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**МЕЖДИСЦИПЛИНАРНЫЕ ИССЛЕДОВАНИЯ |
INTERDISCIPLINARY STUDIES**

Psychophysiological and Psychoendocrine Approaches in Foreign Studies of Stress Response in Police Officers

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The article presents a review of psychophysiological and psychoendocrine approaches in foreign studies of stress response in police officers. The main vectors of psychophysiological response to stress in representatives of dangerous professions are identified. It has been determined that, in combination with the autonomic nervous and immune systems, the hypothalamic pituitary adrenal axis is involved in the formation of an individual response to chronic stress. The main emphasis of foreign works devoted to the study of the psychoendocrine component of the stress response in police officers is to study the influence of the dehydroepiandrosterone and cortisol. Modern technologies for recording stress indicators was also being studied. Further study of psychophysiological and psychoendocrine approaches in studies of stress response in police officers from the point of view of their integration seems promising.

Keywords: psychophysiological approach, psychoendocrine approach, stress response, police.

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Статья представляет собой обзор психофизиологических и психоэндокринных подходов в зарубежных исследованиях стрессового реагирования у полицейских. Выделены основные векторы психофизиологического реагирования на стресс у представителей опасных профессий. Определено, что в сочетании с вегетативной нервной и иммунной системами гипоталамо-гипофизарно-надпочечниковая ось участвует в формировании индивидуальной реакции на хронический стресс. Основной акцент зарубежных работ, посвященных изучению психоэндокринной составляющей стрессового реагирования у полицейских, делается на изучении влияния гормонов ДГЭА и кортизола. Также изучаются современные технологии регистрации показателей стресса. Перспективным представляется дальнейшее изучение психофизиологического и психоэндокринного подходов в исследованиях стрессового реагирования у полицейских с точки зрения их интеграции.

Ключевые слова: психофизиологический подход, психоэндокринный подход, стрессовое реагирование, полицейские.

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Introduction

The incidence of mental disorders among police officers exceeds the incidence of the population of the Russian Federation by 1.3 times, while 75% of mental health disorders are neurotic, stress-related, and somatoform disorders, which can be fully compensated with timely diagnosis and comprehensive treatment [1]. It has been shown that professional stress of representatives of dangerous professions has a negative impact on self-regulation processes, leads to a decrease in labor efficiency, loss of productivity and making erroneous and risky decisions.

It has been proven that stress factors are associated with short-term impairments and long-term health consequences, the emergence of conflicts between work and family, maladaptive behavioral strategies, and burnout in police officers [10; 15]. The impact of stress on the organization as a whole reduces employee productivity [12; 38], emergence of counterproductive work behavior [56] and inappropriate interactions with citizens by using an excessive force [19; 32; 54].

The police profession in society, increased social responsibility for the results, submission to certain requirements and the development of a set of personal qualities and legal consciousness limit the possible discussion of mental health problems and support in this organizational environment [9].

In most studies related to the study of the impact of professional activity on the mental health of specialists, whose work is associated with intense emotional and physical stress, the attention of scientists was focused on a sample consisting exclusively of men. However, the number of female law enforcement officers of the Ministry of Internal Affairs of Russia and abroad, recently, has been steadily growing. According to EUROSTAT (2022), female police officers constitute an average of 21.28% in European police forces [26]. In Russia, all police departments have female officers, their total number reaches 30-50% of the total number of employees: the largest number is in the preliminary investigation units (76.2%), the smallest number is noted in the criminal investigation department (9.5%) [6].

The stress response is an innate, stereotyped, adaptive response to stressors that develops during the process of restoring a non-stressful homeostatic level. It is encoded in specific neuroanatomical regions that activate a specific set of cognitive, behavioral and physiological phenomena. Adaptive reactions, although necessary for survival, can become unregulated and lead to disease [2]. Scientists come to the conclusion that psychovegetative syndrome may be an early initial phase of a psychosomatic or mental illness [3].

Psychophysiological Approach to the Study of Stress Response

It was revealed that stress plays an important role in the formation and maintenance of goal-directed behavior. The stress-induced relapse hypothesis [55] explains this by instrumental learning deficits and reduced goal-directed behavior, reinforcing the types of responses that are habitual for an individual: the choice of behavior is not determined by predictive validity, but by previous favorable experiences with a similar behavior tactics. Acute stress is associated with a shift in brain activation from the ventral (decreased goal-directed behavior) to the dorsal striatum (increased activation of areas responsible for habitual behavior), decreased activation of the right amygdala, infe-

rior/middle frontal gyrus, putamen, reducing the differentiation of judgments about a possible outcome, suppressing learned reactions and using familiar strategies.

It has been shown that the stress response vary across different types of environmental stressors, which are regulated by neuromodulator systems (orexin/hypocretin neuropeptides) that act through different receptors in pro- and anti-stress neurocircuits [48]. Thus, the presence of such a psychological element as control can change the nature of the reaction to stress.

The results of studying the influence of acute stress on the psychophysiology of representatives of dangerous professions showed that the reaction to stress includes a cascade of adaptive neurophysiological reactions initiated by the brain and periphery through the autonomic nervous system and the hypothalamic-pituitary-adrenal axis [58]. The two major components of the stress response have been shown to be the sympathoadrenal medullary system and hypothalamic pituitary-adrenal axis, with the sympathoadrenal medullary system primarily involved in the acute response and the hypothalamic pituitary-adrenal axis being responsible for long-term protection [45].

Besides it was shown that hippocampus is the brain region where glucocorticoid receptors are found [43; 58]. It was found that their activation leads to inhibition of the hypothalamic pituitary-adrenal axis [43] and this has an impact on modulating the adult response to stress and is the formation of learning skills and long-term memories. A sustained decrease in glucocorticoid receptors through epigenetic mechanisms leads to decreased sensitivity to stress hormones. This leads to a decrease in the process of inhibition of the hypothalamic pituitary-adrenal axis. In turn, this affects the increase in the severity of the endocrine response to stress in adulthood and there is deterioration in spatial memory and a decrease in mnemonic functions. Conventionally, the hippocampus is divided into dorsal and ventral parts, which differ in sensitivity to stress: the ventral part is responsible for anxiogenesis (a complex behavioral process involving the neurotransmitter and hormonal systems), restoration of traumatic memories and defensive reactions [33], the dorsal part is responsible for on spatial memory and its modulation in connection with stress [48].

It was revealed that stressors are determined by both real and perceived (psychogenic) stimuli, activating adaptive systems. Internal and external stimuli activate the hypothalamic pituitary adrenal axis [35], which is responsible for organizing the effective use of the body's resources. Neurons of the paraventricular nucleus of the hypothalamus secrete corticotropin-releasing hormone and are transported into the blood vessels, as a result of which the anterior pituitary gland secretes adrenocorticotropic hormone, which is responsible for regulating the secretion of cortisol. In addition to the hypothalamic pituitary adrenal axis, the sympathoadrenal medullary system plays a regulatory role, leading to a general change in the homeostasis of the body and releasing catecholamines (norepinephrine and adrenaline) into the blood, regulating the level of glucose, oxygen and blood supply, which ensures optimal muscle functionality. Although short-term activation of systems may be adaptive to maintain body homeostasis (allostasis), chronically elevated or dysregulated allostasis (allostatic load) can lead to metabolic dysfunction and disease development [16].

It should be noted that studies have shown that chronically elevated cortisol levels and dysfunction of the feedback system within the hypothalamic pituitary adrenal axis play an important role in stress responses, while hyporesponsiveness of this axis is associated with increased susceptibility to chronic diseases [20].

A recent study of an acceptability of a real-time notification of stress and access to self-help therapies among law enforcement officers [36] was conducted to study stress in real time using a specialized FitBits smartwatch that sends notifications when high levels of stress in the form of vi-

bration and visualization at high heart rates, as well as notifications about breathing exercises. The following factors caused an increased heart rate response in police officers: calling, using a weapon, following a suspect, reading dispatch notes reading dispatch notes on the way to their work. Thus, physiological markers of stress and personal technologies have increased police officers' awareness of stress. Also it has helped them start using stress reduction techniques in time and coordinate their actions more effectively [36].

Psychoendocrine Approach to the Study of Stress

Endocrine mechanisms of stress are an important component of studying psychoendocrine correlates of risky behavior and risky decision-making. The endocrine system plays one of the leading roles in the formation of the regulation of the compensation mechanism for various extreme factors affecting the body [5]. From a physiological point of view, each individual stimulus causes a complex neuroendocrine response aimed at overcoming extraordinary circumstances. It is now known that the sympathoadrenal and pituitary-adrenal axis form a nonspecific response to a wide range of stimuli. However, the nature of the stressor, the individual assessment of the stressful situation that has arisen, and the subject's behavior strategy during stress determine the presence of a specific component in the body's reaction.

In modern foreign works, potential diagnostic biomarkers of stress have been identified [47]:

1. metabolic biomarkers: glucose, glycosylated hemoglobin, cholesterol level, triglycerides;
2. endocrine hormones: prolactin, estradiol, oxytocin, growth factor and dehydroepiandrosterone sulfate (DHEAS), cortisol, dehydroepiandrosterone (DHEA);
3. enzymatic and non-enzymatic antioxidants: superoxide dismutase, catalase, glutathione peroxidase, malondialdehyde, ascorbic acid (it participates in the processes of the antioxidant defense system, which is one of the natural defense systems against the harmful effects of reactive oxygen species causing oxidative stress). Therefore the hypothalamic pituitary adrenal axis, the autonomic nervous system, and the immune system are involved in shaping the individual response to chronic stress.

A number of modern studies on the effects of stress on human health, including police officers, have shown a connection between the DHEA/cortisol ratio and the development of disorders in the cardiovascular, nervous and reproductive systems, as well as social adaptation [40; 60]. It was determined that the ratio of dehydroepiandrosterone (DHEA) to cortisol should be considered as a key marker of the body's resistance to any stress [23]. Moreover, to ensure adequate protection in the body, the level of DHEA must always prevail.

There is evidence of differentiation of the cortisol/DHEA ratio depending on the leading affect: anxious, mixed or apathetic [4]. It was found that the ratio of DHEA and cortisol concentrations decreases in proportion to the strength of stress exposure.

Cortisol has been shown to be an end product of the hypothalamic pituitary adrenal axis and helps the body adjust and adapt to internal and external demands [29]. The reliability of salivary cortisol measurements has been demonstrated in short-term stress assays, while hair cortisol assays have been used to measure allostatic load caused by chronic cortisol exposure over a long period of time [31]. Changes in cortisol levels follow a circadian rhythm, are subject to distortion by environmental factors [29] and involve three discrete components: 1) the cortisol awakening response, characterized by a sharp increase in cortisol levels immediately upon waking, followed by a sharp decrease over the next few hours; 2) a gradual decrease in cortisol levels throughout the rest of the

day, reaching its lowest point in the first half of the sleep period (around midnight); 3) an increase in cortisol levels in the second half of sleep (the period before awakening).

Disruption of circadian rhythm and cortisol signaling can affect the functioning of central and peripheral systems, leading to the development of negative health consequences. A systematic review and meta-analysis of diurnal cortisol slopes and mental health found that smoother diurnal cortisol rhythms throughout the day are associated with poorer mental and physical health (depression, internalizing disorder, externalizing disorder, fatigue, immune/inflammatory processes, obesity) [7].

Research findings have shown that chimeric antigen receptor is widely used as a biomarker of hypothalamic pituitary adrenal axis sensitivity to stress and is considered a reliable indicator of cumulative or allostatic load on the body, predicts mental health outcomes health, including dissociation, acute stress disorder and depression, morbidity and mortality rates in police officers and other populations.

In the work of Violanti J.M. (2016), a sharp “dulling” of the cortisol pattern — a damped or flat profile — after awakening was associated with events that police officers identified as stressful: contact with children on calls; murder in the line of duty; situations requiring the use of force; physical attack on a person. Those with low stress scores had a sharp and sustained increase in cortisol levels upon awakening compared to baseline, while officers with moderate to high stress scores had a less pronounced response. Wirth et al. studied the effect of shift work on cortisol levels in police officers: cortisol levels upon awakening were lower in police officers working a rotating schedule (night and day shifts) than in a group of police officers working only day shifts. Physical activity may act as a protective factor by regulating cortisol levels and improving sleep quality in officers [28]. Gender differences have also been reported in factors — sexual dimorphism in brain structures modulating hypothalamic pituitary adrenal axis activity, differences in gonadal steroid hormone secretion, and globulin levels — influencing basal and stress-related hypothalamic pituitary adrenal axis activation and, accordingly, on cortisol levels [29]. A study of hair cortisol concentrations showed an association between cortisol and emotion dysregulation, suggesting a sex-specific association between these measures. However, the perception of stress and regulation of emotions did not differ by gender. Elevated cortisol levels normalize more quickly in men [57] due to greater expression of glucocorticoid receptors, so there may be a link between emotional dysregulation and high hair cortisol levels — a sign of chronic elevation hormone in previous months is quite difficult to diagnose [34; 52].

The neurovisceral integration model [59] proposes that vagal activity indicates an individual’s ability to self-regulate: higher vagal activity allows for greater adaptability and greater behavioral flexibility in challenging environments. According to the reactivity hypothesis [17], exaggerated physiological reactivity to stress poses a health risk, and blunted physiological reactivity tends to be a more adaptive response. However, findings from a study of vagal activity in people with symptoms of depression and burnout support the notion that both exaggerated and blunted physiological responses to stress may be maladaptive and have adverse health consequences. Blunted cardiovascular reactivity is associated with depressive disorder [24; 25; 50] and neuroticism [37]. High levels of police stress (administrative and physical) are also associated with blunted diurnal declines in cortisol levels [8]. A similar point of view is considered by Bhatnagar [13]: a low and inhibited reaction after a stressful stimulus reflects not only stability, but also the absence of an initial reaction to stress, thereby confirming that the same result can indicate opposite qualities of the subjects [13]. Constant adaptation of the hypothalamic pituitary adrenal axis to various stressful stimuli ultimately

leads to its pathological functioning: the response will be exaggerated or minimal, which is reflected in the pattern of cortisol secretion or the amount of the hormone. Stress-related incidents cause a lower or blunted cortisol response [21]. Similar findings are reflected in a study of emergency operator stress levels: chronic exposure to stress can lead to cortisol hyporeactivity [11].

It was determined that according to attentional control theory [27], anxiety reduces the level of attentional control and influences the priority processing of external and internal information that is not related to the goal or threat. Under conditions of acute stress, elevated cortisol levels influence cognitive performance through a shift from goal-directed control to stimulus-driven behavior [35], leading to decreased performance on perceptual-motor tasks [18]. The opposite results were shown in the Regehr's et al. work [51]. It was found that greater cortisol release in response to a realistic police scenario is associated with high performance among police recruits. Thus, stress reactions may reduce efficiency of work but do not necessarily affect its productivity. Attentional control theory posits that decreased performance can potentially be overcome by engaging in additional mental effort.

It was shown that self-control has a positive effect on perceptual-motor performance under stress and can counteract attentional deficits [30]. A similar theory is supported by a study in which police officers with high levels of self-control, heart rate, and anxiety maintained accuracy during shootings [41]. Rather than expending extra effort to suppress their emotional reactions, officers with high self-control made extra mental effort to maintain focused attention. Self-monitoring helps police officers prevent the influence of psychophysiological stress reactions on behavior and attention, without reducing the emotional reaction itself. Attempting to suppress or change unwanted thoughts and emotions during a stressful situation can be counterproductive by reducing the focus of attention [30, 44].

Simultaneously with cortisol, the adrenal glands synthesize dehydroepiandrosterone (DHEA), providing an antagonistic effect and having neuroprotective, antioxidant, antiglucocorticoid and anti-inflammatory effects. Due to intracellular passive diffusion, DHEA enters saliva, which facilitates its collection for analysis. The level of this steroid hormone increases with the onset of puberty; with age, the amount of androgens (DHEA and DHEA-S) decreases; in older people, its gradual decline occurs [42].

However, according to the results of a study by Noser E. et al. [46], high levels of DHEA in men (40-75 years old) are associated with levels of exhaustion. DHEA has also been implicated as a biomarker for neuropsychiatric disorders and high levels of anxiety. The ratio of DHEA and cortisol levels may signal possible dysregulation of the hypothalamic pituitary adrenal axis activity and high/low levels of stress tolerance [34]. From a practical point of view, an increase in DHEA has a positive effect on professionals experiencing increased levels of stress at work (e.g. police officers, etc.), making them more capable and decisive in their actions [49]. At the same time it is noted that they have less pronounced signs of anxiety and emotional tension [14]. High concentrations of DHEA act as a protective factor in the development of depressive symptoms and adaptation to poor sleep quality [56]. Also, increased concentrations of DHEA in hair are characteristic of individuals exposed to trauma and may indicate an intense phase of confrontation with traumatic stress. There are also suggestions [52; 53] that stress in early life "tunes" the hypothalamic pituitary adrenal axis to greater secretion of the hormone DHEA, thereby influencing individual development and subsequent response to stress.

Conclusions

The present review made it possible to systematize the ideas of foreign scientists about the psychophysiological and psychoendocrine approaches to stress response in police officers. The main vectors of psychophysiological response to stress in representatives of dangerous professions are associated with the study of the hypothalamic pituitary adrenal axis and the sympathoadrenal medullary system, which play a regulatory role. Moreover, in combination with the autonomic nervous and immune systems, the hypothalamic pituitary adrenal axis is involved in the formation of an individual response to chronic stress. It should be noted that the bulk of the research of the psychoendocrine component of stress response in police officers is devoted to the influence of the dehydroepiandrosterone and cortisol.

As shown by the review foreign scientists consider the reaction to stress in police officers combining psychophysiological and psychoendocrine approaches, which complement and explain each other. In this regard, further research prospects lie in the integration of these two approaches.

Also, due to the specific nature of police work, the study of modern technologies of recording stress indicators deserves special attention. The use of such technologies will allow respond promptly to changes in the body and provide timely assistance in stressful situations of policemen.

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