Psychoneuroendocrinology (2014) 42, 218—224

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/psyneuen

SHORT COMMUNICATION

Preliminary evidence of salivary cortisol predicting performance in a controlled setting

Franziska Lautenbach [a,*], Sylvain Laborde [a,b], Silvia Achtzehn [c], Markus Raab [a,d]

[a] *Department of Performance Psychology, Institute of Psychology, German Sport University Cologne, Germany*
[b] *UFR STAPS, University of Caen, France*
[c] *Institute of Training Science and Sport Informatics, German Sport University Cologne, Germany*
[d] *Department of Applied Sciences, London South Bank University, UK*

Received 4 October 2013; received in revised form 15 January 2014; accepted 15 January 2014

KEYWORDS
Hormones;
Emotion;
Competition;
Hierarchical regression;
Sport performance

Summary The aims of this study were to examine the influence of salivary cortisol on tennis serve performance in a controlled setting and to investigate if cortisol predicts unique variance in performance beyond a subjective anxiety measure (i.e., Competitive State Anxiety Inventory-2 [CSAI-2]). Twenty-three tennis players performed two series of second tennis serves separated by an anxiety induction (i.e., arithmetic task). Cortisol was assessed six times during the experiment. Results show that cortisol response and a drop in serving performance are positively correlated (r = .68, $p < .001$). Cortisol also explains unique variance in performance (i.e., 19%) beyond CSAI-2 measures. Thus, considering cortisol measurements seems warranted in future research aimed at understanding performance.

1. Introduction

Cortisol is a biomarker that can be measured to assess changes in the hypothalamic—pituitary—adrenal (HPA) system, which responds to a wide range of psychological stressors, such as competitive situations (Gaab et al., 2003). Most individuals have experienced anxiety in a competitive setting, for example, when taking an exam or interviewing for a job. Competitive settings are particularly prevalent in sports, which explains the increasing interest of researchers in assessing cortisol as a marker of anxiety (Hellhammer and Schubert, 2011) in this domain (Salvador and Costa, 2009).

In particular, salivary cortisol provides a measurement tool that is preferable to serum cortisol (i.e., in blood) since it is noninvasive and pain free, thereby ethically inoffensive and leading to higher compliance (Kirschbaum & Hellhammer, 2000). Additionally, it reflects the dynamic HPA axis

* Corresponding author at: Department of Performance Psychology, German Sport University, Am Sportpark Muengersdorf 6, 50933 Cologne, Germany. Tel.: +49 221 4982 5690.
E-mail addresses: F.Lautenbach@dshs-koeln.de, franzi_Lautenbach@hotmail.com (F. Lautenbach).

0306-4530/$ — see front matter
http://dx.doi.org/10.1016/j.psyneuen.2014.01.011

activity more precisely (Gozansky et al., 2005) and is therefore recommended for sports settings (Crewther et al., 2010).

Most research in the sports setting has focused on either cortisol changes before (i.e., anticipatory rise) and after a competition (recovery; e.g., Crewther et al., 2013) as well as training (for a review, see Gatti and De Palo, 2011) or on the connection between competition outcome (i.e., winner vs. loser) and salivary cortisol (e.g., Filaire et al., 2009; Jiménez et al., 2012) as well as serum cortisol (e.g., Suay et al., 1999) and other hormones (for a review, see Salvador and Costa, 2009), such as testosterone (e.g., testosterone; Gaviglio et al., 2013). Nevertheless, outcome does not entirely reflect the processes involved in reaching it, since an athlete, or for that matter a job candidate or a student, can lose a competition or a job offer or receive a bad grade on an oral exam even when performing well, depending, for example, on the opponent, other job candidates, or luck regarding the questions asked. Thus, an increased focus on performance is necessary to understand the influence of cortisol on the processes involved in reaching an outcome.

Cortisol is generally acknowledged to influence cognitive functions by inhibiting and altering information processing (for a review see Putman and Roelofs, 2011) as well as to have an impact on physical performance (e.g., speed and strength in rugby players; Crewther et al., 2009). The underlying mechanisms explaining these relationships are cortisol passing the blood—brain barrier and glucocorticoid receptors being found in almost every organ in the body (Suay and Salvador, 2012). Thus, an impact of cortisol on performance in competitive sports settings is very likely; hence, such settings are a readymade environment for this kind of research and provided the context for the study reported here.

To date, studies that have focused on cortisol and performance have produced contradictory findings. No significant correlation between salivary cortisol and performance evaluation was found in basketball (Robazza et al., 2012). Performance evaluation here was subjective and corresponded either to the athlete's own evaluation or to the coaches' technical evaluations. In the same line, no correlations were found between the rank of dancers and salivary cortisol concentration during a competition, whereas significant correlations were reported for dancers' own evaluation of performance and peak cortisol level (Rohleder et al., 2007). More specifically, lower satisfaction with performance was associated with a higher peak in cortisol levels (Rohleder et al., 2007). A negative relationship between salivary cortisol and golf score ($r = -.51$) during a 36-hole golf competition was found by Doan et al. (2007). In the same line, lower salivary cortisol responses were associated with better coaches' evaluations and overall performance indicators in a rugby study (Cook and Crewther, 2012). A contradictory result was found in a weight-lifting study, in which official weight-corrected performance was found to be positively correlated with salivary cortisol (Passelergue et al., 1995). Overall, all three possible relations (i.e., no relation, negative relation, or positive relation) between cortisol and performance have been found so far.

It is possible that these contradictory findings regarding cortisol and performance can be attributed to the studies having been conducted in real-life settings. While a real-life environment offers high ecological validity, which is shown by results that demonstrate a significantly higher increase in salivary cortisol due to a real competition in comparison to a simulated competition (e.g., Passelergue et al., 1995; Crewther et al., 2011), confounding variables such as the behavior of opponents or teammates can influence the cortisol—performance relationship. Another drawback is that in three cases, performance was assessed retrospectively and/or subjectively (Rohleder et al., 2007; Cook and Crewther, 2012; Robazza et al., 2012). Therefore, in this study we first aimed to investigate the cortisol—performance relationship in a controlled setting, combining a standardized performance task and a standardized anxiety induction. The standardized performance task was the second serve in tennis. In tennis this stroke is not influenced by the opponent and puts pressure on the server because the ball must land in the opponent's service box or the server will lose the point immediately. The standardized anxiety induction was an arithmetic task. We did not make specific predictions regarding the relationship between cortisol and performance that could be expected from our design, due to the contradictory findings identified earlier.

Another concern in recent research is that the added value of measuring cortisol to predict performance in comparison to subjectively measuring anxiety has not yet been explored (Passelergue et al., 1995; Doan et al., 2007; Robazza et al., 2012). So far, studies have focused on correlations between subscales of the Competitive State Anxiety Inventory-2 (CSAI-2) and cortisol measurements before competitions, stating different results. In the golf study a significant positive correlation between the somatic anxiety subscale and cortisol was found (Doan et al., 2007), whereas in a judo and a tennis competition significant positive relationships between cortisol and cognitive anxiety were additionally reported (judo: Filaire et al., 2001; tennis: Filaire et al., 2009). Since subjective anxiety measures such as the CSAI-2 have consistently been found to influence performance (Craft et al., 2003) and have been shown to correlate with salivary cortisol (Filaire et al., 2001; Doan et al., 2007; Filaire et al., 2009), our second aim was to investigate if cortisol predicts unique variance in performance beyond a subjective anxiety measure. Consequently, we successively tested in an explorative fashion the amount of unique variance predicted by cortisol and by a subjective anxiety measure. Due to the absence of studies addressing this aspect no specific predictions regarding this second aim are formulated.

2. Materials and methods

2.1. Participants

Twenty-three regional tennis players (13 males, 10 females, $M_{age} = 24.04 \pm 4.76$ years, age range 16—36 years) participated in the study. They all had at least 7 years of competitive tennis experience ($M_{experience} = 15.44 \pm 4.67$ years, experience range 7—27 years). Prior to data collection the athletes (and the parents of athletes under the age of 18) signed an informed consent form, following requirements of the Declaration of Helsinki. Participants were all nonsmokers. They were not on any medication and did not abuse drugs. Further, they had no history of endocrine disorders.