

## **BIOMEDICAL INDICATORS OF PRE-COMPETITIVE STRESS IN FEMALE AND MALE JUDO PLAYERS**

**Helena Mroczkowska**

Institute of Sport-National Research Institute, Warsaw, Poland

**Jan Supiński**

University School of Physical Education, Wrocław, Department of Psychology, Poland

**Artur Litwiniuk**

University of Physical Education J. Pilsudski, Warsaw Faculty of Physical Education and Health, Biala Podlaska, Poland

**Zbigniew Obmiński**

Institute of Sport-National Research Institute, Warsaw, Poland

**Abstract.** *The aim of the present paper is to monitor changes of selected mental and physiological stress indicators in both female and male sportsmen in the subsequent days prior to an International Judo Tournament in Poland and on the competition day. The study included 9 men and 9 women, participants of the training camp that ended with a tournament. Every morning, on the three consecutive days preceding the competition (day -3, -2, -1) and on the competition day (day 0) capillary blood was sampled to determine serum cortisol (C) and testosterone (T) levels, then the subjects assessed their night sleep quality (SQ) with the use of a 5-point Likert scale, and perceived anxiety using the State-Trait Anxiety Inventory questionnaire by Spielberger (STAI - Polish version). SQ insignificantly deteriorated, and C and anxiety levels increased with the time to event. The inter-group analysis for the entire period showed higher scores in average anxiety and higher average level of C in women than men. The relative changes in these biomarkers could indicate higher pre-competitive stress in women, however without taking into account the sports class of the opponents individually for each of the groups one cannot imply gender-specific susceptibility to stress as a general principle.*

**Keywords:** *anxiety, arousal, competition, gender, judo, hormones, stress.*

### **Introduction**

In the fifties of the 20th century Hans Selye, the Canadian physiologist, carried out experiments on animals that revealed physiological mechanisms of "alarm" reactions of the body exposed to strong and long-term physical stimuli. Selye called these reactions stress and referred to the stimuli as such as stressors. The effect of stressors initially involved adaptive changes in the body, however prolonged exposure led to reversing adaptive changes causing the state of exhaustion and loss of defence mechanisms. Selye published many scientific

articles on stress and also popularized the practical knowledge of the causes and consequences of sensory overload in his popular science monographs (*Stress of Life* 1956). Since that time the concept of stress has come to the scientific and colloquial language, where it is often treated as either the effect or the cause. What is more, the conceptual scope of this notion is constantly widening. With the development of analytical techniques the number of biochemical markers useful for identifying stress reactions increases. For classification of stress causes, i.e. stressors, two basic categories of stress inducement stimuli, physical and psycho-social were adopted. The former group includes exposures of the body to the adverse external conditions such as high or low ambient temperature, the deficit of oxygen in the air (hypobaric or normobaric hypoxia), presence of factors harmful to health, large gravity acceleration, physical injuries (injuries, pain), large physical effort and somatic diseases. Harmful psycho-social stimuli include e.g. disturbances in personal relationships, e.g. aggressiveness, anti-social behaviors and excess of responsibilities at work, which as time goes by leads to chronic fatigue and deterioration of health (Rose, 2017)

All these stimuli induce momentary or long-term psycho-physiological changes according to their intensity and duration. These changes are also valuable markers of stress reactions and are used to assess the degree of "resistance to stress". Similarly to the stimuli, also stress reactions can be assigned to the group of somatic or psycho-emotional reactions. The group of somatic reactions includes changes in the activity of the hormonal, immunological, autonomous and cardiovascular systems, since they are most sensitive to stimuli. Therefore, measured somatic reaction indicators are measurements of concentrations of so-called stress hormones in bodily fluids (cortisol, testosterone, growth hormone, adrenaline and noradrenaline and dopamine), concentration of  $\alpha$ -amylase in saliva and heart rate and blood pressure. Questionnaires of emotional states and moods used in psychological tests serve to measure the intensity of psycho-emotional reactions.

A special place in research on collective stress experienced by populations is given to observations of Post-Traumatic Stress Disorder (PTSD) syndrome. An example are multi-annual studies of dynamics of PTSD among residents of New York after the terrorist attack carried out on 11 September 2001 (Bromet et al., 2016; Galea, 2002) or in inhabitants of Japan after the great earthquake (Fujiwara, 2017). Traumatic disorders following the above mentioned risks manifested themselves in the growth rate of psychiatric symptoms, increased anxiety and deterioration in the quality of sleep, which was more frequently reported by women than men. The most commonly used parameter that specifies the current stress intensity before the competitions is the result of anxiety tests. There are two components of this state, cognitive anxiety (CA) and somatic anxiety (SA). The first signal of the psychogenic stressor is activation of the

amygdala. This is a part of the limbic system that analyzes the external situations and stimuli and sends signals to the cerebral cortex showing which of them are important to the body, including those involving some risk. Then alarm signals are sent to the hypothalamus. Here a cascade of physiological responses covering the entire body is triggered. These reactions are at the heart of the phenomenon known as SA. Therefore, increased CA precedes the emergence of SA.

Sport is an important area of exploration to researchers of the stress phenomenon. In economically developed countries, in this part of the population to whom physical exercise at work is reduced or is not present at all, physical activity during leisure time plays an important role in prevention of civilization diseases. The level of this activity is a choice that depends on age, needs and exercise capacity and varies between typical recreation and competitive sports practised at a professional level (Litwiniuk, 2019). Competitive sport involves large training loads during the competition and training season, mandatory participation in the competitions and risks of injury. Intense training drills, i.e. physical stressors, are accompanied to a larger extent by an elevated level of SA, yet as for sports rivalry both CA and SA occur. The waiting for participation in important competitions may induce such great mental arousal that as its consequence strong physiological responses emerge that are defined as pre-competitive stress. A similar condition expressed by increased perceived stress and the anxiety level was also noticed in students of 1st academic year of both sexes before important examinations (Balaji et al., 2019). In this study, results show a higher stress level and anxiety connected with examinations in female students. The cause of psycho-physiological response before an important test of skills in athletes or students is anxiety in connection with failure and a negative assessment of the task performance level.

One of the less frequently undertaken lines of research on pre-competitive stress in sportsmen is the effect of sex. The results obtained by various authors are unambiguous. One of the studies suggests a higher anxiety level before tournaments in women. For example, before the first game in tennis the average pre-competitive level of cognitive anxiety (CA) was by 23 percent higher in women than in men (Filaire et al., 2009). Also a higher level of CA before the tournament in table-tennis was observed in women (Kurimay, 2017), and in girls than in boys, swimmers, tested several times on different days during the training season (Da Silva, 2019). However, the changes in CA level in short term period before the competitions indicate a slightly higher anxiety level in men (Hagan, 2017). The results of the cortisol reaction to competitions in both sexes are also divergent. In tennis before competitions, women presented a higher cortisol level (Filaire et al., 2009), but before and during the taekwondo

tournaments a lower concentration of this hormone could be noticed (Chiodo, 2011).

Among a large number of sports disciplines, eastern martial arts seem to be interesting for the purpose of exploring the phenomenon of stress in both sexes. These are contact sports that require extreme efforts and cause the risk of injury. For this reason in Poland only a small part (approx. 3%) of physically active persons practises this form of physical activity at an amateur or professional level (Biernat, Krzepota, & Sadowska, 2018). The number of scientifically described studies on our athletes is not too high. Even less attention was paid to exploration of pre-competitive stress in both sexes. These studies showed a significant deterioration in the quality of sleep in the night before the high-level international tournament (Obmiński & Mroczko, 2015) in judo females athletes, and in one of the players on the competition day a dramatic decrease in blood testosterone concentration down to a non-physiological value in men and a very high concentration of cortisol were observed (Obmiński, 2009). In addition to the biochemical and circulatory stress bio-markers, it is worth mentioning about parallel measurements of skin electrical conductivity changes known as electrodermal activity (EDA) and comparing the data with personality traits. These studies carried out among the young taekwondo players, participants of the national team selection competition revealed significant correlations between EDA results and certain parameters of the Big Five personality traits: extraversion, agreeableness conscientiousness, emotional stability and openness. This shows the practical importance of research on the personality profile in exploration of pre-competitive stress (Bingboga et al., 2012).

For technical reasons, there are not many results of tests on parallel dynamics of biochemical and psychometric stress indicators directly before the tournament in both sexes in combative sports, but they seem to be valuable. They showed a consistent direction of changes in the cortisol concentration and alpha-amylase and state anxiety (Capranica, 2017). Unfortunately, the subjects in this study along with their coaches did not consent to the last measurement of anxiety immediately before the fight as it was considered too time-consuming and distracting participants, and a small group of subjects (3 women and 6 men) did not allow the authors to perform an assessment of sex-dependent differences.

In order to examine possible differences between sexes in reactions to stress that are a sign of anticipation of high level judo competitions, a group of female and male judokas was examined.

### **Material and methods**

Senior judokas took part in diagnostic routine tests, namely women aged 24-26 years (n=9) and men (n=9), participants of a one-day international judo tournament (Warsaw Judo Tournament) that had taken place for many years

annually in Poland. Athletes of both sexes were among the national elite in this sport and repeatedly participated in high level competitions in Poland and abroad. Biomedical observations started at the end of 2-week training camp that finished two days before the competition day. At the end of the camp, both groups left the training centre and were checked in one the day before the competition at the hotel near the tournament hall. Hormone and psychological tests were carried out every day for 4 consecutive days, 3 consecutive days before the tournament (-3D, -2D, -1D) and in the same manner on the day of the tournament (0D). Every morning before breakfast (7:00) capillary blood was sampled from the earlobe, after breakfast current mood (SA) was examined using Trait/State Anxiety Inventory by Spielberger (Polish version), then the sleep quality (SQ) was measured using the 5-point Likert scale (where 5p reflected deep, continuous sleep and 1p referred to insomnia). In blood plasma, hormone concentrations were determined, namely: cortisol (C) and testosterone (T), using ELISA, DRG-GERMANY analytical kits. In each series of sample analyzes carried out in duplicates, control samples of known hormone concentration were added in order to control and calculate the level of inter-assay error, the relative value of which did not exceed 8 % for the analyses of both hormones. In the immediate pre-competitive period and at the time of the tournament, club coaches and the main coach provided psychological support and advice to their athletes. The differences between sexes and subsequent days of tests were analysed by means of two-way analysis of variance (ANOVA) and post-hoc Bonferroni's test.

### Results

Table 1 shows results of measurements as mean values and standard deviations for hormone concentrations, the anxiety level and sleep quality in four consecutive days in both sexes.

*Table 1 Descriptive statistics for scores of cortisol (C) and testosterone (T) levels, and scores of state anxiety (SA) and sleep quality (SQ) in female (F) and male (M) judo competitors*

variable	sex	Time to event (Days)				Entire period	Between group differences
		-3D	-2D	-1D	0D		
C nmol/L	F	560±83	574±123	605±95	673±103	603±107	Significant F>M
	M	576±91	497±47	525±96	554±38		
T nmol/L	F	2.2±0.6	2.2±0.5	2.5±0.7	2.9±0.6	2.5±1.4	Sex-related dimorphism
	M	24.5±6.0	21.8±5.4	18.2±5.6	21.7±5.8		
SA scores	F	37.0±9.1	38.2±4.9	38.8±4.7	43.0±6.1	39.2±6.3	Significant F>M
	M	36.7±3.2	32.9±3.0	34.6±1.2	38.2±2.3		
SQ scores	F	3.4±1.0	3.1±1.2	2.3±0.6	2.7±0.7	2.9±0.9	No significant
	M	3.1±0.6	3.3±0.9	2.9±0.9	2.8±1.0		

Table 2 presents statistical calculations, differences between sexes and days for hormonal variables, state anxiety and sleep quality.

*Table 2 Differences between average variable values (excluding T) by sex and Day as measured with analysis of variance*

variable	factor	F-value	P-value	$\eta$ square	$\alpha$ -value	differences
C	sex	<b>9.68</b>	<b>0.003</b>	<b>0.131</b>	<b>0.865</b>	<b>significant</b>
	Day	2.37	0.073	0.099	0.567	non sign
	interaction	1.88	0.142	0.081	0.464	non sign
SA	sex	<b>9.84</b>	<b>0.003</b>	<b>0.128</b>	<b>0.872</b>	<b>significant</b>
	Day	<b>3.85</b>	<b>0.014</b>	<b>0.147</b>	<b>0.800</b>	<b>significant</b>
	interaction	0.941	0.943	0.042	0.246	non sign
SQ	sex	0.459	0.500	0.007	0.102	non sign
	Day	<b>2.761</b>	<b>0.049</b>	<b>0.114</b>	<b>0.641</b>	<b>significant</b>
	interaction	0.801	0.498	0.036	0.214	non sign

In Table 3, linear correlation coefficient matrix is presented.

*Table 3 Matrix of correlation coefficients between variables*

Correlation	Females (36 observations)	Males (36 observations)
C • T	<b>0.578</b>	0.133
SA • C	0.296	<b>0.580</b>
SA • T	0.100	-0.056
SQ • C	0.297	-0.121
SQ • T	0.100	0.130
SQ • SA	-0.137	-0.194

In the calculation, a statistically significant difference between the average value occurred for  $p < 0.05$ . The analysis of differences between the sexes showed significantly lower ( $p = 0.003$ ) average SA result in men (10%) for the entire period of study, namely for the number of the two sets after  $n = 36$  observation. In the group of men, average values in consecutive days were subject to slight fluctuations, whereas in women SA on the competition day (0D) was 16% higher than on 3D day, but this difference was not statistically significant. In addition, on the competition day SA was by 11% higher in women and there was a significant difference between groups.

There were no significant inter-group differences in sleep quality scores, however in the entire group ( $n = 18$ ) SQ deteriorated with time and in the night before competitions it was worse by 14.7% in women and by 3.2% in men when compared to the baseline value i.e. on -3D day.

The concentration of cortisol in each of the sexes did not change significantly in the consecutive days of observation. In men an average C value was virtually the same in consecutive days. In women a small progressive increase could be seen during the 4-day-long observation and on the competition day C was higher by 20% than the output value. The average value of C for the whole period was significantly higher in women. Because of the well-known sexual dimorphism for concentrations of testosterone, the intergroup comparison was abandoned, and the differences between the days for each group were examined using only one-way analysis of variance. In women, insignificant progressive increase of T in consecutive days parallel to changes of C was noticed. In men one day before the competitions (-1D) the lowest average T level was observed. It was significantly lower than the one at the beginning of the study. Significant correlations between C and T in women and SA and C in men for the entire period of research presented in Table 3 are due only to the parallel changes of the investigated parameters.

### **Discussion**

In our previous studies on anxiety (CA) and perceived stress (PS) on the judo tournament day carried out on the greater number of female and male athletes (Obmiński & Mroczkowska, 2014), insignificantly higher CA in women ( $44.9 \pm 10.9$ ) than men ( $40.2 \pm 6.4$ ) was observed. The relative difference of this variable (11.2%) between groups was almost the same as in the current study. The fact that in both our studies CA result dispersion, expressed by means of coefficient of variation-CV %, is lower in men, which indicates greater homogeneity of this group, seems to be interesting. In the presented paper, the investigated judokas of both groups were among the sport elite. As regards the pre-competitive anxiety analysis in a larger population one should consider the skill level of the participants. Studies have shown that men from the sport elite show slightly higher CA and SA than those from the semi-elite group, while in women the relationship is reversed (Hagan. 2017). In our research, significant dependence between SA and C was observed in men ( $r=0.580$ ) only. The relationship between these variables before and during the judo competitions was also noted by other authors (Salvador et al., 2003; Filaire, 2001).

Sleep quality in competitive athletes is an important indicator of their psychophysical health and health status. During the training camp, this parameter depends on many circumstances. The anticipation of the first training session, scheduled too early in the morning, shortens the length of sleep (Sargent et al., 2014). In our research SQ deteriorated significantly as the date of competitions approached. But the size of these changes was significantly smaller than the one we saw in our previous studies in five female athletes participating

in more prestigious competitions, namely the European Judo Championships (Obmiński & Mroczkowska, 2015). It should be noted that the sleep quality in athletes is affected by many factors which may interfere with the pre-competitive stress before the competitions. For example, SQ deterioration may result from too high everyday training loads and physical fatigue, which contributes to too high mental activity, experiencing emotions while in bed (Hoshikawa, Uchida, & Horano, 2018).

It can be assumed that pre-competitive arousal in athletes investigated by the authors of the present paper was not too high due to the favorable result of drawing lots to allocate their first opponents who represented a moderate skill level and not too high a position in the ranking. The second reason for a lack of more distinct stress reactions could be significant lower physical activity in the last days of the camp prior to the competitions. This enabled the athletes to have a natural recovery phase after a hard training period preceding the competitions or reduction of physical stressor intensity. In these circumstances the interference of both circumstances could have attenuated the changes caused by anticipation of the tournament.

### **Study limitation**

In the study, the analysis of the stress source, namely cognitive anxiety before the competitions, was omitted. One could speculate that before sports competitions, before examination or any other challenge important for a given person, anxiety connected with failure occurs. As regards tournaments in judo that is a contact sport, some athletes may be afraid of various injuries typical for this sport (Popeco, 2013; Kamitani, 2013). Fortunately, serious injuries are not frequent and they occur in athletes with lesser experience and a lower skill level. Another factor modulating pre-competitive stress are interpersonal relations, particularly athlete-coach interactions. Mental support from the coach relieves stress and also experienced athletes have different strategies to cope with stress that vary depending on e.g. the personality profile (Allen, 2011). Our research omitted identifying the participation of the above mentioned factors affecting the pre-competitive stress.

The research has been approved by the Ethics Commission, Institute of Sport.

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