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REGULAR ARTICLE

Stress hormone levels in saliva after shogi competition are modified by stress coping strategies

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Abstract

Objective Using shogi, a representative table game popular in Japan, to model a stress situation, we investigated the modulatory effects of player characteristics on changes in the levels of cortisol and testosterone in the saliva of the players.

Methods Saliva samples were collected at the following time-points: (1) 30 min after awakening on the day of the shogi convention; (2) immediately before the game; (3) immediately after the game; (4) 30 min after the end of game; (5) 30 min after awakening the following morning. The study cohort comprised 90 healthy male university students who were members of a shogi club, who were subsequently classified into either the emotional strategy (Em) or cognitive strategy (Co) group based on their scores on a Lazarus-type stress coping inventory.

Results Cortisol levels were significantly higher in the Em group than in the Co group the morning following the convention, and this difference was not affected by either outcome (victory or defeat) or perception (competitive or noncompetitive) of the match. A similar but non-significant trend was observed for testosterone levels.

Conclusion Our findings suggest that the Em group had a greater capacity to manage the stress from a shogi convention than the Co group.

Keywords Cortisol · Testosterone · Stress coping · Human saliva · Japanese chess (*shogi*)

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Introduction

Stress is a term in psychology and biology that was primarily propounded in a biological context in the 1930s. However, it has more recently become a commonplace of popular parlance. It refers to the consequences of the failure of an organism—either human or animal—to respond appropriately to emotional or physical threats, whether actual or imagined. The characteristics of a stress reaction are unique because the effects of stress are highly individual, with the reaction to different types of stress differing based on individual characteristics and ability.

Lazarus [1] argued that for a psychosocial situation to be stressful, it must be appraised as such by an individual, and that cognitive processes of appraisal are central to determining whether a situation is potentially threatening, constitutes a harm/loss or a challenge, or is benign. Thus, coping with stress involves how we perceive a potentially stressful situation as well as how we conduct ourselves in and resolve that situation. Both personal and environmental factors influence this primary appraisal, which subsequently triggers the selection of coping processes.

Problem-focused coping is directed towards managing the problem, while emotion-focused coping processes are directed at managing negative emotions. Secondary appraisal refers to the evaluation of resources available to cope with the problem and may alter primary appraisal. Therefore, primary appraisal also includes the perception of how stressful a problem is; estimating the availability of more than or less than adequate resources to cope with the problem affects the appraisal of stress. Furthermore, coping is flexible in that the individual generally examines the efficacy of coping in a given situation; if the coping mechanism does not have the desired effect, different strategies will then be implemented [2].

Stress management encompasses techniques intended to equip a person with effective coping mechanisms for dealing with psychological stress, with stress defined as a person's physiological response to an internal or external stimulus that triggers the fight-or-flight response. Stress management is effective when a person uses strategies to cope with or alter stressful situations.

Competition and stress

Numerous confrontational situations occur in nature. Among these, competition involves two or more individuals struggling to master/achieve the same goal and is therefore associated with both winners and losers. The results from previous research indicate that participation in sports and gambling activities induces stress [3, 4]. However, those studies did not investigate the interactions between winners and losers, and how competitive stress triggers physiological symptoms has not been resolved.

McCaul [5] reported that among individuals who participated in a task entirely controlled by chance (coin tossing), the winners were characterized by relatively higher testosterone levels and more positive moods. In another experiment [6] subjects were awarded $100 prizes that depended on a random lottery. Winners in those situations, who won without expending any individual effort, did not show greater subsequent increases in plasma testosterone levels compared to losers. These experiments were conducted in a casual manner and do not necessarily indicate that the derived conclusion reflects a stress reaction.

Real competition, especially that related to sports, has been well researched in psychoneurotic endocrinological studies, although universal agreement on the number of influencing factors has not been reached. For example, the authors of one study reported that testosterone and cortisol levels in blood samples of winning wrestlers increased relative to those in the previous match as compared with those of the losing wrestlers [7]. However, in another study, these levels were found not to differ between winners and losers [8]. The reason for this discrepancy may be related to physical stress caused by participation in the sporting events. In fact, those stress measurements may have been affected by psychological stress induced by competition.

Ultimately, the ability to cope with stress in a competition is an integral part of performing to the best of one's abilities and depends on being able to entirely utilize cognitive and behavioral coping skills to overcome that stress [9, 10].

Shogi (Japanese chess)

Shogi, Japanese chess, is a two-player board game closely related to Western chess, chaturanga, and Chinese Xiangqi. Shogi is the most popular of all chess variants native to Japan. The earliest predecessor of the game, chaturanga, originated in India in the sixth century A.D. and spread from China to Japan, where it spawned a number of variants. Researchers in Japan have recently postulated that human thinking processes can be studied by observing changes in the brain activity of players playing shogi [11]. Playing this game demands a combination of complicated logical prediction to achieve the final goal (winning) and intuition when experiencing a difficult phase of play.

In the study reported here, we studied subjects who participated in shogi to exclude the effects of physical stress from competitive environments and measured testosterone and cortisol levels in saliva samples. The competitiveness of shogi is partly derived from the comparatively long period of play relative to other games/sports, which suggested that it would be an effective environment to investigate psychological stress. In addition, to determine the intensity of the competition, we reviewed the mechanisms in which competitive stress was affected by strategies adopted by players during the competitive aspects of each game to cope with the stress.

Materials and methods

The study cohort comprised 90 healthy male students who were members of the shogi club of Osaka University and participating in the Western Japan Convention hosted by the Kansai Student Shogi Association. None of our subjects smoked tobacco or were under any kind of medication. Forty-one subjects [mean age ± standard error (SE) 21.3 ± 2.7 years] played shogi during the convention (shogi group) and 49 (19.5 ± 2.0 years) watched the games (control group). All students were informed of the purpose and methods of the study, and informed consent was obtained from all subjects prior to enrollment. The study was approved by the ethics committee of the Graduate School of Medicine at the University of Osaka.

Saliva samples were collected on the day of the shogi convention using a 50-mL polypropylene conical tube (Falcon Blue Max; Becton Dickinson, Franklin, NJ) at the following time-points: (1) 30 min after awakening on the day of the shogi convention, (2) immediately before the games, (3) immediately after the games, (4) 30 min after the end of game; a saliva sample was also collected (5) 30 min after awakening the next morning. The subjects were requested to refrain from eating and drinking for at least 2 h before sample collection [12]. The subjects were also asked to drink normally (alcohol) and take their medicine on the day of the shogi convention. The samples were stored at −30°C until assayed. Salivary cortisol levels were determined using an enzyme-linked immunosorbent assay, and testosterone levels were measured by an enzyme immunoassay as previously described [13–15].

We measured and estimated stress coping using a Lazarus-type stress coping inventory (SCI) [16, 17]. The SCI was administered to the 41 subjects (shogi group), and the scores were calculated using the Likert method in the form of 0–2 points on a 64-item questionnaire rating. We calculated scores of cognitive strategy (Co) and emotional strategy (Em) and subsequently rated subjects with Co > Em scores as Co-types and those with Em > Co scores as Em-types. Co-types relied on problem-focused coping and were more likely to accept a challenge and be active in a stressful situation. Em-types relied on emotion-focused coping; this group comprised individuals who could not relieve their stress and were more likely to experience negative feelings to achieve relief in stressful situations [18]. We also asked the subjects to report their game outcome (victory or defeat) and perception of the game situation (competitive or noncompetitive situation) after the game.

Student's *t* test was used to compare the mean difference in each variable between the two groups at each point in the schedule. Analysis of variance with repeated measures was performed to examine temporal differences, and Bonferroni's test was used for multiple comparisons. An alpha level of 5% was used in all the analyses. The statistical program package SPSS ver. 15.0 (SPSS, Chicago, IL) was used for the analysis. All values are expressed as mean ± SE. Statistical significance was two-tailed and set at $p < 0.05$ for all analyses.

Results

In samples collected from shogi competitors immediately after playing the game, there were significant increases in the levels of salivary testosterone (63.8 ± 21.7–73.2 ± 20.9 pg/mL; $p < 0.01$) and cortisol (0.446 ± 0.281–0.800 ± 0.354 μg/dL; $p < 0.05$), although the increased levels were not maintained in the samples taken 30 min later (testosterone and cortisol levels were 63.7 ± 17.2 pg/mL and 0.473 ± 0.251 μg/dL, respectively) [19]. There were no significant changes in the levels of cortisol and testosterone in the control group.

We confirmed overall trends in cortisol and testosterone levels before, during, and after game (Table 1). Both cortisol and testosterone levels increased significantly immediately after the game, but they had returned to pre-game levels by 30 min after the end of game. The saliva cortisol and testosterone levels on the morning following the game were similar to those on the morning of the game day. The samples were then categorized into two subgroups, the Co and Em groups, based on the strategy pattern of the Lazarus type SCI.

Cortisol levels increased significantly immediately after the game compared with before the game in both the Co and Em groups (Co +62%, $p < 0.01$; Em +48%, $p < 0.01$). However, they returned to pre-game levels at 30 min after the end of game in both groups (Co −36%, $p < 0.05$; Em −47%, $p < 0.001$). Analysis of samples taken the morning following the game revealed that the cortisol levels had returned to previous morning values in the Co group but not in the Em group (Co vs. Em, $p < 0.01$). In both the Co and Em groups, testosterone levels increased immediately after the game compared with before the game, but by 30 min after the end of the game, the testosterone levels became significantly lower in the Em group than in the Co group (Co vs. Em, $p < 0.05$). In both groups, the testosterone levels in samples collected the morning following the game were similar to those in the samples taken the morning of the game.

An analysis of cortisol levels in the Co and Em groups, stratified by winning/losing, i.e., on the outcome of the game, was also performed (Table 2). For both winners and losers, cortisol levels had increased significantly immediately after the game compared with before the game and, at 30 min after the end of game, had returned to the pre-game levels. In samples taken the following morning, cortisol levels had decreased significantly in losers of the Co group but not in losers of the Em group (Co vs. Em, $p < 0.05$), and no such a difference was seen for winners. Also in samples taken the following morning, there was a significant difference in cortisol levels between winners and losers of the Co group (winners vs. losers, $p < 0.05$).

Cortisol and testosterone levels in the Co and Em groups stratified by competitive and noncompetitive subgroups were also evaluated based on the questionnaire results (Figs. 1, 2). In samples obtained following a competitive game, cortisol levels 30 min after the end of game did not differ between the Co and Em groups. However, cortisol levels in the samples taken the following morning returned to previous morning

Table 1 Cortisol and testosterone levels of shogi players during and after shogi convention between cognitive and emotional groups

Sample collection time-points	Cortisol levels (μg/dL)			Testosterone levels (pg/mL)		
	Total ($n = 41$)	Cognitive group ($n = 23$)	Emotional group ($n = 18$)	Total ($n = 41$)	Cognitive group ($n = 23$)	Emotional group ($n = 18$)
Upon wakening on the game day	0.238 ± 0.038	0.218 ± 0.051	0.263 ± 0.059	95.0 ± 4.9	97.7 ± 6.3	91.4 ± 7.9
Immediately before the game	0.446 ± 0.044[a]	0.486 ± 0.070[a]	0.395 ± 0.045	63.8 ± 3.4[a]	64.6 ± 3.0[a]	62.7 ± 6.8
Immediately after the game	0.800 ± 0.055[a,b]	0.784 ± 0.080[a,b]	0.820 ± 0.076[a,b]	73.2 ± 3.3[a]	74.9 ± 3.7[a]	71.0 ± 5.9
30 min after the end of game	0.473 ± 0.040[a,c]	0.500 ± 0.061[a,c]	0.437 ± 0.043[c]	63.7 ± 2.7[a]	68.9 ± 2.6[a]*	56.6 ± 4.9*
Upon wakening on the day after the convention	0.314 ± 0.036	0.220 ± 0.035*	0.434 ± 0.057	115.0 ± 8.2	110.7 ± 6.4	120.8 ± 17.5

Values are given as the mean ± standard error (SE)

* $p < 0.05$: difference between cognitive and emotional groups

[a] Different from the value upon wakening on the game day: $p < 0.05$

[b] Different from the value immediately before the game : $p < 0.05$

[c] Different from the value immediately after the game : $p < 0.05$

Table 2 Comparison of cortisol levels during and after shogi convention between winners and losers

Sample collection time-points	Cortisol levels (μg/dL)			
	Winners ($n = 27$)		Losers ($n = 14$)	
	Cognitive group ($n = 16$)	Emotional group ($n = 11$)	Cognitive group ($n = 7$)	Emotional group ($n = 7$)
Upon wakening on the game day	0.207 ± 0.05	0.296 ± 0.082	0.241 ± 0.106	0.212 ± 0.085
Immediately before the game	0.508 ± 0.088	0.409 ± 0.064	0.435 ± 0.116	0.373 ± 0.062
Immediately after the game	0.845 ± 0.106[a,b]	0.888 ± 0.101[a,b]	0.646 ± 0.095[a]	0.714 ± 0.107[a]
30 min after the end of the game	0.542 ± 0.073[a]	0.500 ± 0.063[c]	0.402 ± 0.112	0.348 ± 0.036
Upon wakening on the day after the convention	0.257 ± 0.045[§]	0.432 ± 0.081	0.112 ± 0.027*[§]	0.438 ± 0.073*

Values are given as the mean ± SE

* $p < 0.05$: difference between cognitive and emotional groups; [§] $p < 0.05$: difference between winners and losers

[a] Difference from the value upon wakening on the game day: $p < 0.05$

[b] Difference from the value immediately before the game : $p < 0.05$

[c] Difference from the value immediately after the game : $p < 0.05$

values in the Co group but not in the Em group (Co vs. Em, $p < 0.05$) (Fig. 1). In samples obtained following a noncompetitive game, this difference was not observed.

In samples obtained following a competitive game, testosterone levels 30 min after the end of game decreased larger in the Em group to a greater extent than in the Co group (Co vs. Em, $p < 0.01$) (Fig. 2). In contrast, testosterone levels in samples taken following a noncompetitive game did not show such a difference.

Discussion

The primary finding of our study is that the levels of cortisol in the saliva of the Em group on the morning following the shogi competition were significantly higher than those of the Co group at the same time-point. This difference did not vary by outcome (victory vs. defeat) and by competitive situation (competitive vs. noncompetitive.

Lazarus and Folkman [16] made a basic distinction between the problem-focused and emotion-focused coping categories [20]. These fundamental coping types are based on the intention or function of the coping efforts [21]. Some types (such as subjects in the Em group) adjust to emotion and distress, while others (such as subjects in the Co group) cope with the problem caused by the distress. Based on results from a survey of 967 care attendants, Ashitomi [22] reported that the Em group showed significantly lower psychosomatic health performance, such as GHQ-28 score [23], than the Co group; that is, the Em

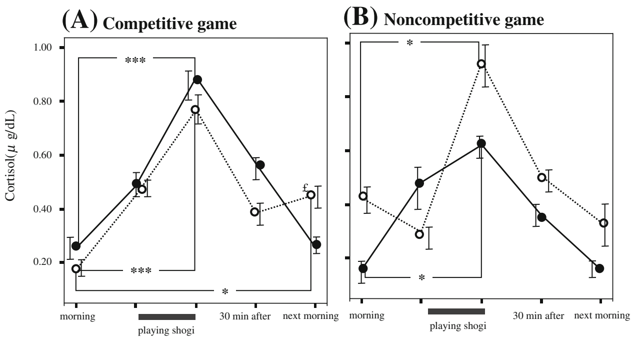

Fig. 1 Mean ± standard error (SE) of cortisol levels (μg/dL) during a shogi convention between competitive ($n = 26$) and noncompetitive groups ($n = 15$) for cognitive (*filled circles*) (competitive, $n = 16$; noncompetitive, $n = 7$) and emotional (*open circles*) (competitive, $n = 10$; noncompetitive, $n = 8$) groups. *Difference from the value upon wakening on the game day, $p < 0.05$; ***difference from the value upon wakening on the game day, $p < 0.001$; £difference between cognitive and emotional groups, $p < 0.05$

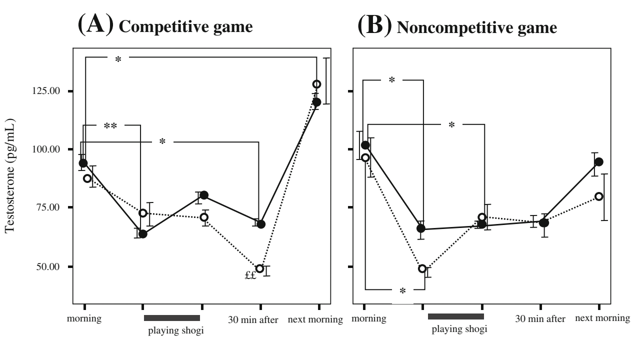

Fig. 2 Mean ± SE of testosterone levels (pg/mL) during shogi convention between competitive ($n = 26$) and noncompetitive groups ($n = 15$) for cognitive (*filled circles*) (competitive, $n = 16$; noncompetitive, $n = 7$) and emotional (*open circles*) (competitive, $n = 10$; noncompetitive, $n = 8$) groups. *Difference from the value upon wakening on the game day, $p < 0.05$; **difference from the value upon wakening on the game day, $p < 0.01$; ££difference between cognitive and emotional groups, $p < 0.01$

group is more likely to feel stress and suffer from persistent stress.

A cortisol response appeared among both winners and losers in both the competitive and noncompetitive situations. This finding is consistent with the results of a previous study showing that there were no differences in cortisol levels in blood samples collected from the winners and losers taken before and after a match involving male judo wrestlers [24]. Other studies on judo matches [24–27], wrestling competitions [7], basketball games [28], and shogi competition [19] also found no significant differences in cortisol responses. Suay et al. [29] researched serum cortisol levels in 26 judo fighters involved in competitions and showed that those subjects who perceived themselves as capable of winning, but ended up losing, showed the greater increase in cortisol levels, relative to pre-competition levels. Furthermore, among the losers, cortisol levels after the competition were correlated positively with their self-efficacy to win. Another study showed that elevated cortisol response is associated with negative mood just after the competition [26].

The second major finding of our study is that testosterone responses were different from cortisol responses in terms of their association with stress-coping strategies. In the competitive game, testosterone levels that increased during shogi competition declined more in the Em group than in the Co group 30 min after the end of game. In one study, male voters who supported a presidential winner had stable testosterone levels, whereas in those who supported a loser, testosterone levels dropped 40 min after the news of election outcome [30]. This study suggests that motivation is a strong driver of testosterone levels. Therefore, within the framework of our study, we assume that the post-game motivation decreased more in the Em group than in the Co group.

There are several limitations to our study. This results of this study may depend on other confounding factors, such as the length of each shogi competition, how experienced the subjects are, their expectations of winning, self-efficacy, among others. Additionally, age has not yet been studied, and gender has only begun to be considered in recent years.

In conclusion, saliva stress hormone levels after a shogi competition may be modified by the strategy adopted to cope with stress. Our findings suggest that people adopting an emotional strategy have a greater tendency to sustain the stress of shogi competition than those with adopting a cognitive strategy.

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