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Changes in pain perception and hormones pre- and post-kumdo competition ☆

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ABSTRACT

The psychological stress of competition is a powerful stimulus affecting numerous hormones, which in turn change how pain is perceived. This study investigated whether a kumdo (kendo) team competition may be related to changes in hormones and pain. Seventeen healthy male kumdo practitioners participated in this experiment. Pain experiments were conducted by applying noxious stimuli with a thermal stimulator 10 min before a kumdo competition and 30 min post-competition. Serum testosterone, cortisol, beta-endorphin levels, pain thresholds, pain ratings at 48 °C and during blood sampling (sampling pain), anxiety, blood pressure, and heart rate were measured pre- and post-competition. Anxiety, pain threshold, testosterone/cortisol ratio, and blood pressure were significantly higher pre-competition compared to post-competition, while cortisol and pain ratings were significantly lower pre-competition than post-competition. There were significant correlations between the number of previous competitions and testosterone levels both pre-competition and post-competition. In pre-competition measurements, sampling pain increased with an increase in systolic blood pressure, heart rate, and beta-endorphins, and a decrease in age. In post-competition measurements, sampling pain increased with an increase in diastolic blood pressure and a decrease in testosterone levels. These results indicate that severe psychological pre-competition stress was associated with reduced pain ratings, perhaps in order to improve athletic performance. This also suggests that competitors may be at risk of potential injury due to changes in pain perception, and careful consideration should be taken to avoid potential injury before and during competition.

Introduction

Competition is the central focus of sport (Salvador, 2005), and the psychological stress from competition compounds the stress caused by physical exertion, creating powerful stimuli that are capable of affecting numerous hormones (Howlett, 1987; Suay et al., 1999). Moreover, severe psychological pre-competition stress may reduce pain perception compared to post-competition. This notion is supported by previous studies showing that intense fear (e.g., parachute jump, shock, or trauma) can inhibit the perception of pain (Janssen and Arntz, 1999; Pitman et al., 1990; Rhudy and Meagher, 2001b; Vlaeyen and Linton, 2000; Willer et al., 1981). It is generally accepted that the induction of anxiety may increase sensitivity to pain, whereas the induction of fear decreases sensitivity to pain (Butler and Finn, 2009; Meagher et al., 2001; Rhudy and Meagher, 2000, 2001a). A negative stimulus with high arousal (e.g., fear) has been shown to limit pain perception, but such a stimulus with low-to-moderate arousal (e.g., anxiety) increases pain perception (Rhudy and Meagher, 2003). Competition stress, particularly in team competition, imposes a substantial burden on an athlete resulting in a negative stimulus with high arousal.

A decrease in pain due to severe competition-associated stress may improve athletic performance, although extremely severe competition-associated stress may itself decrease athletic performance as based on the Yerkes–Dodson law (Yerkes and Dodson, 1908). However, a decrease in the pain of severe stress may predispose athletes to injury because pain is now no longer functioning as a sign of injury. In severe pre-competition stress, the probability of victory increases as pain perception decreases during times when pain-related behavior might interfere with competition (Rhudy and Meagher, 2001b). This type of decreased pain perception leads athletes to engage in strategies to win. However, during times of low arousal, such as post-competition, in which severe psychological pre-competition stress is relieved, the

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body's tendency to protect itself from external stimuli would likely increase if pain is enhanced, thereby minimizing potential injury (Rhudy and Meagher, 2001b).

Sport competition has been known to be a useful setting for studying both physiological and psychosocial stressors, as sports inherently incorporate competitiveness and uncertainty regarding outcomes (Salvador et al., 2003). Higher testosterone and cortisol levels are found during physical competition than during non-competitive physical efforts and non-physical effort situations (Suay et al., 1999). In addition, these higher hormone levels appear before an event, suggesting an anticipatory and preparatory response to competitive situations (Booth et al., 1989; Mason et al., 1973; Mazur et al., 1997). Therefore, testosterone and cortisol levels were measured pre- and post-competition in order to investigate hormonal responses to competition stress. In competition, pain may result from exertion, contact, and injuries sustained during competition activity (Sullivan et al., 2000), which may be potentiated by competition stress. If there are changes in pain perception during competition, risk of potential injury may be increased. Therefore, it is important to know whether pain perception changes before and during competition.

Accordingly, we hypothesized that kumdo (kendo) team competition imposes a high level of stress on competitors, thereby impacting hormone levels and pain perception. Kumdo is a type of martial art that combines swordsmanship practice with vigorous exercise. The aim of this study was to investigate whether stress associated with kumdo team competition may be related to changes in hormone levels and pain perception.

Methods

Participants

Seventeen healthy male Korean amateur kumdo practitioners volunteered for this study and agreed to participate in this experiment during a local kumdo team competition. All volunteers provided written informed consent acknowledging the following: (1) they would experience experimental thermal pain; (2) no tissue damage would result from this stimulation; (3) all of the methods and procedures were clearly explained; and (4) they were free to withdraw from the experiment at any time. The Medical Ethics Committee of Yonsei University Wonju College of Medicine approved this study. Participants with peripheral and central nervous system diseases or any other significant clinical conditions were excluded from the study, as were participants using medications that could affect sensory perception, such as neuropsychotropics and analgesics.

Competition

Each fight consisted of one 3-min round and three individual fights were considered a match. The competition was set up as a tournament in which the winning team of each match continued on to play additional matches until only one team remained. In order for a team to win the tournament, an individual on that team must win at least four fights. The first and last fight occurred within 2 h of each other on the same day, and therefore there were less than 2 h between pre- and post-competition testing. This minimized circadian variations in beta-endorphin and hormone release.

Hormones

To determine testosterone, cortisol, and beta-endorphin levels, venous blood samples were drawn from an antecubital vein with a 21-gauge needle. Participants were instructed to avoid eating 2 h before blood sampling. Blood samples were collected between 1000 and 1500 h (all kumdo matches were finished by 1500 h) and 10 min before the first match and 30 min after the last match of the competition. When different experimenters sample blood, differences in the sampling skill of different experimenters may result in differences in the degree of pain during blood sampling. In order to reduce the variation in sampling pain due to difference between experimenters, all blood samples were collected by a single anesthesiologist with 17 years of experience. Testosterone and cortisol levels were measured using the COBRA 5010 Quantum γ-counter (PACKARD, CA, USA) with kits Coat-A-Count Testosterone (SIEMENS, Los Angeles, CA, USA) and Coat-A-Count Cortisol (SIEMENS). The intra- and inter-assay coefficients of variation were 3.9 and 5.9% for testosterone and 5.1 and 4.0% for cortisol, respectively. Beta-endorphin levels were measured using Microplate Reader-VERSA Max (Molecular device, CA, USA) with kit Human Endorphin-beta ELISA Kit (USCNK, Wuhan, China).

Procedures

The pain experiments were conducted twice using the exact same methodology; once 10 min before the first match of a kumdo competition (pre-competition) and once 30 min after the last match of a competition (post-competition) (Table 1). Participants sat in a chair and placed the left hand comfortably on the thigh. Before applying thermal pain, blood pressure and heart rate were measured on the brachium using an automatic sphygmomanometer. Pre-competition self-assurance regarding the positive outcome of the competition was assessed, where a score of zero represented no self-assurance and 100 represented highest self-assurance. Participants were asked to rate their anxiety before pain application at both pre-competition and post-competition. Participants were also asked to report the total number of kumdo competitions each player had participated in previously. The number of previous competitions included the total number of kumdo competitions each respondent had participated in and excluded the competitions in the tournament at which this study took place. Immediately after the blood draw, participants were asked to rate the degree of pain during sampling. Sampling pain was defined as the pain that participants perceived when the needle pierced the skin and blood vessel and it also represents the pain that patients experience in clinical practice. Ratings were assessed using the numerical rating scale (NRS), which ranges from 0 to 100 (0 = no pain and anxiety; 100 = maximum imaginable pain and anxiety).

Pain experiment

Noxious thermal stimuli were delivered with a computerized thermal contact stimulator (contact-heat evoked potential stimulator, CHEPS; Medoc Advanced Medical Systems Ltd., Ramat Yishai, Israel). The CHEP-stimulator thermode has a circular contact area of 27 mm in diameter. To determine pain threshold, a thermode was placed tightly on the volar side of the wrist using an elastic strip. Heat temperature was increased from 32 °C to the participant's pain threshold at a rate of 1 °C/s. Pain threshold was defined as the lowest temperature at which the participants reported pain. After reaching the pain threshold, heat temperature returned to 32 °C at a rate of 30 °C/s. Final pain threshold was calculated as the mean of three pain thresholds acquired during three consecutive thermal stimulus repetitions. After the pain threshold

Table 1
Experimental sequence. This sequence was identical both pre-competition and post-competition.

Step 1	Step 2	Step 3
Measure blood pressure and heart rate. Ask participant to rate their anxiety. Ask participant how many competitions they have participated in previously.	Ask participant to rate the pain associated with blood sampling. Measure pain threshold.	Measure pain rating at 48 °C for 5 s.