Original article

DOI: 10.5114/areh.2020.91526
Advances in Rehabilitation, 2020, 34(1), 40–46

The psychophysiological status of the handball players in pre-competitive period correlated with the reactions of autonomic nervous system

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A – preparing concepts
B – formulating methods
C – conducting research
D – processing results
E – interpretation and conclusions
F – editing the final version

Received: 2018-12-20
Accepted: 2019-04-15
Published: 2020-01-19

Abstract

Introduction: The aim of the study was to analyze the changes in the indices of the autonomic nervous system and the adaptive capacity of Ukrainian Super League handball players prior to significant competitions.

Material and methods: This research involved 39 handball players from the Ukrainian Super League aged 18–22 years old. The study examined the overall tone of the autonomic nervous system (ANS) measuring electrodermal activity of the athletes. Reactivity of the ANS of players was monitored by the method of R. Baevskyy, the efficiency of competitive activity in handball was analyzed by the integral index of technical and tactical handball skills.

Results: Before the competition, the reaction in the sympathoadrenal system was launched for vagotonics as the intended response to the upcoming games. The measured indicators marked mental stress and activation of the sympathoadrenal system for the sympathotonics group. The atonics group provided the emotional ground due to the balanced influence of para- and sympathetic divisions of the autonomic nervous system.

Conclusions: The index of functional changes in all participants detected a satisfactory level of adaptation. The highest sympathetic activity was observed for atonics, the lowest – for vagotonics. The best results were documented for athletes who did not have autonomic dysfunction and those who had a slight predominance of the sympathetic component of the autonomic regulation.

Keywords: cardiovascular system, technical skills, handball players

Introduction

Stress occurs regularly, has diverse characteristics that can be both mental and physical. Stress is typically associated with increased anxiety, which affects athletic performance and efficiency. Important work on the physiological response to stress in sports is provided by the famous Russian scientist and physiologist Shlyk [1–3]. For example, her studies provide data from National Olympic team in canoe slalom and Udmurtia National

and junior national teams in biathlon. These studies discuss the close connection between the autonomic dysfunction, autonomic reactivity, decreased functional and adaptive-reserve opportunities of sportsman and sports outcomes. Competition alters the athlete's mental state, increases their mental stress and influences behavior and performance. In these conditions, human body is a complex self-regulating system that maintains its homeostasis by activating all necessary regulative systems. Autonomic nervous system (ANS) is a leading system responsible for athletes' adaptation to stress and readiness for action.

The competitive mental state differs significantly from the athlete's mental state during practice. This often leads to the fact that the athlete shows much better results during training than during competition [4]. Hence, maintaining the autonomic balance in the body before the competition commences can help to prevent stress escalation. The trainer's task at this stage is to help athletes to keep a state of relaxation during stressful situations and to maintain readiness for the upcoming competitions.

The assessment of athletes' psychophysiological condition is crucial to the precompetitive period [5]. It is important to assess the psychophysiological condition diagnosis, determine physiological markers of emotional stress, evaluate current psychophysiological state in galvanic skin response, etc. There is a paucity of literature that explores the altered mental state of athletes' and how the initial state of ANS may affect the response [5–7]. In particular, people with different ANS statuses show different individual tolerances to hypoxia or distinct reactions to cardiovascular system loads. It is also noted that in the case of an acute adaptation, the physiological mechanisms of the athlete's cardiovascular system regulation depend not only on the age of the sportsman but also on the current status of the ANS [8]. Analysis of evoked cutaneous sympathetic potentials (ECSP) is considered as the most informative and sensitive clinical method of ANS functional status assessment [9, 10]. ECSP analysis presents a change in electrodermal activity in response to stress stimulus. ECSP analysis provides information regarding the functional state of ANS. The interest in ECSP as in a method of ANS assessment has been steadily increasing since the method is simple and easy to implement, and, in addition, it directly reflects the state of ANS [11,12].

Variation in the mental processes is related to receiving and processing incoming emotional information [13–15]. The training and competitive activity may experience various psychological conditions that cause ambiguous changes in the body and will have different effects on the athlete in the upcoming competition. Consequently, the aim of the study was to analyze the changes in some of the indices of the ANS and the adaptive capacity of Ukrainian Super League handball players before significant competitions.

Material and methods

Participants

Thirty-nine Ukrainian Super League handball players aged 18–22 years old participated in the experiment. All athletes volunteered to participate in the test. Prior to the testing, the procedures were explained to the handball players, including the possible risks involved, and an informed consent form was signed. The research was approved by the Institutional Ethics Committee (number 2017/12–11), complied with all the relevant national regulations and institutional policies, followed the tenets of the declaration of Helsinki and was approved by the authors' institutional review committee.

Methods of the research

1. A Neuro-Soft device was used to determine the ECSP. The ECSP testing was conducted in comfortable, supine position of the athlete. Electrodes were installed on the palms (the active – in the middle of the palm, the reference – on the 2nd phalanx of the middle finger). Before utilizing the electrodes on the skin, electrically conductive gel was applied on the body. Firstly, the threshold value of current, which caused a slight deviation from the contour, was determined. Then amperage stimulation was conducted equal to double or triple the threshold value. To find the threshold current force of the ECSP, disposable stimulation was used with increasing amplitude of 4 mA and higher. Rectangular impulses of 0.1 ms duration were applied. The time interval between repeated stimulation was not less than 60 seconds to restore reactivity. 3–4 most reproduced responses were averaged. The analysis of standard parameters was conducted (latency, the amplitude of phases 1 and 2, the duration of phase 1 and 2, the initial state recovery time, the ratio of positive and negative portions of the response phase, the ratio of ECSP amplitudes) [16,17].

The following parameters were evaluated in dynamics: the latent period (LP – Duration of synaptic response delay of the brain level) [18,19], the maximum amplitude (A max – intensity of autonomic responses), the ratio of negative amplitudes (A1) and positive (A2) component response (tone predominance in autonomic regulation), the response time (T-quality adjustment part of the central unit) [11]. Diagnostic integral coefficient (DIC) was calculated by the method described in the patent for utility model that had been developed in

Tab. 1. Calculation of diagnostic integral coefficient (DIC)

T (duration of respond)	Number of points
3.09–3.69 sec	0 points
3.69–4.8 sec	1 point
4.9–7.9 sec	2 points
T < 3.08 sec or T > 8.0 sec	3 points
SA (spontaneous activity)	Number of points
Missing	0 points
Exist	1 point
Predominance of tonus	Sign
sympathetic	"+"
parasympathetic	"–"
LP (latent period)	Number of points
1.3–1.48 sec	0 points
1.1–1.29 sec or 1.47–1.5 sec	1 point
0.8–1.1 sec or 1.51–1.65 sec	2 points
LP < 0.8 sec or T > 1.65 sec (or not > 1.8 sec)	3 points
A max (maximum amplitude)	Number of points
0.69–0.95 мВ	0 points
0.5–0.68 мВ or 0.96–1.45 мВ	1 point
0.4–0.5 мВ or 1.45–2.8 мВ	2 points
A max < 0.4 мВ or A max > 2.81 мВ	3 points

Tab. 2. Express assessment induced cutaneous sympathetic potentials

The total number of points	Interpretation
0–2 points	autonomic dysfunction data is absent
3–4 points	slight predominance of the sympathetic or parasympathetic link in autonomic regulation
5–7 points	moderate predominance of the sympathetic or parasympathetic link in autonomic regulation
8–10 points	significant predominance of sympathetic tonus and parasympathetic link in autonomic regulation
+	predominance of sympathetic tonus (sympathotonics)
–	predominance of parasympathetic tonus (vagotonics)

the "University Clinic" [20]. Thus, based on the results of ECSP for each athlete, DIC was calculated and evaluated in points using criteria (Tables 1, 2).

2. The size of the adaptive capacity of the athlete was calculated by the formula of R. Baevskyy [16]:

$$AP = 0.011\ HR - 0.014\ SBP + 0.008\ DBP + 0.014\ B - 0.009\ BM - 0.009\ L - 0.273,$$

where AP – adaptive capacity of the athlete (absolute unit, AU); HR – heart rate, beats/min; SBP – Systolic blood pressure, mm Hg.; DBP – Diastolic blood pressure, mm Hg.; BM – Body mass, kg; L – Body length, cm; A – age, 0.27; 0.014; 0.011; 0.009; 0.008 – coefficients of equation of multiple regression.

Based on this formula the values of AP identified following levels of adaptive capacity of the athlete:

- satisfactory adaptation (sizes of AP constituted <2.1 si.u.)
- tension of adaptation mechanisms (2,11–3.2 si.u.)
- unsatisfactory adaptation (3.21–4.3 si.u.)
- failure adaptation (>4,3 si.u.).

3. Defined vectors preparation for the competitive activity in the sphere of sports became a part of the technological information through the implementation of the scientific potential. Therefore, the efficiency of competitive activity in handball, the integral index of technical and tactical handball skills (IITTHS) was determined and developed by the group of scientists [16]. It involves determining the basic technical and tactical parameters of the athlete, and has been calculated by the formula:

$$33.33 \times (\sum g/\sum g\text{-}t + t/T) + 1.4 \times PS + 1.3 \times A + 1.2 \times IN + 1 \times B + 0.5 \times OT - 1 \times SUS - 1.2 \times TB,$$

where Σg – goals, numbers; Σg-t – goal-throws, numbers; t – time on the court, minutes; T – time of the game, minutes; PS – earned a penalty shot (7-m); A – assists, numbers; IN – interception, numbers; B – block numbers; OT – opponent's turnover during the game, numbers; SUS – suspension of the player, number; TB – turnover the ball, numbers; 33.33; 1.3; 1.2; 1; 0.5; –1; –1,2 – coefficient of multiple regression equation.

The levels of the integral index of technical and tactical handball skills are shown in Table 3.

Tab. 3. The levels of the integral index of technical and tactical handball skills (IITTSHP)

Level IITTSHP	Points
Low	Below 25
Below the average	25.01–35
Average	35.01–45
Higher the average	45.01–55
High	Above 55

4. Data recorded (mean, and standard error of the mean) were analyzed using Statistica for Windows (version 8.00). Before concluding analysis, data was evaluated for normality assumption, homogeneity, and occurrence of extreme scores. The distribution of the data recorded was tested using the Shapiro-Wilk test. This analysis was performed as preliminary measure before parametric calculations of the analysis of difference.

Results

We divided all of the athletes using autonomic tonus source into 3 groups at the beginning of the study DIC: 36% of all participants were handball players with a predominance of parasympathetic activity in the heart rate regulation (vagotonics); 18% of the players with a predominance of sympathetic activity in the regulation of heart rate – sympathotonics; and 46% of participants with a balanced activity of both divisions of the autonomic nervous system – atonics (Table 4).

In addition, integral index of technical and tactical skills of handball players (IITsTSHP) and the level of the adaptive capacity (AC) of the player were calculated for each group. Before the competition, we conducted the re-evaluation of the athletes. Results of evaluation are presented in Table 5.

The reaction sympathetic-adrenal system was launched for vagotonics as the intended response to the upcoming games. Also, athletes have encountered the state of satisfactory adaptation. However, IITTSHP decreased, but remained at an average level.

Analyzing sympathotonics group, indicators marked mental stress comprising the novelty elements as suggested activation of the sympatho-adrenal system (as

Tab. 4. Distribution of handball players on the vegetative status during the study

DIC, points	Numbers	Preparation period	Numbers	Precompetitive period
Atonics				
0–2	28	48.1 ± 2.3	21	62.2 ± 1.5
(+)3–4	–	–	5	47.4 ± 2.2
(+)5–7	–	–	2	45.5 ± 1.8
Vagotonics				
3–4	6	43.3 ± 2.6	4	40.1 ± 1.7
5–7	11	38.5 ± 3.1	13	36.2 ± 2.3
8–10	5	32.4 ± 3.7	5	28.7 ± 1.6
Sympathotonics				
3–4	6	45.8 ± 2.7	3	46.8 ± 2.4
5–7	3	44.7 ± 3.2	7	47.5 ± 2.2
8–10	2	40.9 ± 2.6	1	26.8 ± 1.5

Tab. 5. Dynamics indicators of the vegetative status, adaptive capacity and technico-tactical skills for handball players during the study, X ± m

Indicators		Preparation period		t	Precompetitive period	
Atonics	IITTSHP	48.1	2.3	5.13***	62.2	1.5
	DIC	1.28	0.05	1.27	1.37	0.05
	AC	1.7	0.25	0.25	1.82	0.4
Vagotonics	IITTSHP	43.3	2.6	1.03	40.1	1.7
	DIC	4.2	0.6	0.30	4.5	0.8
	AC	2.05	0.1	0.35	2.1	0.1
Sympathotonics	IITTSHP	45.8	2.7	0.28	46.8	2.4
	DIC	4.5	0.72	0.23	4.3	0.5
	AC	2.15	0.1	0.28	2.11	0.1

IITTSHP – integral index of technical and tactical skills of handball players; DIC – diagnostic integral coefficient; AC – adaptive capacity; *** – $p < 0.001$.

manifestation of stress response). The index of functional changes was in the range of values of satisfactory adaptation.

The atonics' group provided the emotional ground with the balanced influence of para – and sympathetic divisions of the autonomic nervous system. IITTSHP improved significantly and moved to a new functional level – high, indicating that the appropriate preparation level for competitive activity, which is confirmed by the indicator of DIC.

The index of functional changes indicated about satisfactory level of adaptation in all of the participants. The highest sympathetic activity was observed for atonics, the lowest – for vagotonics. The connection between the average score IITTSHP, AC and DIC has been developed, which showed that if DIC is higher, then the performance of competitive activity is worse (Table 6).

When exposed to stress, ANS is trying to increase the adaptive capacity of the organism due to activation

Tab. 6. Correlation of the vegetative status and adaptive capacity of the organism with indicators of technical and tactical skills for handball players during the study

Indicators	IITTSHP	DIC
ATONICS		
DIC	–0.77 perfect negative correlation	–
AC	0.83 (perfect positive correlation)	0.81 (perfect positive correlation)
VAGOTONICS		
DIC	–0.74 perfect negative correlation	–
AC	0.81 (perfect positive correlation)	0.75 (perfect positive correlation)
SYMPATHOTONICS		
DIC	–0.82 perfect negative correlation	–
AC	0.82 (perfect positive correlation)	0.75 (perfect positive correlation)

IITTSHP – integral index of technical and tactical skills of handball players; DIC – diagnostic integral coefficient; AC – adaptive capacity.

of the sympathetic component. As an example, it has been noticed in atonics. However, if the balance of ANS original tone is already initiated, then we follow the tendency to deterioration in indicators of DIC. That reflects on a decrease in adaptive capacities of ANS during stress and deepening of autonomic dysfunction

EDA method is quite informative in a quantitative way to study the functional state of ANS. The compliance of EDA registration procedure is a unified concept interpretation of the results along with the creation of a unified technical base that standardize methodology EDA. The improvement of the technical equipment of the method (mostly, the reliable appearance of recording electrodes, simplifying the registration process) allows to restore interest of EDA method and introduces it in the traditional daily examination of athletes with different specializations.

The described testing system permits to evaluate the readiness of handball players based on their individual characteristics. Information could be used as the formation of national teams during international competitions at various levels.

Discussion

In anticipation of the competition in the functional state of the athlete there are significant changes. The competition stimulates the appearance in athletes of a state of increased neuropsychic stress, significantly different from the training one and affecting its behavior and performance. Nevertheless, in this particular case, the stressful situation occurs when handball players with parasympathetic activity experience an innovation, which has a constructive impact on the work of higher nervous activity. All these parameters corresponded to the classical description of the leading experts in this specific field [19–22].

It might be assumed that the atonics group's functional system is more stable and less influenced by the upcoming games. Sympathotonics and vagotonics groups also perform the search for the functional stability system, the connections are more flexible and stronger exposed to prestart conditions. That reflects the lack of forming in functional systems, which are looking for new connections to ensure competitive activity [2].

It should be considered that the detected syndromes of autonomic dysfunction, in handball players, was observed in the context of occurrence on the ground of severe or chronic stress in psycho-physiological nature. The emotional and autonomic endocrine reaction to severe stress is a normal physiological response of the body and cannot be evaluated pathologically [22,23].

The acquired data of the study allow to understand better the original psychophysiological status of handball players depending on the degree of adaptive systems' tension in the body and to evaluate the mechanisms regulating their current functional status. Therefore, EDA method can reliably confirm the presence of autonomic dysfunction and to determine the orientation of the general tone of ANS, which was confirmed in our study.

Conclusions

The index of functional changes in the organism of all participants was recorded a satisfactory level of adaptation. The highest sympathetic activity was observed for atonics, the lowest – for vagotonics. The connection between the average score IITTSHP, AC and DIC has been developed, which showed that if DIC is higher, then the performance of competitive activity is worse.

The best results were documented for athletes who didn't have autonomic dysfunction and those who had a slight predominance of the sympathetic component of the autonomic regulation.

Funding
This research received no external funding.

Conflicts of interest
The authors declare no conflict of interest.

Acknowledgement
The research was realized with the support of the handball clubs «Motor», ZTR, «Donbas», ZNTU-ZAB, SCA Lviv, «Portovik». The authors are grateful to the coaches and athletes, who participated in the study.

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