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Research Article

The application of modern psychophysiological hardware and software complexes in prediction of resistance to combat psychological stress

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Modern concepts about the dynamics of states of servicemen following combat mental trauma are presented. Psychological mechanisms of the development of post-traumatic stress disorder are described. The results of the psychological examination of servicemen-combatants are briefly summarized. It is shown that 40% of them have negative psychological consequences of combat stress in the form of signs of partial post-traumatic stress disorder, which correlate with manifestations of neurotic disorders. Signs of partial post-traumatic stress disorder in healthy military combatants reduce the self-assessment of the quality of life but do not significantly affect the professional aspect of social functioning in favorable conditions, which does not allow identifying the presence of negative psychological consequences of combat stress by commander expert assessment.

In addition to the psychological examination, the servicemen underwent stress testing on the "Rehacor" hardware psychophysiological software complex, which consisted in the fact that the subject was alternately presented with stress stimuli consisting of video and audio sequences on the monitor screen and in headphones in accordance with a pre-compiled scenario. In the course of stress testing the physiological parameters of the subject were recorded. In military personnel with signs of partial post-traumatic stress disorder, a decrease in the threshold of sensitivity to stress was found, which in combat conditions can lead to the development of acute stress-induced mental disorders and be the reason for the growth of violations, mistakes, the adoption of incorrect operational and tactical decisions, the demoralization of personnel, the growth of sanitary and irretrievable losses and losses of military equipment and weapons.

Based on the physiological parameters obtained during stress testing, a method for diagnosing signs of partial post-traumatic disorder has been developed. This method makes it possible to objectify the identification of the negative psychological consequences of combat stress and can be used in the interests of psychological and psychiatric intelligence.

Keywords: combat psychological stress; military combatants; psychological and psychiatric intelligence; partial post-traumatic stress disorder; psychophysiological hardware and software complex; psychophysiological stress testing; stress resistance.

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Научная статья

Использование современных психофизиологических аппаратно-программных комплексов в прогнозировании устойчивости к боевому стрессу

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В статье приведены современные представления о динамике состояний военнослужащих после боевой психической травмы. Описаны психологические механизмы развития посттравматического стрессового расстройства. Изложены результаты психологического обследования военнослужащих-комбатантов. Показано, что у 40 % из них имеются негативные психологические последствия боевого стресса в виде признаков парциального посттравматического стрессового расстройства, которые взаимосвязаны с проявлениями невротического регистра. Признаки парциального посттравматического стрессового расстройства у здоровых военнослужащих-комбатантов снижают самооценку качества жизни, но не оказывают заметного влияния на профессиональный аспект социального функционирования в благоприятных условиях, что не позволяет идентифицировать наличие негативных психологических последствий боевого стресса по экспертным оценкам командиров.

Помимо психологического обследования военнослужащие проходили стресс-тестирование на аппаратном психофизиологическом программном комплексе «Реакор», которое состояло в том, что обследуемому на экране монитора и в наушники в соответствии с предварительно составленным сценарием поочередно предъявляли стресс-стимулы, состоящие из видео- и аудиорядов. В ходе стресс-тестирования регистрировали физиологические показатели обследуемого. У военнослужащих с признаками парциального посттравматического стрессового расстройства обнаружено снижение порога чувствительности к стрессу, что в условиях боевых действий может приводить к развитию острых стресс-индуцированных психических расстройств и быть причиной роста нарушений, ошибок, принятия неправильных оперативно-тактических решений, деморализации личного состава, роста санитарных и безвозвратных потерь и потерь боевой техники и вооружения.

На основании физиологических показателей, полученных при стресс-тестировании, разработан способ диагностики признаков парциального посттравматического расстройства. Этот способ позволяет объективизировать выявление негативных психологических последствий боевого стресса и может быть использован в интересах психолого-психиатрической разведки.

Ключевые слова: боевой психологический стресс; военнослужащие-комбатанты; парциальное посттравматическое стрессовое расстройство; психолого-психиатрическая разведка; психофизиологический аппаратно-программный комплекс; психофизиологическое стресс-тестирование; стрессоустойчивость.

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BACKGROUND

Combat stress is one of the main damaging factors of military operations, which can lead to significant personnel losses because of the development of mental disorders. Mental disorders related to combat mental trauma can be acute or delayed. Acute mental disorders are transient mental disorders of varying severity that last several hours or days. Posttraumatic stress disorder (PTSD) is the most common among delayed mental disorders, which can be noted for several weeks, months, or years. Statistical data on the prevalence of mental disorders was contradicting because of the different nature of accounting and assessment criteria, such as diagnostic approaches, nature or stage of the armed conflict, and category of the servicemen examined. Thus, in 1945, during the fighting on Okinawa Island, Japan, relocates from the combat zone, because of combat psychological stress in American troops, accounted for 48.8% of the total number of wounded. In the Korean conflict, this figure decreased to 20%–25%, and during the Vietnam War, it increased significantly again, reaching 35%.

According to various data from American researchers, PTSD is clinically diagnosed in 12.5%–44.0% of combatants, and individual signs, partial PTSD (PPTSD), are detected in 63.0%–91.5% of healthy military personnel, often accompanied by deviant forms of behavior (suicidal, addictive, delinquent, etc.). Thus, by the early 1990s, approximately 100 thousand Vietnamese veterans committed suicide and 40 thousand combatants lived aloof from the world. Many American sources emphasize that the number of suicides far exceeds the number of those killed in the war. A high violence rate and issues in family relations and social contacts were noted among this category of veterans [1].

Numerous and sometimes contradictory concepts have described mechanisms of PTSD development, based on the physiological, psychological, phenomenological, sociocultural, and other levels of research. Currently, the category of concepts that best explain the mechanisms of PTSD development includes biopsychosocial models of the occurrence of this disorder, in which three groups of pathogenetic factors (biological, psychological, and social) correspond to three groups of etiopathogenetic mechanisms (psycho-traumatic situations, personality characteristics, and disease aspects). An example of such an approach is the A. Maercker multifactorial concept [2]. In this concept, three main groups of factors, the combination of which causes PTSD, were deemed important:

1) Factors associated with a traumatic event, namely, injury severity, suddenness, and uncontrollability.

2) Protective mechanisms of coping, namely, the ability to comprehend the event and the presence of social support.

3) Risk factors, namely, age, negative past experience, history of mental disorders, intelligence level, and socioeconomic living conditions.

As one of the mechanisms, PTSD is considered a disorder of intrapsychic adaptation following exposure to combat psychological stress. Adaptation after exposure to psychological traumatic stress can develop depending on the situation, i.e., positive, negative, and mixed scenarios. Following an injury, the initial period of an acute emotional reaction to stress lasts for 1 month, and gradually, the severity of the primary experiences weakens and disappears completely. With positive adaptation, the gradual reconstruction of the destroyed inner world, system of basic life values, and connections with the environment occur based on constructive coping strategies. Positive assessments of the event are retained in the mind, and the resulting traumatic experience is perceived as having an unconditionally positive effect on later life.

Three main categories of the consequences of traumatic experience are positively assessed, namely, (1) these are changes in self-perception and self-esteem ("became stronger," "new opportunities appeared," and "I know what I stand for"), (2) changes in relationships with others ("began to understand people better" and "learned to appreciate friendship"), and (3) changes in the general philosophy of life and the ideological foundation of being ("learned the value of life," "learned to enjoy life," "learned to understand the complexity of life," etc.). Successfully overcoming the negative psychological consequences of traumatic experiences results in the personal growth of a participant in a traumatic situation. In this case, the positive coping strategy is action-oriented, i.e., involvement in active social activity and the use of acquired experience as a source of achievement motivation. In this case, the stress resistance of military personnel increases. With impaired adaptation, experiences gained are not processed, and painful memories are forced out of consciousness. The leading coping strategies are nonconstructive behaviors, namely, avoidance, self-isolation, and self-accusation. Various clinical manifestations of PTSD emerge. Unconstructive coping strategies lead to a decrease in social contact and self-isolation and can be complicated by various forms of deviant behavior. In the violation of adaptation, incomplete mental processing of traumatic experience and the development of a complex of prenosological posttraumatic conditions occur, which can manifest as a decrease in working capacity, proneness to conflict, unsociability, and various complaints of deterioration in well-being. The stress resistance of a serviceman in this case is low [3–7].

MATERIALS AND METHODS

Combatants (n = 40), who performed special tasks >6 months ago, underwent a psychological examination (standardized interview, determination of the expert assessment of military personnel by unit commanders,

operator performance indicators, the Mississippi scale (MS) questionnaire, symptomatic neurotic disorder questionnaire, and quality-of-life questionnaire 12) and stress testing on the hardware–software complex (HSC)"Reacor" (NPKF Medicom MTD, Taganrog). During stress testing, participants were alternately presented with stress stimuli consisting of video and audio sequences on the monitor screen and headphones in accordance with a precompiled scenario. During stress testing, physiological parameters were recorded using four channels, namely, electrocardiogram (heart rate [HR], beats/min and respiratory arrhythmia of the heart [HR RAH], beats/min), respiratory recursion (RR), e.g., galvanic skin response (GSR), %; photoplethysmogram (systolic wave amplitude [SWA], pm).

RESULTS

The results of the cluster analysis in terms of MS indicators enabled identifying two groups of participants with significantly different cluster centers, where 16 people had 56.94 points and 24 had 40.3 points ($p < 0.000$). Thus, the PPTSD group accounted for 40% of all participants, whereas the rest of the servicemen were assigned to the control group (CG). PPTSD signs correlated with the manifestations of the neurotic register. Among neurotic manifestations, signs of somatovegetative disorder were found in 62.5% of cases; affective stressing in 50%, sleep disorders in 43.8% of cases, and anxiety–phobic disorder in 43.8% of cases. Military personnel with PPTSD signs also have a statistically significant decrease in the scores in the self-assessment of quality-of-life indicators such as general health, mental health, and social functioning. The negative correlation of quality-of-life indicators with PPTSD signs indicates that this disorder affects the quality of life. Results of expert assessment by unit commanders and operator performance were not significantly different between servicemen with and without PPTSD signs. Thus, PPTSD signs in healthy military combatants reduce the self-assessment of the quality of life but do not have a noticeable effect on the professional aspect of social functioning in favorable conditions [8].

Analysis of the results of stress testing at the HSC "Reacor" revealed that none of the studied parameters (HR, HR RAH, RR, and GSR), except SWA, differed in the CG and PPTSD group. SWA, starting from the stage of audio stimulation, was statistically significantly lower in the PPTSD group and correlated negatively with the indicators of the MS technique (Fig. 1).

Thus, military combatants with PPTSD were established to present with altered physiological reactivity, manifested as a decrease in SWA. Apparently, it is caused by the narrowing of the peripheral vessels because the HR does not change. The results indicate a decrease in the threshold of sensitivity to stress in combatants with PPTSD signs, which under combat conditions can increase the frequency of violations, and mistakes, incorrect operational and tactical decisions, development of acute stress-induced mental disorders, demoralization of personnel, combat, and noncombat sanitary, irretrievable losses, and losses of military equipment and weapons.

Based on the results of the discriminant analysis, a method was developed for the psychophysiological diagnostics of PPTSD in healthy military combatants, based on linear classification functions (LCF) using SWA indicators obtained during stress testing. We present a technique of using the developed method on specific examples of several military combatants. We substitute the SWA indicators obtained during the stress testing at the HSC "Reacor" at the stages of rest, start, and finish (SWA_{start}, SWA_{rest}, SWA_{finish}) into the equations:

$LCF1 = -1.13671 \times SWA_{rest} + 0.67812 \times SWA_{start} + 1.55106 \times SWA_{finish} - 1.91536$;

$LCF2 = 1.57987 \times SWA_{rest} - 0.48947 \times SWA_{start} + 0.08717 \times SWA_{finish} - 2.53516$.

LCF1 and LCF2 values were determined, and if LCF1 is greater than LCF2, then the serviceman has PPTSD

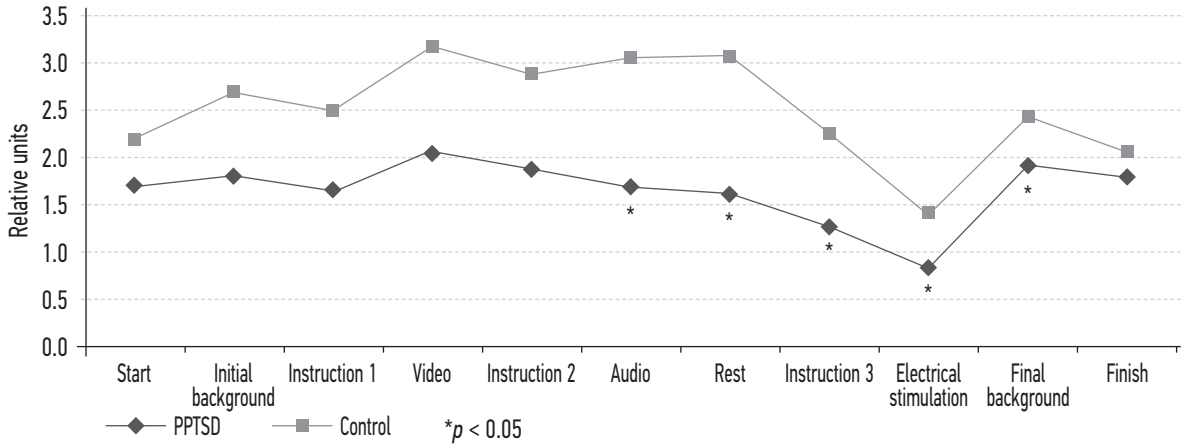

Fig. 1. Dynamics of SWA changes by stages of stress testing in military personnel with PPTSD and КГ military personnel

signs, and if LCF2 is greater than LCF1, then he/she does not have them.

Example 1. According to the results of stress testing, serviceman N., who performed special tasks, had SWA_{rest} of 2.63 pm, SWA_{start} of 2.41 pm, and SWA_{finish} of 3.39 pm. These values were substituted into the equations for LCF, and LCF1 of 1.99 and LCF2 of 0.74 were obtained. LCF1 was greater than LCF2, which indicated that the serviceman had PPTSD signs.

Example 2. According to the results of stress testing, Serviceman M., who performed special tasks, had SWA_{rest} of 0.85 pm, SWA_{start} of 0.96 pm, and SWA_{finish} of 0.89 pm. These values were substituted into the equations for LCF, and LCF1 of –0.85 and LCF2 of –1.58 were obtained. LCF1 was greater than LCF2, which indicated that the serviceman had PPTSD signs.

Example 3. According to the results of stress testing, Serviceman L., who performed special tasks, had SWA_{rest} of 3.05 pm, SWA_{start} of 2.62 pm, and SWA_{finish} of 2.62 pm. These values were substituted into the equations for LCF, and LCF1 of 0.46 and LCF2 of 1.23 were obtained. LCF2 was greater than LCF1, which indicated that the serviceman had no PPTSD signs.

The developed method was registered in the State Register of Inventions of the Russian Federation, and the Military Medical Academy received a patent for the invention dated June 24, 2019 [9]. In contrast to the currently generally accepted survey methods, this method enables objectifying the identification of PPTSD signs.

CONCLUSION

HSC Reacor is a research tool not suitable for mass screening because it requires rapid assessment in a short time. However, at present, psychophysiological software systems are becoming more portable, convenient, and affordable. Wireless data collection, various computing platforms, including portable ones, such as laptops or mobile phones, open up broad prospects for the use of the developed method in the interests of psychological and psychiatric intelligence, which is aimed at, within medical intelligence, the prediction of the possible consequences and dynamics of the situation for planning and organization of psychological and psychiatric care under special operations.

In the continuum of modern trends, this study is in the automation of psychological and psychophysiological methods for diagnosing pre-nosological and adverse functional conditions of military personnel to create high-tech devices and equipment with artificial intelligence components that can process large amounts of data and enable remote express diagnostics and forecasting of the state and behavior under combat conditions and assess the risk of neuropsychic breakdowns and behavioral deviations.

ADDITIONAL INFORMATION

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Conflict of interest. The authors declare no conflict of interest.

Ethical considerations. The study was approved by the local ethics committee of the S.M. Kirov Military Medical Academy, Ministry of Defense of the Russian Federation.

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