Changes in salivary physiological stress markers associated with winning and losing

Masako HASEGAWA, Masahiro TODA and Kanehisa MORIMOTO

Department of Social and Environmental Medicine, Osaka University Graduate School of Medicine, Osaka, Japan

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ABSTRACT

Using a representative table game popular in Japan known as *shogi*, or Japanese chess, we investigated the effects of winning and losing on saliva composition. The subjects were 90 healthy male university students who were members of a *shogi* club. Saliva samples were collected immediately before and after playing *shogi*, and again 30 min later. Salivary cortisol and testosterone levels in the samples were determined by ELISA and EIA, respectively. After finishing each game, the competitiveness of the game was evaluated using questionnaires. In the samples taken after playing *shogi*, there was an increase in the levels of salivary testosterone and cortisol, regardless of whether the subject won or lost, and the tendency was more pronounced in competitive games. There were no such changes in the control group, who did not play a game prior to providing the samples. Our results suggest that stress response is intimately linked with competition and could be used to determine which players are more capable of handling stress in a competitive environment.

There are a number of confrontational situations that occur in nature. Of those, competition involves two or more individuals struggling for mastery while attempting to achieve the same goal. Thus, along with winners there are also losers. Previous research indicates that sports and gambling participation induce stress (3, 14). However, those studies did not investigate the interactions between winners and losers, and how competitive stress triggers physiological symptoms has not been revealed.

McCaul (13) reported greater increases of testosterone in saliva and more positive moods in winners than losers among individuals who participated in a task entirely controlled by chance (coin tossing). In another experiment (11), subjects were awarded

\$100 prizes depending on a random lottery. Winners in those situations, who won without any effort of their own, did not show subsequent testosterone increases in blood that were greater than those of the losers. These experiments, conducted in a casual manner, do not necessarily indicate that the derived conclusion reflects stress reaction.

Real competition, especially related to sports, has been well researched in psychoneurotic endocrinological studies, though universal agreement on a number of factors has not been reached. For example, one study reported that levels of testosterone and cortisol in blood samples from winning wrestlers rose higher above the level of the previous match as compared to the losing wrestlers (15), whereas another study reported that those levels were not different between winners and losers (5). The reason for this discrepancy may be related to physical stress caused by participation in sporting events. In fact, those stress measurements may have been affected by psychological stress induced by competition.

Address correspondence to: Prof. Kanehisa Morimoto
Department of Social and Environmental Medicine,
Osaka University Graduate School of Medicine, 2-2
Yamada-Oka, Suita, Osaka 565-0871, Japan
Tel: +81-6-6879-3920, Fax: +81-6-6879-3929
E-mail: morimoto@envi.med.osaka-u.ac.jp

In the present investigation, we studied subjects who participated in a table game popular in Japan known as *shogi*, or Japanese chess, in order to exclude the effects of physical stress from the environment of competition, and measured the levels of testosterone and cortisol in saliva samples. The competitiveness of *shogi* is partly derived from its comparatively long period of playing, thus we considered it an effective means to study psychological stress. In addition, we reviewed the competitive aspects of each game, to determine the intensity of the competition.

MATERIALS AND METHODS

The subjects were 90 healthy male students, who were members of the *shogi* club at Osaka University and participating in the Western Japan Convention hosted by the Kansai Student Shogi Association. None were smokers or taking any medications. Forty one of the subjects (mean $\pm$ SD, 21.3 ± 2.7 years old) played *shogi* during the convention (*shogi* group) and 49 (19.5 ± 2.0 years old) watched the games (control group). All subjects gave consent to participate in the study, after being informed of its purpose and method. Saliva samples were collected from both groups immediately before and after the games were played, and again 30 min later (Fig. 1) using a 50-mL polypropylene conical tube (BLUE MAX™). The subjects were requested to refrain from eating and drinking at least 2 h before the first sampling (19). The samples were stored at -30°C until the assay. Salivary cortisol levels were determined by ELISA (enzyme-linked immunosorbent assay) and testosterone levels by EIA (enzyme immunoassay), using previously described methods (7, 8, 18). Following each game, the *shogi* group reported whether the game was competitive or non-competitive. Values were converted to percentages of the baseline (before playing *shogi*). ANOVA with repeated measures was performed to examine time-

Fig. 1 Experimental protocol

related differences and Bonferroni's test was used for multiple comparisons. Values were considered to be significantly different at $p < 0.05$.

RESULTS

In samples from the *shogi* group taken after playing the game, there were significant increases in the levels of salivary testosterone (63.8 ± 21.7 to 73.2 ± 20.9 pg/mL; $p < 0.01$) and cortisol (0.446 ± 0.281 to 0.800 ± 0.354 $\mu\text{g/dL}$; $p < 0.05$) (Fig. 2), though 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 $\mu\text{g/dL}$, respectively). As for the control group, there were no significant changes in the levels of cortisol and testosterone. We categorized the samples taken from the *shogi* group into 2 sub-groups, winners and losers, based on the outcome of the game, however, found was no significant difference in salivary tes-

Fig. 2 Mean values ($\pm$ SE) are presented as percentages of the baseline values obtained before playing a game. (a) Salivary testosterone and (b) cortisol in samples taken from the *shogi* (▲, $n = 41$) and control (■, $n = 49$) groups. *Significantly different ($p < 0.05$) as determined by repeated measures ANOVA and Bonferroni's test.

tosterone level between the sub-groups (Fig. 3). However, the increase seen in the winners had a relatively greater amount of reduction in the samples taken 30 min later. Salivary cortisol showed the same tendency, and the difference was not significant. We also categorized the samples taken from the shogi group into 2 sub-groups, competitive and non-competitive, according to the questionnaire results. In the samples taken following a competitive game, there were significant increases in the levels of salivary testosterone (66.0 ± 23.9 to 76.8 ± 20.7 pg/mL; $p < 0.01$) and cortisol (0.477 ± 0.305 to 0.880 ± 0.380 μ g/dL; $p < 0.05$) (Fig. 4), whereas there were no such changes in the samples taken following a non-competitive game.

DISCUSSION

Rising levels of salivary testosterone and cortisol were identifiable in samples taken from the shogi

group, whereas those from the control group were considered to reveal no effect from the game on the endocrine system. It has been reported that the perceptions of winning and losing regardless of actual performance or merit had different influences on testosterone levels. In a previous study, testosterone levels showed increases and decreases in fans, depending on the outcome of their team (2). For this reason, we expected that the levels of testosterone in samples from the control group would change, however, we were not able to confirm such results. We attributed this to the fact that the present control group differed in a number of ways from fans cheering for their team.

As for the participants, Mazur *et al.* (12) compared samples taken following competitive and non-competitive chess games, and found that the levels of salivary testosterone were significantly different. Our results (Fig. 4) confirmed those and suggested that stress response is intimately linked with com-

Fig. 3 Mean values ($\pm$ SE) are presented as percentages of the baseline values obtained before playing a game. (a) Salivary testosterone and (b) cortisol levels were measured in the winners ($\bullet$, $n = 15$) and losers ($\circ$, $n = 26$). *Significantly different ($p < 0.05$), as determined by repeated measures ANOVA and Bonferonni's test.

Fig. 4 Mean values ($\pm$ SE) are presented as percentages of the baseline values obtained before playing a game. (a) Salivary testosterone and (b) cortisol levels in samples taken following non-competitive ($\blacklozenge$, $n = 14$) and competitive ($\square$, $n = 27$) games. *Significantly different ($p < 0.05$), as determined by repeated measures ANOVA and Bonferonni's test.

petitiveness, based on our assumption that the sense of stress following a competitive game would continue 30 min later. On the other hand, in a non-competitive game, players are able to anticipate the result before the game is finished, resulting in a lower sense of stress, because of feeling of resignation from defeat or relief from victory toward the end of the game. Thus, the stress responses of participants are inhibited during a non-competitive game.

In the shogi group, there were no differences in levels of salivary testosterone and cortisol between the winners and losers. This supports a previous report (16), which found that there were no differences in samples collected from male judo wrestlers in regard to the levels of testosterone and cortisol in blood taken before and after a match. Some studies have suggested that testosterone levels are related to positive coping behavior (9, 10). That is, positive coping behavior in individuals sensing stress causes elevated levels of testosterone and activity of the sympathetic nervous system. In addition, when an individual has self-confidence and experiences positive emotions, they tend to view stressful situations as challenging (2, 4, 6). Therefore, in the present study, it is possible that the winners demonstrated positive coping behavior and the losers negative coping behavior. It is important for future studies to examine the relationships among the endocrine system and a number of factors that influence stress response, such as lifestyle, personality, and stress coping behavior. Additionally, because the mechanism for such a testosterone effect is unclear even in non-human animals (17), we intend to reveal it in future studies.

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