Journal of Physical Education and Sport ® (JPES), 17 Supplement issue 4, Art 212, pp. 2089 - 2096, 2017
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Assessment of human psychophysiological responses to intense exercise: a survey of Greco-Roman wrestlers and unqualified competitors

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Published online: Octomber 31, 2017
(Accepted for publication September 25, 2017
DOI:10.7752/jpes.2017.s4212

Abstract

The concepts of stimulus-response specificity and individual response stereotypy confirm the importance of viewing psychophysiological stimuli as a reflection of numerous interacting organ systems (e.g., motor, cardiovascular and skeletal-muscular systems). The objective of this paper is to capture recent, detailed insights into the psychophysiological states experienced by athletes and highlight the present knowledge of reflective heart rate responses to orthostatic load which is of crucial importance to our understanding of human normal muscle function. It is proved that in the dynamics of adaptation to intense exercise there is an improvement in a human's visual perceptual processing capacity. Simultaneously, there is evidence that the information processing speed increases while adapting to intense exercise and results in the tension of heart rate regulatory mechanisms. The research has shown that athletes with different cognitive processing abilities need different time for certain mental operations. From an information-processing perspective, motor behaviors consist of encoding relevant environmental cues through the utilization of attentional strategies, processing the information through an ongoing interaction between working memory and long-term memory, making an action-related decision; consequently athletes' with low cognitive processing abilities might reduce their performance. Thus, athletes need to engage in correct training programs which include sports specific exercises in order to achieve and maximize their sporting excellence.

Key words: psychophysiological response, intense exercise, adaptation, Greco-Roman wrestlers, unqualified competitors.

Introduction

The concepts of stimulus-response specificity and individual response stereotypy confirm the importance of viewing psychophysiological arousal as a reflection of numerous interacting organ systems (e.g., motor, cardiovascular and skeletal-muscular systems).

Several recent reviews and book articles deal with various aspects of a human physical activity as an exercise that collaborates with other aspects of lifestyle to influence the molecular substrates of cognition; the understanding of the mechanisms by which exercise affects cognitive abilities has been nourished from several fronts as well as excellent performance is determined by adaptive changes in the mechanisms of heart rate (HR) regulation (Platonov, 2004; Solodkov, 2005; Blagoy, 2015; Galan, 2017; Andrieieva, 2017; Kozina, 2017; Melnyk, 2017). With respect to any physical activity we should consider physical load and the impact of physical intense exercise on psycho-emotional state and perceptual-cognitive performance that is dependent on the type of the induced physical exercise (Dudnuk, 2008).

This perspective is supported by the relevant academic literature in the domain of neurodynamic and psychophysiological functions that are critical for human psycho-emotional reactions to vigorous muscle activity. Available research includes essential background information detailing in modern professional or Olympic sports as one of the varieties of human extreme activity that is characterized by vigorous-intensity physical activity, increased requirements for vegetative energy resource base, coordination abilities and psycho-emotional state (Vysochin, 2001; Kovalenko, 2005; Korobeynikov, 2006; Lyzogub, 2007; Lazareva, 2016; Galan, 2016; Ivashchenko, 2017).

Much information is available on physiology of sports and sports medicine that highlights most works devoted to sports topics relate to athletes' typological characteristics of the functional state of their regulatory systems in different conditions of training, competitions and team practice sessions (Korobeynikov, 2008; Lazareva, 2010; Kozina, 2015; Bliznevsky, 2016; Lazareva, 2016; Korobeynikov, 2017). However, little is known about integral criteria for athletes' functional responses based on integrated assessment of their psychophysiological state. Regardless of lack of a single terminological notion of 'a human psychophysiological

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state', modern studies increasingly use the very term (Kokun, 2003). Besides the conceptual and technological problems already mentioned, a number of factors may account for the lack of research in this area, including the fact that few researchers have been interested or knowledgeable in both cognitive and psychophysiological issues.

The objective of this paper is to capture recent, detailed insights into the psychophysiological states experienced by athletes and highlight the present knowledge of reflective heart rate responses to the orthostatic load which is of crucial importance to our understanding of human normal muscle function.

From our point of view, the psychophysiological response of a human is determined by psychophysiological functions in humans exposed to stimuli, that is any intense physical activity or motion can alter responses, and basal levels of arousal and responsiveness can differ among individuals and even between situations. The notion of 'the functional state of a human body' denotes a functional system that is responsible for a particular type of activity. Simultaneously, scientific studies on the problem of changes in psychophysiological functions in conditions of extreme activity, aggravated with high psycho-emotional and physical stress have received scant attention from researchers, as a result, the authors inquire into this aspect, immensely developing and contributing to understanding of the importance of the characteristics of the functional organization of human psychophysiological responses in intensive muscular activity conditions. All abovementioned reasons and causes presuppose the novelty of our investigation.

Materials and Methods

Various methods were applied at the prime stage of our experiment as a means of familiarizing with the problems under study and enabling to elucidate what specific issues should be targeted. To judge the validity of our study we'd rather provide a clear and precise description of the research methods as followed: calculation method 'Cardio +' (Ukraine) was applied for a computer diagnostics of heart rate vegetative regulation as one of the components of human psychophysiological responses. The statistical parameters of cardio intervals in the dynamics of adaptation to stressful muscle activity were determined: namely, the average duration of RR intervals, the mean square deviation, the performance of Mode, the amplitude of Mode, the variational velocity, the stress index. At the same time heart rate spectral analysis parameters were recorded: VLF, LF, HF and LF/HF. In the analysis of nonstationary transients of the heart rate regulation system under the conditions of orthostatic loading, the skaterogram was used as a nonparametric method of analysis. The scaper parameters were defined: SD1 (display of periodic heart rate fluctuations) and SD2 (characteristic of slow heart rate fluctuations).

It should be emphasized, that the computer diagnostic method 'Diagnostic-1' (Ukraine) was applied to evaluate the state of psychophysiological functions. Data were analyzed by measuring sensorimotor variables in adapting to intense exercise: specifically, latent period of a simple visual-motor reaction, coefficient of variation of latent period of simple visual-motor reaction; reaction time of motor responses; latent period of three stimuli and motor response on two choice reaction time tasks; the temporal architecture of the central information processing; coefficient of variation of complex visual-motor reaction and reaction time of motor responses.

The critical importance of Spielberger's State-Trait Anxiety Inventory for scoring a human reactivity and hypertension susceptibility was demonstrated by concluding that anxiety levels may contribute to the variable blood pressure response to acute stressors and, therefore, should be assessed when measuring cardiovascular reactivity.

To examine our hypothesis, 107 male athletes were monitored: 83 of which were 18-25-year-old-aged high-skilled athletes – members of the Ukrainian team of Greco-Roman wrestling; and 24 athletes-unqualified competitors, school students and graduates from the specialized sports lyceum aged 16-22.

Noteworthy, the study was carried out in four stages**.** The first stage covered the characteristics of functional organization of human psychophysiological responses to intense muscular activity. The second stage included the investigation of the dynamics of a human adaptation to intense exercise; meanwhile the third stage was dedicated to the research of reflective heart rate responses to orthostatic challenges and finally the fourth stage comprised analysis and generalization of the findings, using methods of mathematical modeling.

Results

Obtained data of sensorimotor reactions and the level of adaptation to intense exercise are quite sufficient to support the conclusion about improvement in a human's visual perceptual processing capacity. Simultaneously, there is evidence that the information processing speed increases while adapting to intense exercise and results in the tension of heart rate regulatory mechanisms (Table 1).

It was studied and concluded that functional changes of the vegetative regulation of the cardiovascular system in intense exercise result in an autonomous heart rate regulation by reduced cardiac sympathetic tone. In addition to triggering on the balance of a human vagus-sympathetic tone under the conditions of adapting to intense exercise, we can't but mention about concurrent decline in sympathetic and parasympathetic divisions of the autonomic nervous system, which testifies to the human's adaptation to intense muscular activity.

Table 1. Sensorimotor variables in intense muscular activity adapting (median, upper and lower quartile)

Indices	Adaptation to intense muscular activity	
	High=27	Medium n=24
Latent period of a simple visual-motor reaction (ms)	278,21 246,75; 312	246,135 229,8; 286,44
Coefficient of variation of latent period of simple visual-motor reaction %	21,12 16,47; 29	30,115* 24,33; 36,49
Reaction time of motor responses, ms	114,215 99,62; 142	189,62* 164,84; 228,46
Latent period of three stimuli and motor response on two choice reaction time tasks (ms)	428,33 388,61; 482	447,465* 413,98; 492,68
Coefficient of variation of complex visual-motor reaction %	15,26 12,86; 19	16,945 16,49; 20,88
Reaction time of motor responses, ms	121 108,32; 146	204,415* 188,16; 232,97
The temporal architecture of the central information processing , ms	146,57 127,86; 185	201,165* 177,47; 220,02

Note: * - p <0.05, if compared to the group of subjects with a high level of adaptation to intense muscular activity.

Collectively, the wealth of research information provides extensive insight into the evidence of lesser impact of both sympathetic and parasympathetic tones on vegetative regulation of heart rate in the terms of adaptation to intense exercise. To study this process we conducted a mathematical modeling of the dynamics of capacity for vigorous muscular activity.

Presently, for practical reasons, we have taken into account the fact that the process of intense exercise adaptation is a discrete one and consists of a number of relevant physiological and psychophysiological responses of the human body, we have applied an analysis of the quantitative evaluation of information (to determine the appropriate psychophysiological state in people with different levels of adaptation to intense muscular activity (the Shannon entropy (Hm), which reflects human psychophysiological responses. Moreover, the ability to rapidly and accurately process visual information received with each eye movement is determined by the number of processed stimuli and the maximal option for processing one information stimulus.

The understanding of the mechanisms by which exercise affects cognitive abilities has been nourished from several fronts. In particular, the Shannon entropy analysis showed the functional possibility reserve of a human's cardiovascular system and the level of autonomic heart rate (HR) control as well as information processing.

Based on the earlier findings, the study of the formation of a functional organization of psychophysiological response in the dynamics of adaptation to intense exercise was conducted during the Ukrainian National Greco-Roman wrestling team practice session and training.

The dynamics of adaptation to intense muscular activity points out to faster speed of information processing based on complex sensory-motor response to the differentiation of stimuli. At different stages of adaptation to intense muscular activity the sheer speed of information processing increases owing to various components.

Cross-sectional research has also supported the association between information processing and reaction time during the mid-time team practice sessions, the increase of information processing occurred due to a motor reaction time decrease and the time of central processing of information, that is due to the speed and accuracy characteristics. To the point, faster speed of information processing occurs due to the improvement of qualitative characteristics closer to the end of the team practice session and training.

The growth of the information processing characteristics in the dynamics of adaptation to intense exercise occurs with the simultaneous increase in the level of tension of regulatory mechanisms by strengthening the sympathetic division of autonomic heart rate regulation.

The obtained data testify to the improvement of wrestlers' vagus-sympathetic balancing in the dynamics of adaptation to intense muscular activity. However, the attenuation of both high-frequency (HF) and low-frequency (LF) of heart rate variability spectra points to the phenomenon of simultaneous activation of the sympathetic and parasympathetic divisions of the autonomic nervous system that might be caused by physical exhaustion and stress (Table 2).

Table 2. Spectral analysis of heart rate variability in athletes' adaptation to intense exercise (median, upper and lower quartile)

Indices	Start	Midspan of the training	Finish
Very low frequency (VLF), ms^2	1890,12 1220,89; 2599,52	1803,38 749,55; 2702,54	842,32*** 177,87; 1281,89
Low frequency (LF), ms^2	1697,78 1377,38; 2386,93	2038,28* 1538,73; 4096,73	2056,55* 1651,34; 3240,89
High frequency (HF), ms^2	884,73 822,98; 1143,56	1010,38* 755,56; 1095,52	1585,57* 916,34; 2064,78
Ratio LF/HF	2,28 1,27; 2,91	2,15 1,48; 3,87	1,72*** 0,45; 2,83

Notes: We chose a critical p-value lower than 0.05 as significant
1.*-$p<0.05$, if compared to start of athletic training
2. **-$p<0.05$, if compared to mid-span of athletic training

Intra-subject analysis demonstrates that the information processing speed increases while adapting to intense exercise and results in the tension of heart rate regulatory mechanisms. To be more precise, midspan of the team practice session showed that the ability to rapidly and accurately process visual information received with each eye movement is determined by the number of processed stimuli and the maximal option for processing one information stimulus.

We hypothesized that a strenuous exercise would lead to substantial alterations in a certain human functional capacity that presupposes the internal systematic and inter-system interactions. For this purpose, Spearman rank correlation coefficient was applied to measure linear dependence between two variables that constitute the functional system responsible for the adaptation process. The result of the latter is human psychophysiological responses; let's say different physiological bases of psychological processes, in our case heart rate responses to stimuli during exertion. Elements of this functional system are indicators of psychophysiological functions and parameters of autonomic heart rate regulation.

The study attempts to quantify essential aspects of the formation of a functional organization of psychophysiological responses in the dynamics of adaptation to intense muscular activity, while conducting a bivariate analysis of psychophysiological function variables and the indices of autonomic control of heart rate regulation. Thus, our bivariate analysis testifies to the valid correlations in the dynamics of adaptation to intense muscular activity. It is concluded that at the beginning of the team practice session there is close interrelation between bases of psychophysiological state which maintains high level of efficient activity during trainings and competitions. The outcomes of our research point out that endurance training causes the effectiveness of the sensorimotor response and consequently, raises the heart rate regulation systems to its maximum. With regards to the central nervous system (CNS), the obtained data reveal, that the CNS, while processing information, respectively, enhances energy exchanges of cellular metabolism.

As a result, data obtained from this experiment indirectly supports a hypothetical framework of athletes' different cognitive processing abilities requiring different time for certain mental operations. From an information-processing perspective, motor behaviors consist of encoding relevant environmental cues through the utilization of attentional strategies, processing the information through an ongoing interaction between working memory and long-term memory, making an action-related decision; consequently athletes' with low cognitive processing abilities might reduce their efficient performance.

What is more, this article focuses on the impact of physical activity on cognition, since the team practice session showed that functional systems consist of multiple components, located at different levels and may be performed by variable neurophysiologic and psychological processes that require information processing. Furthermore, the effectiveness of sensorimotor response is interrelated with the state of the cardiovascular system. Perception and recognition of information increase results from local vasodilatation of the muscle vasculature caused by increased metabolism of the muscle cells. Additional increase results from a simultaneous elevation of arterial pressure and heart rate (leading to increased cardiac output) during the exercises; at the same time that the motor areas of the nervous system become activated to cause exercise, most of the reticular activation system of the brain stem is also activated, which includes greatly increased stimulation of the vasoconstrictor and cardio acceleratory areas of the vasomotor centre. The parasympathetic portion of the autonomic nervous system decreases sinus node automaticity and slows AV node conduction.

As a result, the dynamics of adaptation to intense muscular activity is characterized by efficient cognitive capacity. During the mid-time of practice sessions the speed of information processing improves due intense exercise. At the end of practice sessions, the speed of information processing increases with the improvement of qualitative characteristics.

It should be stressed that the visual skills required vary according to sport and subsequently demand the use of different aspects of visual processing. Monitoring heart rate appeared to be a reliable method for determining effort during exercise.

The findings from the present study suggest that extreme endurance exercise induced an increase of sympathetic activity, visual processing involved an amalgamation of the central nervous system, skeletal-muscular system and the visual system; in particular, the athletes, exposed to excessive amounts of strenuous exercise, experienced the autonomic nervous system response. No significant changes in the latency or amplitude of visual evoked potentials were observed in the athletes during the tests. Neural conductivity in the visual pathway after exercise partially dependent on the individual's personal training adaptation state spoke of the quality of visual information processing. These results confirm the possibility that physical exercise can facilitate improving mental performance and revealed the connection between physiological regulations of human functional systems: heart rate regulatory mechanisms and visual information processing systems.

One of the most cutting edge trends of physiological cybernetics is the diagnosis of human psychophysiological responses in different conditions. Psychophysiological responses represent the integral complex of elements of a functional system, which is responsible for an athlete's effective performance. Significantly, intense exercise can selectively facilitate multiple cognitive processes i.e. under certain conditions; in addition, exercise can enhance response accuracy and response speed as well as facilitate the cognitive processes which are central to goal orientated actions and problem-solving.

Taking into account martial arts and wrestling, the authors single out three key components of an athlete's psychophysiological response ensuring effective performance: autonomic nervous system reactivity, motor coordination, and emotional episode.

A-three-component model (somatic-vegetative, psychophysiological and emotional) was constructed to serve as a unifying thread for better understanding athletes' psychophysiological responses (Table 3).

Table 3. Differential assessment of athletes' psychophysiological responses

Indices	**Psychophysiological assessment**				
	High	**High medium**	**Medium**	**Low medium**	**Low**
	5	**4**	**3**	**2**	**1**
Somatic-vegetative component					
R-R intervals of the ECG, (ms)	≥0,83	0,82-0,78	0,77-0,70	0,69-0,62	≤0,61
Root-mean square differences of successive R-R intervals (ms)	≥0,098	0,097-0,086	0,085-0,051	0,05-0,021	≤0,02
Psychophysiological component					
The latent period of simple sensorimotor reactions (ms)	≤189	190-236	237-268	269-315	≥316
The latent period for a complex reaction (ms)	≤344	345 – 427	428 – 482	483 – 565	≥566
Emotional component					
Reactive anxiety	≤27	28-33	34-39	40-45	>45

The next step to be undertaken was the statistical analysis of the heart rate variability through evaluation of the somatic-vegetative component. The psychophysiological component was investigated according to the latent period s of simple and complex visual-motor reactions (the choice of two of the three stimuli): parameters of the average latent periods of the simple and complex visual-motor reaction, coefficients of variation of the latent periods of the simple and complex visual-motor reaction, the number of errors in processing of information, time of motor reaction and time of central processing of information. The emotional component was determined according to Spielberger's (STAI) questionnaire, there was measured the level of reactive anxiety and emotional stability of the person.

The research has shown that athletes with different cognitive processing abilities need different time for certain mental operations. From an information-processing perspective, motor behaviors consist of encoding relevant environmental cues through the utilization of attentional strategies, processing the information through an ongoing interaction between working memory and long-term memory, making an action-related decision; consequently athletes' with low cognitive processing abilities might reduce their efficient performance.

The division of the surveyed athletes into adaptive groups was performed according to their psychophysiological responses, enabling authors to considerably improve the differentiated diagnosis of heart rate variability. Studies have found that athletes with high-intensity psychophysiological response showed the improvement in their sensorimotor functions.

Within this framework, cognition encompasses a wide variety of CNS activities ranging from sensory registration to the complex processes involved in problem solving and the generation of new responses from previously learned information. Obviously, a tremendous number of different physiological mechanisms could be involved in the various aspects of information processing. Studies show that deceleration capacity is a psychological concomitant of an athlete's level of cognitive processing, as a consequence, can negatively affect their sporting excellence.

Furthermore, studies evidenced that athletes with high-intensity psychophysiological response show inalterability of psychophysiological component in the dynamics of adaptation to intense exercise. In particular, a more positive affective response occurred during the moderate-intensity trial than during the vigorous-intensity trial. The results indicate that there were no significant correlations of the intensity preference and the self-efficacy components with the psychophysiological responses.

This finding demonstrates that the changes in affective responses to exercise differed as a function of the exercise intensity trial. In order to form a functional system responsible for adaptation to intense exercise, the definition of the measure of the organization of the system of information processing and the system of vegetative regulation of the heart rate in the dynamics of adaptation (R, Antonomov Yu., 1968) was used. It is concluded that at the beginning and the end of the team practice session athletes with high indices of psychophysiological response, if compared to athletes with medium indices, showed more adjusted autonomic control of heart rate regulation. Midspan of the team practice session, however, showed that the ability to rapidly and accurately process visual information is considerably reduced, pointing out to the autonomic regulatory drives within a transitional period of the AOT, that, eventually, enhanced the active orthostatic test results. In athletes with relatively balanced ergotropic and trophotropic effects, the AOT transitional period was characterized by correlations of nearly all indices of autonomic regulation of the heart rate.

The revealed tendency points out to the regularity of the growth of the system of perception and processing of information in athletes in the dynamics of adaptation to intense exercise. As noted previously, emotional episode has been considered central to the ANS stimulus accompanying cognitive tasks. Significantly, emotional experience is tested and considered to be a function of the perception of afferent feedback from peripheral organ systems. Emotion was believed to reflect the physiological activation occurring in differential response patterns related to the nature of the stimulus condition. On a larger scale, identifiable peripheral response patterns may reflect differences in the psychophysiological response accompanying the information processing demands of a task. Hence, the differential response to different emotions appears to be a fairly robust finding that occurs even in the presence of imagined emotional situations.

Thus, our study examined the impact of psychological states on physiological system responses in the process of adaptation to intense exercise. From an adherence perspective, stochastic psychophysiological state indicates an imperfection of the corresponding regulatory mechanisms of adaptation or transition, which results in the search and transition of the functional system to the optimal level of functioning.

One of the key components of the psychophysiological state of a person in conditions of intense exercise is autonomic control of heart rate regulation. There are many different approaches to detecting the nature of the response of the cardio-interval system to the corresponding orthostatic load. However, heart rate variability (HRV) as a relevant marker reflecting cardiac modulation by sympathetic and vagal components of the autonomic nervous system (ANS) was assessed for tracking the time course of training adaptation/maladaptation of athletes and in setting the optimal training loads leading to improved performances. Notably, active orthostatic test, assessing the orthostatic cardiovascular adjustments, was done.

The active lying-to-standing test using continuous blood pressure monitoring was applied to study the quick cardiovascular responses directly after active standing and could detect initial orthostatic hypotension; the central volume of blood decreased by about 20 percent; the cardiac output was about 1-2,7 liters/minute[1]. As a result, the arterial pressure fell, being a strong stimulus for central chemo receptors on baroreflex function. Heart rate variability analysis was done over a sympathetic maneuver, active orthostatic test (AOT) and a vagal one; skaterogram indices were studied. When analyzing an orthostatic test, it is necessary to take into account that transient processes of regulation of the heart rhythm that arise during a load are nonstationary. Therefore, nonparametric methods are used to analyze these processes, one of which is a skaterogram. According to existing concepts, the analysis of the RR-variability skaterogram gives information on periodic (mostly slow) and aperiodic (random) fluctuations of the heart rate.

To gauge heart-beating during intense physical activity/ processing of records of RR-intervals, we built the skaterogram. The scaper parameters were defined: SD1 (display of periodic heart rate fluctuations) and SD2 (characteristic of slow heart rate fluctuations). The reduced heart rate results from an increase in activity of the parasympathetic nervous system, and from a decrease in activity of the sympathetic nervous system. The activity of periodic slow heart rate fluctuations reflects the longitudinal proportion of the scale axis (SD2). Random aperiodic fluctuations of cardio intervals are represented by the transverse axis of the skaterogram (SD1). Regarding the physiological mechanism aspect of appropriate heart rate fluctuations, the SD1 reflects the sympathetic, and SD2 is a parasympathetic activation of the autonomic heart rate regulation. In addition, the ratio of the indicator SD1 to the indicator SD2 reflects the predominance of the sympathetic tone over parasympathetic under the conditions of external influences.

Aiming to assess the effect of psychophysiological and functional states on exercise performance identify, an orthostatic test engaged 29 high-skilled athletes who can smoothly adapt to intense exercise. According to the previous analysis of the system of heart rate variability, scale to assess the comprehensive symptom burden and severity of neurogenic orthostatic hypotension (NOH) was suggested: optimal, moderate intensity, excessive loading. It was studied and concluded that functional changes of the vegetative regulation of the cardiovascular system in intense exercise result in an autonomous heart rate regulation by reduced cardiac sympathetic tone. In addition to triggering on the balance of a human vagus-sympathetic tone under the conditions of adapting to intense exercise, we can't but mention about concurrent decline in sympathetic and parasympathetic divisions of the autonomic nervous system, which testifies to human's adaptation to intense muscular activity. The obtained data testify to the improvement of wrestlers' vagus-sympathetic balancing in the dynamics of adaptation to intense muscular activity. However, the attenuation of both high-frequency (HF) and low-frequency (LF) of heart rate variability spectra points to the phenomenon of simultaneous activation of the sympathetic and parasympathetic divisions of the autonomic nervous system that might be caused by physical exhaustion and stress.

It should be stressed out that the experimental verification revealed that 34 per cent of monitored participants experienced optimal heart rate response to orthostatic load; 52 per cent had moderate heart rate regulation and 14 per cent experienced overstrain heart rate regulation.

Discussion

A thorough conceptual literature review, a meta-analysis and research findings of both domestic and foreign scholars underpin the principal aim of our research on assessing human psychophysiological responses to intense exercise: a survey of Greco-Roman wrestlers and unqualified competitors. These findings indicate that there is a tendency to decrease the absolute values SD1 and SD2 in the lying state, namely, at orthostatic test the heart rate response decreased significantly. It was found that periodic fluctuations predominate in individuals with different types of reaction to orthostatic loading.

This indicates the fact that the corresponding physiological reaction is not sufficiently located in the lying position. The authors conclude that sympathetic and parasympathetic influences on the heart are determined by adapting to load challenges and achieving optimal performance. Power spectral analysis of heart rate variability (HRV) has been used frequently to assess cardiac autonomic function. LF power is tested to provide an index not of cardiac sympathetic tone but of baroreflex function. Several lines of evidence, however, argue against the validity of LF power, with or without adjustment for HF or total power, as an index of sympathetic outflow especially to the heart. Yet, our strong conviction is further research is needed on possible in-depth analysis of heart rate variability (HRV) as a relevant marker reflecting cardiac modulation by sympathetic and vagal components of the autonomic nervous system (ANS) in the context of physical exhaustion and stress.

Conclusions

Evidence-based data give us the grounds to declare the effect of vigorous sports specific exercises on performance related parameters required for sporting excellence. The study of psychophysiology of emotion has provided an important foundation upon which an understanding of the relationship between electrophysiological activity and cognitive processing can be based. Thus, athletes need to engage in correct training programs which include sports specific exercises in order to achieve and maximize sporting excellence.

The research has shown that athletes with different cognitive processing abilities need different time for certain mental operations. From an information-processing perspective, motor behaviors consist of encoding relevant environmental cues through the utilization of attentional strategies, processing the information through an ongoing interaction between working memory and long-term memory, making an action-related decision; consequently athletes' with low cognitive processing abilities might reduce their efficient performance.

This is the first study to show acute, substantial psychophysiological responses to intense exercise in wrestlers, that is the consistency of different functional systems of the human body has been proved in the conditions of psychophysiological state formation.

The authors delved into this aspect, immensely developed and contributed to understanding the importance of the effectiveness of sensorimotor response interrelated with the state of the cardiovascular system. Perception and recognition of information increase results from local vasodilatation of the muscle vasculature caused by increased metabolism of the muscle cells. Additional increase results from a simultaneous elevation of arterial pressure and heart rate (leading to increased cardiac output) during the exercises; at the same time that the motor areas of the nervous system become activated to cause exercise, most of the reticular activation system of the brain stem is also activated, which includes greatly increased stimulation of the vasoconstrictor and cardio acceleratory areas of the vasomotor centre.

The actual material on the functional organization of an athlete's psychophysiological responses in the dynamics of adaptation to intense muscular activity is obtained. It was found that results of our studies suggest the adaptation to intense exercise facilitates biological determinism and autonomic nervous system response patterns of relevant psychophysiological responses.

Competing Interests

The authors declare that they have no competing interests.

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