al., 1998). Similarly, male cichlid fish demonstrate a surge in testosterone concentrations after viewing con-specifics engaged in an aggressive interaction (Oliveira et al., 2001).

Most studies on testosterone and human competition have been conducted within the context of competitive sports (see Salvador, 2005 for review). Given that physical activity is known to influence testosterone (see Kraemer and Ratamess, 2005 for a review), it is difficult to determine the contribution of psychological versus physical factors that contribute to the 'winner/loser effect'. Nonetheless, there is some evidence from non-physically taxing competitions (e.g., chess, reaction-time competition) which suggest that psychological

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mechanisms may contribute to the 'winner/loser effect' (see Archer, 2006 for meta-analysis; but see Schultheiss et al., 2005; Mehta and Josephs, 2006; Carré and McCormick, 2008 for null findings).

Here, we used a novel approach to examine the 'winner/loser effect' and 'audience effect' in men. In two studies, we examined the extent to which NCAA Division I hockey players would experience an increase in testosterone after watching a video of a previous victory.

2. Methods

2.1. Participants

Twenty-three men from an NCAA Division I hockey team (mean age = 22.64, SD = 1.43) provided saliva samples before and after watching a video of themselves engaged in a previous successful competitive interaction (i.e., victory). Fifteen of these men also provided saliva samples before and after watching a video of themselves engaged in a previous unsuccessful competitive interaction (i.e., defeat). Five of the men who provided saliva samples for the win session did not play in the game that was being viewed. Moreover, three of the men who provided saliva samples for the loss session did not play in the game that was being viewed. The team under investigation had a .300 win percentage. The win session was played against a team with a .574 win percentage and the loss session was played against a team with a .425 win percentage. All procedures were approved by the Canisius College Institutional Review Board.

2.2. Testosterone assay

Saliva samples were collected in polystyrene tubes from participants. Samples were stored at −20 °C until assayed using an in-house enzyme immunoassay procedure (full procedure described in Carré et al., 2006). All samples were assayed in duplicate and on the same day. The intra-assay coefficient of variation was 5.66%.

2.3. Procedure

Samples were collected 10 min prior to and 10 min after watching each of the videos. In the first session, players watched a video depicting a previous game they had won, and the second session (2 weeks later) the players watched a video depicting a previous game they had lost. Both videos were approximately 60 min in length, were viewed at the same time of day (3:00 p.m.), and were projected on a screen that was 69 in. high by 92 in. wide.

2.4. Statistical analyses

In keeping with previous research on testosterone and human competition (Bateup et al., 2002; Edwards et al., 2006; van Anders and Watson, 2007; van Anders et al., 2007; Carré and McCormick, 2008), change in testosterone scores from pre- to post-video were calculated using percent changes [(post-video testosterone minus pre-video testosterone)/(pre-video testosterone) × 100]. One-sample *t* tests were then computed on the percent change scores to test whether testosterone concentrations increased above baseline after watching a victory and/or defeat. A paired sample *t* test was computed to examine whether testosterone responses from the win session were different than testosterone responses from the loss session.

2.5. Results

A paired sample *t* test indicated that there were no differences in baseline testosterone between the win and loss video sessions ($t_{14} = 0.02$, $p = 0.98$). One-sample *t* tests indicated that watching the video depicting a victory produced an increase in testosterone (mean increase = 42%, $t_{22} = 3.46$, $p = 0.002$; Cohen's $d = 0.72$), whereas watching the defeat did not produce a significant change (mean increase = 17.3%, $t_{14} = 0.95$, $p = 0.36$; Cohen's $d = 0.25$). A paired sample *t* test indicated that the mean increase in testosterone for the win session was not significantly greater than the (non-significant) mean increase in testosterone from the loss session, $t_{14} = 1.04$, $p = 0.32$, Cohen's $d = 0.38$ (see Fig. 1a). Results from the win session did not change when the analysis was restricted to individuals who provided saliva samples for both win and loss video sessions (mean increase = 41.7% increase, $t_{14} = 3.34$, $p = 0.005$; Cohen's $d = 0.86$). Moreover, the results remained the same when the analysis was restricted to individuals who: (1) provided samples for both games; and (2) played in both games that were being viewed (win session, mean increase = 44.97%, $p = 0.01$; loss session, mean increase = 23.70%, $p = 0.22$). Individuals who did not play in the win video ($n = 5$) demonstrated a mean increase of 33.43%, while individuals who did not play in the loss video ($n = 3$) demonstrated a mean decrease of 8.12%.

Study 1 indicates that watching a previous victory produces a surge in testosterone. Notably, even individuals who did not participate in the team's victory demonstrated a similar pattern of testosterone responses. In Study 2, we attempted to replicate our effect of an increase in testosterone after watching a previous victory. However, in this study, the players provided saliva samples during the viewing of a neutral video (documentary film) instead of a video depicting a previous defeat.

3. Methods

3.1. Participants

Twenty-one men from another NCAA Division I hockey team (mean age = 21.59, SD = 1.56) provided saliva samples before and after watching a video of themselves engaged in a previous successful competitive interaction (i.e., victory). Twenty of these men also provided saliva samples before and after watching a neutral video (insufficient saliva was provided by one player for the neutral video session). Five of the men who provided saliva samples for the win session did not play in the game that was being viewed. The team under investigation had a .405 win percentage. The win video was played against a team with a .680 win percentage. All procedures were approved by the Canisius College Institutional Review Board.

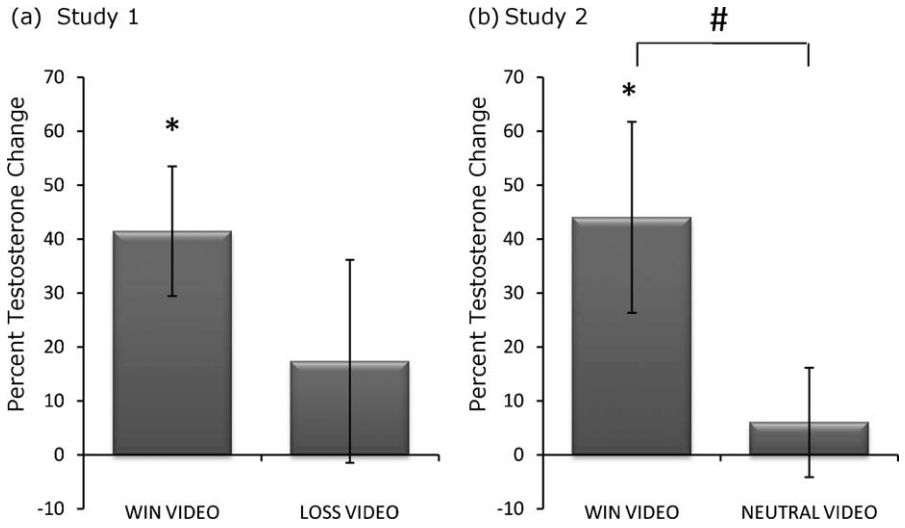

Figure 1 (a) Study 1: mean percent testosterone change from baseline for videos depicting a previous victory and a previous defeat. (b) Study 2: mean percent testosterone change from baseline for a video depicting a previous victory and a neutral video. Error bars represent standard errors of the mean. *Note:* *Significant increase above baseline, #difference between change in testosterone for the win video and neutral video, $p = 0.075$.

3.2. Testosterone assay

Saliva samples were collected in polystyrene tubes from participants. Samples were stored at −20 °C until assayed using commercial enzyme immunoassay kits (DRG International, Inc.). All samples were assayed in duplicate and on the same day. The intra-assay coefficient of variation was 8.34%.

3.3. Procedure

Samples were collected 10 min prior to and 10 min after watching each of the videos. Players watched a video depicting a previous game in which they had won and 1 week later watched a neutral video (*Gulf Stream and the Next Ice Age*). Players were led to believe that they would be watching two videos depicting previous victories. This instruction was given to ensure that if there was any anticipatory rise in testosterone (see Archer, 2006 for meta-analysis), we would expect players to demonstrate this testosterone response prior to both video sessions. As in Study 1, both videos were approximately 60 min in length, were viewed at the same time of day (3:00 p.m.) and projected on a screen that was 69 in. high by 92 in. wide.

3.4. Statistical analyses

One-sample *t* tests were computed on the percent testosterone changes to test whether testosterone concentrations increased above baseline after watching a victory and/or neutral video. A paired sample *t* test was computed to examine whether testosterone responses from the win session were different than testosterone responses from the neutral session.

3.5. Results

There were no differences in baseline testosterone between the win and the neutral video sessions ($t_{19} = 0.09$, $p = 0.93$). Players demonstrated a significant increase in testosterone after watching the video depicting a previous victory (mean increase = 44.0%, $t_{20} = 2.48$, $p = 0.02$; Cohen's $d = 0.54$), but not after watching the neutral video (mean increase = 6.0%, $t_{19} = 0.60$, $p = 0.56$; Cohen's $d = 0.13$). The increase in testosterone for the win session was greater than the increase for the neutral session, although this effect only approached statistical significance, $t_{19} = 1.88$, $p = 0.075$, Cohen's $d = 0.63$ (see Fig. 1b). The results remained the same when the analysis was restricted to individuals who played in the win session being viewed (mean increase = 36.76%, $p = 0.04$; Cohen's $d = 0.63$). Individuals who did not play in the win video ($n = 5$) demonstrated a mean increase of 67.25%.

4. General discussion

Together, these findings indicate that watching oneself engaged in a previous successful competitive interaction produces a surge in testosterone whereas watching a previous defeat, or watching a neutral video does not. These findings provide a novel extension to the 'winner/loser effect' observed in male athletes involved in competition (see Archer, 2006 for meta-analysis) and the 'bystander effect' observed in fish and human spectators (Oliveira et al., 2001; Bernhardt et al., 1998). However, the spectators in the current study were watching themselves compete, and thus, our findings are conceptually different than those previously reported.

Despite these novel findings, there are some limitations that should be noted. First, it is possible that an order effect may have occurred, such that irrespective of the content of the videos (e.g., win, loss, or neutral), those presented in the first session may produce an increase in testosterone, while videos presented in the second session do not. For Study 2, this possibility is unlikely given that previous research examining the influence of sexually explicit videos and neutral videos on testosterone responses in men reported that irrespective of the order in which the videos were presented, sexually explicit

videos always produced an increase in testosterone, whereas neutral videos never produced an increase in testosterone (Hellhammer et al., 1985). Nonetheless, future studies may wish to counterbalance the presentation of videos depicting victories and defeats to eliminate the possibility of order effects. Another issue is that the players viewed all videos in a group environment, which may have an effect on testosterone responses. An interesting follow-up study would be to have athletes watch a video of a previous victory in the presence and/or the absence of others and examine whether such a manipulation would have a differential influence on testosterone dynamics.

Researchers have argued that changes in testosterone in response to competition may serve to influence ongoing and/or future competitive and aggressive behaviours (Leshner, 1975; Mazur, 1985; Wingfield et al., 1990; Mazur and Booth, 1998; Oliveira, 2004; van Anders and Watson, 2006; Archer, 2006). Recent evidence in non-human species provides some compelling experimental support for this hypothesis. Male mice that received testosterone injections following successful competitive interactions (e.g., resident-intruder paradigm) were significantly more aggressive in future interactions (Trainor et al., 2004; Gleason et al., 2009) and were more likely to win subsequent contests than those who received saline injections following successful competitive interactions (Gleason et al., 2009). Moreover, in a study of male cichlid fish, Oliveira et al. (2009) found that winners who received an anti-androgen treatment following a competitive interaction were much less likely to win subsequent aggressive interactions against novel males (44% of the experimental males won) compared to control males that did not receive the treatment (88% of the control males won).

Evidence in people indicates that natural fluctuations in testosterone predict subsequent competitive (Mehta and Josephs, 2006; Carré and McCormick, 2008) and aggressive behaviours (Klinesmith et al., 2006; Carré et al., 2009). Although these findings are consistent with evidence in non-human species, it is important to note that these human studies did not directly manipulate testosterone, and as such, should be considered correlational. Nonetheless, acute pharmacological administration of testosterone in women influences a number of behaviours that may be relevant within the context of competition (e.g., increased cardiac responses to angry faces, van Honk et al., 2001; decreased fear-potentiated startle, Hermans et al., 2006; increased visuospatial performance, Aleman et al., 2004).

In sum, we have demonstrated that watching a previous victory can potentiated testosterone release in elite male athletes. Given that natural fluctuations in testosterone can influence competitive and aggressive behaviours, the current studies may have important practical implications for individuals involved in elite athletics. Future research should investigate the extent to which viewing oneself compete in a previous successful competition is associated with better athletic performance, and whether this association is mediated by a rise in testosterone concentrations.

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Conflict of interest

There are no conflicts of interest for any of the authors.

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