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## **ABSTRACT**

The sporting environment is a stress eliciting in that it encapsulates perceived uncontrollability, unpredictability and requires ego involvement. The HPA axis has been shown (indicated by cortisol release) to respond to anticipated sport competition up to a week prior to the event. Research also alludes to the importance of individual differences such as optimism and trait perfectionism in moderating the impact of cortisol upon performance. 41 (male n = 27) national (n=38) and international (n=3) swimmers were recruited from North-East England and Australia. Swimmers completed a measure of resilience and also provided buccal saliva swabs from which total cortisol release prior to and during the event was calculated. Findings include that resilience significantly predicted performance and the influence of AUC (cortisol release) upon performance was moderated by resilience. These Findings suggest that resilience can influence sport performance either directly or indirectly through appraisal (interpretation of the stressor to be facilitative and non-threatening).

*Key words:* performance, swimming, competition, stress, psychophysiology, appraisals.

## **INTRODUCTION**

The stress response involves a complex signalling pathway among neurons and somatic cells. The hypothalamic-pituitary-adrenal (HPA) axis is one of the physiological systems involved in this response and its activation results in the secretion of several hormones including cortisol (for an overview, see Ehrlenspiel & Strahler, 2012). Cortisol is a primary glucocorticoid hormone and is essential for maintaining homeostatic metabolism and glucose regulation (Munk, Guyre & Holbrook, 1984). However, consistently elevated cortisol levels are characteristic of an ongoing perceived threat and can have several negative

outcomes e.g., immunosuppression (Dickerson & Kemeny, 2004). Cortisol secretion typically follows a relatively stable diurnal circadian rhythm in that levels of the hormone reach a peak level around one hour after awakening and then decrease throughout the day, with virtually undetectable levels at midnight (Debono, Ghobadi, Rostami-Hodjegan, et al., 2009).

Despite its relative stability over time, the Cortisol Awakening Response (CAR) can be used as a measure for the acute reactivity of the HPA axis (Schmidt-Reinwald, Pruessner & Hellhammer, 1999). On a physiological level, CAR reflects the psychological anticipation of the demands of the respective day and typically, higher anticipated demands lead to a more pronounced CAR. Thorn, Hucklebridge, Evans, and Clow (2009), for example, report a correlation between day-to-day changes in self-reported psychological (state) arousal and CAR. A latent-state-trait model also showed that in addition to its trait characteristic, the CAR also incorporates a high occasion specificity (Hellhammer, Wust & Kudielka, 2009). Therefore, cortisol has been utilised as a biomarker for situation specific stress.

Sport is a competitive and stress eliciting arena (Rohleder, Beulen, Chen, Wolf & Kirschbaum, 2007) in that it encapsulates perceived uncontrollability (competitors, external factors), unpredictability and requires ego involvement (Biondi & Picardi, 1999). The anticipation of a sporting event can bring about an elevation in cortisol levels as much as a week prior to the event (Bonifazi, Sardella & Lupo, 2000; Filaire, Duche, Lac, et al., 1996; Filaire, Alix, Ferrand, et al., 2009). A framework proposed by Frankenhaeuser (1991) highlights the moderating influence of individual differences (such as appraisals of challenging situations) and social support are important in determining emotional and physiological responses to stress. Research that examines these differences in 'event' appraisal is necessary to better understand performance on a psychophysiological level.

Relatively few research studies have attempted to explain individual differences in hormonal changes from the measurement of psychological variables (Quested, Bosch, Burns, Cumming, Ntoumanis & Duda, 2011).

One study, by Wirtz, Elsenbruch, Emini, Rudisuli, Groessbauer & Ehlert (2007), found negative trait perfectionism to be associated with more pronounced cortisol responses to the Trier Social Stress Test. Moreover, positive psychological traits such as dispositional optimism (a tendency to expect life outcomes and future events to be positive) have been found to moderate the potential negative impact of stress (heightened cortisol levels) upon autoimmune functioning (Cohen, Kearney, Zegans, Kemeny, Neuhaus & Stites, 1999). Moreover, research has noted a significant, inverse relationship between self-efficacy and cortisol response to a physical exercise task in both trained and untrained males (Rudolph & McAuley, 1995).

Indeed, situational factors also play an important role in responses to stress. To this end, Hogue, Fry, Fry & Pressman (2013) manipulated goal achievement orientations and found that those exposed to ego orientated environments (normative performance indications were provided) typically experienced a more pronounced increase in cortisol levels than those who were provided with task development orientated feedback. Moreover, the task orientated experimental group reported higher perceived enjoyment, effort, self-confidence and interest in engaging with tasks in the future.

One psychological feature that has important theoretical relationships within the context of stress is resilience. A particularly fruitful model proposed by Martin & Marsh (2006) conceptualises resilience in an academic setting. The model emphasises the importance of self-belief, a sense of control, low anxiety (composure) and persistence

(commitment) as characteristics of resilience. In summary, the two characteristics of resilience are that a) some significant level of adversity and pressure is experienced and b) the individual is still able to experience positive outcomes, i.e., successful performance (Fletcher & Sarkar, 2013).

Resilience appears to manifest at a physiological, cognitive, affective and behavioural level. However, the physiological correlates of resilience, particularly an important biomarker i.e. cortisol, are yet to be satisfactorily tested. This study therefore investigated the relationship between the cortisol awakening response and resilience in a group of highly trained, high performing swimmers. In line with research evidence (Filaire et al., 2009), it was expected that participation in competition would lead to a significant increase in acute salivary cortisol concentrations (from baseline), but that total cortisol release over the competition race would be higher for the poorest performers and those with lower self-reported scores of resilience. It was also expected that resilience would moderate the potential detrimental impact of high cortisol levels upon performance.

## **METHOD**

### **Participants**

Participants were recruited from North-Eastern English and Australian swimming clubs. Forty-one competitive (male  $n=27$ ) swimmers ( $M_{\text{age}} = 15.2$  years) ranging from national ( $n=38$ ) to international ( $n=3$ ) standard took part in the study. The amount ( $M_{\text{hours}} = 32.4$ ,  $S.D. = 1.34$ ) and intensity of training leading up to the competition was similar for each participant, as these variables can influence cortisol levels (Bonifazi et al., 2000). Prior to taking part in the study, all participants were informed of their right to withdraw, provided informed consent and ethical clearance was awarded by the University Ethics Committee.

Participants were free of any medication, were non-smokers and had no history of endocrine disorders.

## **Measures**

Resilience.

The Academic Resilience Scale (Martin & Marsh, 2006) was adapted to suit the sporting context. Participants were required to respond to 6 items, such as “I don’t let a bad swim/performance effect my confidence” anchored by a 7 point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree. Support for the factorial validity of the measure is reported by Martin & Marsh (2006).

Cortisol.

*Saliva testing protocol.* Swimmers were invited to provide saliva swab samples (in a private room on poolside) at 8.00am, 8.30am and 9.00am (both on the competitive day and before a low intensity, tapered training session one week prior to the event). The swim event occurred between 10am-11am for each swimmer. The sampling procedure was conducted in this way to lessen the effect of the circadian diurnal rhythm upon cortisol levels (Refinetti, 2006).

*Collection.* To represent the unbound serum levels of cortisol, saliva samples (salivary cortisol level is a non-invasive and reliable marker of HPA activity; Hellhammer, Wust & Kudielka, 2009) were collected (producing a volume of 1-3 ml for each sample). Saliva sampling is an accurate measure of serum levels (the biological active fraction; Mendel, 1992; Pearson-Murphy, 2000) correlations between the two values are highly significant,  $r(47) = 0.91$ ,  $p < 0.0001$  (Ellenbogen, Santo, Linnen, Walker & Hodgins, 2010). Participants, received instruction on salivation before each sampling stage (chew on the salivette swab for sixty seconds and place it into the plastic tube) and were requested to refrain from consuming any drinks or food other than water up to 1 hour prior to sampling. Participant-administered

samples are a reliable method of sampling when clear, concise instructions are provided and the individual has had prior practice (Hanson & Chen, 2010).

*Assaying.* Samples were stored at around  $-30^{\circ}$  Celsius and were subsequently thawed and centrifuged to separate the mucins prior to analysis. Salivary cortisol levels were produced in duplicate (nanograms per milliliter) by using commercial enzyme-linked immunosorbent assay (ELISA) kits (Salivary Cortisol ELISA, SLV-2930, DRG Instruments GmbH, Germany) with a sensitivity of 0.537 ng/ml, intra-assay variation of 1.80% ( $M = 12.79$  ng/ml) and inter-assay variation of 7.16% ( $M = 23.29$  ng/ml). All samples were assayed in the same session to avoid the confounding influence of different testing procedures and environment.

*Cortisol calculations.* The Cortisol Awakening Response was indexed via calculating Area Under the Curve (AUC) utilising trapezoid formulae (Pruessner, Kirschbaum, Meinlschmid & Hellhammer, 2003). The baseline AUC score (the first four saliva samples) was then subtracted from the competition AUC index (four competition samples), in order to represent the difference in total cortisol release on the day of competition, compared to the individuals' own resting state (baseline measurement).

Performance.

Participants performed a 100m sprint event at a National level competition in their respective countries. Performance was calculated by subtracting personal best time from the time swum in the measured competitive event, in order to provide a relative performance index.

## **Procedures**

Participants refrained from consuming food or caffeine one hour prior to sampling (Kudielka, Hellhammer & Wüstb, 2008). The saliva sampling protocol took place on two occasions: one week prior to the event and on the day of the actual event (see saliva testing

protocol). Half an hour prior to the swim event, participants also completed the survey package containing self-report questionnaires. Participants also provided responses (on a Likert scale from 1-9) to measures of perceived importance and satisfaction (Kuczka & Treasure, 2005) following the competitive swim. These state variables have been shown to influence cortisol release (all participants reported that they were either mostly or completely satisfied with their performance and perceived it to be a very important event). Moreover, female participants were asked to report their stage of the menstrual cycle (this was found to not significantly correlate with cortisol production:  $r=0.12$ ,  $p>0.05$  and therefore the female and male samples were dealt with as a combined sample in subsequent analyses).

### **Data analyses**

The descriptive data (Table 1) demonstrated adequate skewness and kurtosis values and therefore normality was assumed. Pearson's Correlation Coefficient identified significant relationships (those that were stronger than 0.3 were considered; ref) between CAR (baseline and competition AUC), resilience and swimming performance. Furthermore, a one-way repeated measures ANOVA was performed to determine the change in cortisol level from basal to pre-competitive measurements.

### **Focal analysis**

Resilience and the cortisol index (competition AUC) were regressed onto performance scores. Gender, age, perceived satisfaction and importance were entered as control variables in order to eliminate the influence of these variables. The control variables were entered on Step 1. The main effect variables were entered on Step 2 (and zero-centred to test interactions on subsequent steps; Aiken & West, 1991). On Step 3, the two-way interaction term was entered (resilience x AUC).

## **RESULTS**

Baseline cortisol levels were in the normal range (Dorn, Lucke, Loucks & Berga, 2007). There was a significant difference in cortisol level between participants' resting baseline concentration and their pre-competitive levels ( $F(1, 40) = 84.29, P < 0.001, \eta = 0.33$ ). It was therefore assumed that the competitive event was perceived with sufficient stress intensity in order to create a significant anticipatory rise in cortisol.

Table 1: Correlation matrix

### **Moderated Hierarchical regression analysis**

The regression analysis showed that step one did not add significant variance to the model. At step 2 Cortisol ( $\beta = -.291; p = .04$ ) and Resilience ( $\beta = .432; P = .003$ ) added 21% to the model. Increased difference in cortisol between baseline and competition was associated with poorer performance and greater levels of resilience with improved performance. There was also a significant increase in variance explained in the third step (Cortisol x Resilience). This step explained an additional 12% of the variance ( $\beta = -.403; P = 0.009$ ).

Figure one demonstrates that the best performers were most resilient and had the lowest levels of cortisol.

Figure 1: Resilience X AUC interaction

## **DISCUSSION**

The present study investigated the association between cortisol concentration (neuroendocrine stress response) self-reported trait resilience scores and swimming performance. As expected, the competition event generated significant cortisol increases for the swimmers and therefore the sporting event was characterised as stressful (Filaire et al., 2009). Some research studies have suggested that habituation (the cortisol response to stress

reduces as exposure to that stressor becomes familiar) occurs rapidly for competitive athletes, as they are exposed to competition regularly. However, the swimmers' appraisal of the competition as important is likely to have contributed to the notable increase in cortisol (all swimmers reported scores of 6+ on a 1-7 likert scale of perceived importance). Expectedly, the data also demonstrated that resilience was significantly, positively associated with performance, i.e., those reporting greater resilience performed best in the competitive swim event.

Further analysis revealed an interaction between resilience and cortisol secretion (AUC). The influence of AUC upon performance was moderated by resilience. This effect suggested that the most successful performers self-reported high levels of resilience and had a reduced cortisol response to competition. This finding suggests that resilience can influence performance directly and indirectly through appraisal.

Those swimmers who had relatively lower levels of resilience and a reduced response to competition performed the poorest. A blunted cortisol response (an ability to respond sufficiently to stress) is perhaps typical of an inability to rebound from failures and manage competition stress. Perhaps more surprisingly, in those swimmers with a pronounced physiological response to the competitive event, higher levels of resilience were associated with poorer performance than those with lower levels of resilience. One possible explanation for this finding is that there is another moderating variable that influences performance (that hasn't been assessed in the current study e.g., emotions). In that, if an individual perceives an event to be a threat, they will experience negative emotions but possess resilience, i.e., they are able to experience a more positive outcome at a difficult time (one characterised by negative emotions). Future research could examine the interaction between resilience, emotions and physiological response is necessary to substantiate this claim.

Another possible explanation for this interaction is that the influence of psychological variables becomes less prominent in times of extreme physiological stress (indicated by cortisol level). So in those who respond moderately to stress (those in the low cortisol category), being psychologically resilient (the perception that one can rebound from failure) is adaptive for performance. In a sense, this finding concurs with relatively recent catastrophe theories (Hardy et al., 1994); this suggests that an individual can manage physiological stress up to an optimum or 'critical' point (their maximum stress threshold) and up to this point, psychological variables and strategies will mitigate any negative impact upon performance. However, beyond this point, the individual is overwhelmed by the event and psychological factors are no longer relevant or able to manage to perceived demand. Future research may wish to examine inter-individual differences in cortisol response, resilience and performance across several competitions in order to further explore this suggestion.

Resilience or psychological recovery from failures is particularly important in a sport such as swimming as competitors typically swim more than one race in a single competition session. A grounded theory model of resilience (Fletcher & Sarkar, 2013) found that athletes commonly reported meta-cognitions as central to resilience, i.e., an awareness of one's own cognitions and an ability to appraise them in a way that is facilitative for future behaviour (e.g., an athlete has a poor performance, initially appraises this negatively but later uses the experience to motivate them to train harder). Perhaps future research may wish to examine the nature of these meta-cognitions, along with measures of pre-competitive anticipation (emotions) and post-event attributions (the cognitive appraisal of event outcomes) and their relationship with cortisol secretion and performance.

We acknowledge the heterogeneous sample of swimmers included in this study, meaning that generalisations cannot be made beyond this population. This approach was chosen as concentrations of hormones can be dependent upon the sport, i.e., amount and type

of physical exertion required, number of unpredictable/ uncontrollable variables, standard and importance of competition. Having said this, the current study is the first to consider resilience and its relationship with cortisol patterning and swimming performance. It should also be noted that hormones rarely operate in isolation. Indeed, there are agonist and antagonist hormones, e.g., dehydroepiandrosterone and allopregnanolone (both neuroactive steroids) that dampen the effect of cortisol post-stress (Charney, 2004). Perhaps future research could consider more comprehensive profiles of hormonal levels as biological markers of psychological functioning (Jimenez, Aguiler & Alvero-Cruz, 2012). It is important to understand the nature of such relationships in order to strengthen theoretical understanding of resilience and develop more objective markers for the construct.

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