Changes in Psychological Anxiety and Physiological Stress Hormones in Korea National Shooters

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Abstract

Background: Psychological and physiological management is closely related to the athlete's performance, especially the shooting competition. Thus, we aimed to investigate the changes of psychological anxiety and physiological stress hormones immediately before the shooting competition in Korea National shooters.

Methods: Seventy-two Korea National Shooting athletes (Rifle = 62, Pistol = 8, Shotgun = 2) were recruited for the present study. The physiological stress hormones state was assessed based on saliva cortisol level, salivary immunoglobulin A level. The psychological stress state was assessed based on Beck anxiety inventory questionnaire.

Results: Significant higher cortisol concentration ($p < .05$) and cortisol secretion rate ($p < .05$) were in severe anxiety group. No significant SIgA concentration and SIgA secretion rate in among the groups. A positive correlation was found between BAI score and cortisol concentration ($p < .05$).

Conclusions: This study indicates that changes of psychological anxiety and physiological stress hormones immediately before the shooting competition in Korea National shooters. Therefore, these findings provide preliminary evidence indicating that the psychological anxiety affects physiological stress, therefore negative effect on athletes' performance. Thus, research is needed to build a strategy to reduce physiological stress.

Background

Shooting is a type of sport assumed to be sensitive to psychological tension and anxiety pressure [1]. This sport athlete needs attentional control to focus on skill execution and prevent distracting thoughts from impairing performance [2]. Therefore, psychological and physiological control is important for improving shooting performance.

The Beck Anxiety Inventory (BAI) is widely used for a prominent screening and outcome research tool for measuring the psychological anxiety [3]. Identified two factors for the BAI: somatic and subjective anxiety/panic by Beck et al. [4]. It is a 21-item self-report inventory designed to assess the severity of anxiety symptoms in adults and adolescents [5]. Previous studies reported that 150 runners' BAI anxiety scores positively correlated with distress [6], and a negative significant relationship was also demonstrated between the athletes' competitive anxiety level, and their athletic experiences [7].

In addition, higher BAI scores were associated with impaired physical performance [8]. This is the reason why mental and emotional states (i.e., anxiety states) directly affect the autonomic nervous system [9]. Anxiety is a stress on elite shooters. Stress is defined as a state of threatened homeostasis following exposure to extrinsic or intrinsic adverse forces [10]. Continuing and excessive stress causes instability in the body's homeostasis, cardiovascular system, musculoskeletal response, emotional stability, and

immune function [11]. In physiological as well known two components of stress response - salivary cortisol and secretory immunoglobulin A (SIgA) - have been proposed [12–14].

Previous studies reported that concentrations of salivary cortisol and SIgA were significantly increased immediately after a competitive 5,000 m race [15]. The SIgA concentrations in volleyball players were significantly lower compared with those in sedentary controls, and the salivary cortisol concentrations in volleyball players were markedly higher compared with those in sedentary controls [16].

Therefore, psychological and physiological management is closely related to the athlete's performance, especially the shooting competition. However, research on psychological anxiety and physiological stress of shooting athletes is insufficient. Thus, we aimed to investigate the changes of psychological anxiety and physiological stress hormones immediately before the shooting competition in Korea National shooters.

Methods

Participants

Seventy-two Korea National Shooting athletes (Rifle = 62, Pistol = 8, Shotgun = 2) were recruited for the present study. Those with one or more of the following criteria were excluded for measure stress through saliva: Those with one or more of the following criteria were excluded: (1) heart, lung or metabolic disorders, (2) diagnosed with major depression and bipolar disorder, and schizophrenia (DSM-IV) within the past one year, (3) within the last three months there are mental symptoms such as anxiety and agitation, (4) have a musculoskeletal disorder that does not safely participate in shooting competitions.

All subjects who agreed to participate in the study had the study explained to them to ensure a complete understanding of its purpose and the methods used with the ethical standard of the Declaration of Helsinki. The subjects also signed an informed consent form before participation. This study was approved by This study was approved by the Institutional Review Board at Korea Institute of Sport Science, Seoul, South Korea (KISS-1906-016-01).

Beck Anxiety Inventory (BAI) Questionnaire

Subjects completed the Beck Anxiety Inventory (BAI). The BAI is a 21-item self-report inventory for assessing severity of clinical anxiety [4]. Subjects rate each item on a 4-point scale ranging from 0 ("Not at all") to 3 ("I could barely stand it") with regard to their anxiety-related symptoms during the past week. The BAI is scored by summing the severity ratings across all 21 items; total scores can range from 0–63. Scores were classified as follows: of 0–9, no anxiety; 10–19, mild anxiety; 20–29, moderate anxiety; over 30, severe anxiety. Internal consistency and test-retest reliability of the Korean BAI have been reported as 0.91–0.93 and $r=0.84$, respectively [17, 18].

Saliva collection

Saliva samples were collected by the method of a previous study [19]. Participants sat and rinsed their mouths with distilled water for 30 s three times and then rested for 5 min. Saliva production was stimulated by chewing a sterile cotton (Salivette; Sersted, Vümbrecht, Germany) at a frequency of 60 cycles per min. Obtained saliva samples were separated from the cotton by centrifugation at 3,500 rpm for 10 min. We measured this saliva volume secreted by chewing for 1 min and expressed as saliva flow rate (mL/min). After measurement of the sample volume, saliva samples were frozen at -50 °C and stored until the end of the study period.

Stress hormones determination

Salivary stress hormones that cortisol and SIgA were obtained immediately before the competition. Saliva volume was estimated assuming saliva density to be 1.00 g·mL⁻¹ [20], and saliva flow rate was calculated from saliva volume and collection time. The salivary stress hormones concentration was determined in duplicate by sandwich enzyme-linked immunosorbent assay (ELISA), the within assay coefficient of variation being 2.8±3.5%.

For analysis of stress hormones levels, data were expressed in two forms: (a) absolute concentration of cortisol and SIgA (µg/ml); (b) stress hormones secretion rate (ml/min), or the total amount of stress hormones appearing on the mucosal surface per unit time. Stress hormones secretion rate was calculated by multiplying absolute stress hormones concentration (µg/ml) by saliva flow rate (ml/min), which was calculated by dividing the total volume of saliva obtained in each sample (ml) by the time taken to produce the saliva sample (minutes) [21].

Statistical analysis

The SPSS statistical package version 25.0 for Windows (SPSS, Inc., Chicago, IL, USA) was used to perform all statistical evaluations. Means and standard deviations were computed for all variables, and normality was checked with the Shapiro Wilk test. Non-normal data were converted using square root (saliva flow rate) or logarithmic (concentration and secretion rate of stress hormones) transformations which achieved normality for all variables. Stress hormones by level of anxiety was verified through a one-way analysis of variance (ANOVA). Correlation analysis and a step-wise multiple regression analysis were conducted to examine the effect of the level of stress hormones on anxiety. Post-hoc analysis (Tukey HSD test) was used to compare specific differences when significance was found. Statistical significance was accepted at the 0.05 level.

Results

Cortisol due to BAI Anxiety

The cortisol concentration and secretion rate according to BAI anxiety are presented in Figure 1 and Figure 2. Saliva flow rate was 3.02 ± 0.29 ml/min. One-way ANOVA revealed significant higher cortisol

concentration in severe anxiety group ($p<.05$). Cortisol secretion rate was also significant higher in severe anxiety group more than moderate anxiety group ($p<.05$).

SIgA due to BAI Anxiety

The SIgA concentration and secretion rate according to BAI anxiety are presented in Figure 3 and Figure 4. Saliva flow rate was 3.02 ± 0.29 ml/min. One-way ANOVA revealed did not significant SIgA concentration in among the groups. SIgA secretion rate was also did not significant in among the groups.

Correlations coefficients between the BAI score and the stress hormones

Table 2 shows the correlation coefficients of the BAI score and the stress hormones. A positive correlation was found between BAI score and cortisol concentration ($p<.05$). And positive correlations were found between concentration and secretion rate in both stress hormones ($p<.01$; $p<.01$, respectively).

Multiple regression analysis between BAI anxiety and cortisol concentration

Subsequently, a multiple regression analysis was conducted based on the above correlations. These results are presented in Table 3. As indicated in Table 3, there was a significant relationship between shooting athletes' BAI anxiety and cortisol concentration ($p<.05$). Thus, shooting athletes' anxiety is suggested to increase cortisol of stress hormone.

Discussion

The present study, we investigated the changes of psychological anxiety and physiological stress hormones immediately before the shooting competition in Korea National shooters. The main finding of the study that significant higher cortisol concentration and cortisol secretion rate were significant higher in severe anxiety group more than moderate anxiety group. In addition, a positive correlation was found between BAI score and cortisol concentration.

Statistically significant associations are also seen between sports psychological abilities and different measures of mood in athletes [22]. Among the most relevant psychological signs associated with sports performance is competitive state anxiety, which must be improve the process of adaptation to competition [23]. Cause by higher anxiety in athletes can be detrimental in these performance situations [24]. Ngo et al. reported that athletes with lower levels of anxiety get better results in competitions while individuals with high levels of anxiety obtain worse results [25]. Romyn et al. shown that athletes' anxiety increased before 7-day training week and a 7-day competitive tournament [26]. Present study demonstration that BAI anxiety state of athletes, mild anxiety was 12 athletes, moderate anxiety was 21 athletes, and severe anxiety was 39 athletes according to immediately before the competition. 54.17% athletes were got a severe anxiety at immediately before the competition. In particular, shooting competitions are individual sports that require high concentration. Individual sport athletes are more likely to report anxiety and depression than team sport athletes [27]. Moreover, in this study reported that severe anxiety group was higher cortisol concentration level and secretion rate more than other groups. Levels of

state-anxiety and trait-anxiety are positively and directly related in both types of sports, although it is more stressed in individual sports.

Cortisol and SIgA are steroid hormones that change in response to psychological and physical stress [28]. An increase in cortisol is associated with relatively intense psychological [29]. Higher SIgA is associated with mental state [30]. Positive correlation between psychological stress and cortisol levels and negative association between psychological stress and SIgA levels [31]. Oshima et al reported acute physiological training stress was observed an increase in plasma resting cortisol concentration [32]. He et al. reported that significant decreases in secretion rates concentrations of slgA was observed at times of intense training and competition [33]. Intensive training in combination with rapid weight changes affects the increased of SIgA and cortisol stress response of the elite female taekwondo athletes [34]. In this study observed that significantly increased cortisol concentration and secretion rate levels in severe anxiety group more than moderate and mild anxiety groups. However, no significantly in SIgA concentration and secretion rate levels in among the groups. Perceived stress in humans activates the central nervous system (CNS), releasing corticotropin-releasing hormone (CRH) from the hypothalamus, adrenal corticotrophic hormone (ACTH) in the anterior pituitary gland, and cortisol in the adrenal cortex [35]. The entire hypothalamus-pituitary-adrenal system is designed to allow organisms to adapt to physical, mental and social changes in their environment [35]. These results suggest that immediately before the competition stress may be involved in the release physiological stress hormone of cortisol. In additional, result of positive correlations between the BAI anxiety and cortisol concentration levels, and multiple regression analysis was a significant relationship between shooting athletes' BAI anxiety and cortisol concentration.

Previous studies about SIgA is unclear. No changes were observed for SIgA measurements before the Jiu-Jitsu matches [36]. A significant increase was observed during competition in slgA and cortisol, results demonstrate that performance in major competition induces a stress response in athletes [37]. In this study no significantly in SIgA concentration and secretion rate levels in among the groups, however, moderate anxiety group is higher than severe anxiety group. But the elevated stress response observed, modifications to individual postrace recovery protocols may be required to enable athletes to maximize performance across all days of competition [37].

The present study has some limitations and points to suggestions for further research. We did not control such factors as social stress and addictive activity. We assumed that because the subject lived a monotonous life for several years, there was no significant difference in social stress and addictive activities. Another limitation is that the small number of subjects included could limit the statistical power of the result, and further studies with larger populations are required to validate our findings. Last one is about change of SIgA. Further research on SIgA changes is needed.

Conclusion

In conclusion, this study indicates that changes of psychological anxiety and physiological stress hormones immediately before the shooting competition in Korea National shooters. In addition, higher cortisol concentration and cortisol secretion rate were significant higher in severe anxiety group more than moderate anxiety group. Moreover, positive correlations between the BAI anxiety and cortisol concentration levels, and multiple regression analysis was a significant relationship between shooting athletes' BAI anxiety and cortisol concentration.

Therefore, these finding provide preliminary evidence indicating that the psychological anxiety affective physiological stress, therefore negative effect on athletes' performance. Thus, research is needed to build a strategy to reduce physiological stress.

Declarations

Acknowledgments

We thank all the study participants and staff for their assistance.

Authors' contributions

Sang-Hyuk Park and Eunjae Lee contributed to conception and design of the study.

Sang-Hyuk Park and Seung-Taek Lim implemented the measurements. Sang-Hyuk Park and Eunjae Lee analysed the participant data. All authors interpreted and discussed the results. All authors drafted parts of the manuscript. All authors read and approved the final manuscript

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Availability of data and materials

Full data for this research is available through the corresponding author upon request.

Ethics approval and consent to participate

The study was approved by Korea Institute of Sport Science Review Board, and conducted in agreement with the Declaration of Helsinki. In advance of their participation, all of the participants were fully informed about the purpose and experimental procedures of the study. All of the participants completed consent forms. The participants were informed that all data collected would be processed anonymously.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1
The characteristic of the subjects

Variable	Rifle athletes (n = 62)	Pistol athletes (n = 8)	Shotgun athletes (n = 2)	Total (n = 72)
Male (n)	18	6	0	24
Female (n)	44	2	2	48
Age (years)	23.68 ± 4.64	20.00 ± 1.51	26.00 ± 0.00	23.33 ± 4.50
Careers (years)	11.74 ± 4.58	7.75 ± 1.58	7.00 ± 0.00	11.17 ± 4.51

Table 2
Correlations coefficients between the BAI score and the stress hormones

Variable	BAI score	CC	SC	CSR	SSR
BAI score	-				
CC	.248*	-			
SC	.109	.044	-		
CSR	.220	.988**	.013	-	
SSR	.081	.063	.987**	.040	-
BAI, beck anxiety inventory; CC, cortisol concentration; SC, SIgA concentration; CSR, cortisol secretion rate; SSR, SIgA secretion rate					
*: $p < .05$, **: $p < .01$					

Table 3
Multiple regression analysis between BAI anxiety and cortisol concentration

Dependent variable	Independent variable	R ²	R ² C	β	F-value
BAI anxiety	Cortisol	.061	.061	-.248	4.583*
* $p < .05$					

Figures

Figure 1

The comparison of cortisol concentration according to BAI anxiety * $p < .05$

Figure 2

The comparison of cortisol secretion rate according to BAI anxiety * $p < .05$

Figure 3

The comparison of SIgA concentration according to BAI anxiety

Figure 4

The comparison of SIgA secretion rate according to BAI anxiety