

Criteria for Determining the Adaptive Capacity of Students of Higher Medical Institutions

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Abstract

The article focuses on the importance of the adaptive capacity of students of higher medical institutions in the process of their professional training. The criteria for evaluating the adaptive capacity of students depending on their age were determined. The main mechanisms of forming the adaptive capacity at the organism level were found to be: 1) biochemical mechanisms which manifest themselves in the intracellular processes, e.g. the change in enzyme activity or their number; 2) physiological mechanisms, e.g. increased sweating as the body temperature rises; 3) morphofunctional mechanisms, i.e. the features of body structure and functions which are associated with lifestyle; 4) behavioural mechanisms – e.g. the creation of comfortable living conditions, etc.; 5) ontogenetic mechanisms, i.e. the acceleration of individual development or its slowdown contributing to the survival when conditions change.

Keywords

adaptation; adaptive capacity; physiological features of youth

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Problem statement and analysis of the recent research

Public health, especially health status of young people is one of the urgent problems of social development and life sciences. The problem of adaptation to the emotional and intellectual overload in the critical periods of ontogenesis is of special scientific interest. Since the most significant changes in morphofunctional parameters occur in the period of youth, there is a higher probability of changes in health indicators as the frequency of borderline physiological states increases. In the period of youth, i.e. a period that spans late adolescence and early adulthood, physical development and puberty are completed. Therefore, the acceleration of the development or its slowdown is considered as a risk factor in normal ontogenesis. Adaptive capabilities of the body form and constitute health reserve.

The significance of the problem is actualized by the task set by the president of Ukraine to implement the priority national project “Healthy Nation”. One of its main goals is the development of measures to prevent and reduce the morbidity among the population with the involvement of scientific potential based on the achievements of life sciences.

The conversion of health to disease is known to be characterized by a gradual reduction in adaptive capabilities of the body alongside with the development of various borderline states resulting in prenosological or premorbid health disorders (Ahadzhanian NA et al., 2000, 2004, 2005; Altman DA, 2003; Baranova AA, Shcheplyagina LA, 1998; Burkova NA, 2004; Butova OA, Ahadzhanian NA, 1998; Butova OA et

al., 1998; 2000; 2002; Varfolomeieva NA, 1986; Sydykova LA, 2003; Kliorin AI, 1986; Markin SP, Chyzhov AYa, 2003; Frolov VA, 2003; Barnett HL et al., 2001; Falkner B et al., 2004; Maestri K et al., 2005).

The objective of the research was to make the theoretical analysis of the term “adaptation” and to determine the criteria for evaluating adaptive capacity of students of higher medical institutions/

1. Discussion

One of the most complex and global tasks of modern psychology is to solve the problem of adaptation. The adaptation is a constant process of adapting to the physical and social environment occurring at all the levels of human psyche and body functioning. Many researchers, namely F.Z. Meier-son, G. Selie, V.I. Medvediev, F.B. Berezin, A.A. Rean, A.A. Nalchadzhian, A.H. Maklakov, Yu.A. Oleksandrivskiy have studied the problem of adaptation.

The study in a higher education institution is associated, to a certain extent, with the problem of adaptation. Entering higher medical institutions, students adapt to an unfamiliar environment that triggers the adaptation processes in the body and personality.

Accordingly, both study success and becoming a future professional will depend on adaptation success. According to B.H. Ananiev, basic and special education for adults fulfill not only cultural and technical functions, but they help in achieving high vitality and viability. The development of intelligence and personality, the ability to learn, and constant

self-education of an adult person is an immensely powerful force that resists the involuntal processes [10].

The study is of great relevance since knowing the adaptation process principles, as well as understanding physiological processes of developing the adaptive capacity of students may promote more effective teaching and learning process.

It is worth mentioning that the problem of adapting to the environment of higher educational institutions has been studied by many researchers (Yu.S. Babakhaie, K.Ye. Bekhmakhanova, A.K. Hryshanov, S.A. Madorskyi, T.V. Pavlushkin, E.H. Pionkova, T.I. Ronhinskaia, L.I. Ruvinskyi, A.B. Siomichev, A.H. Tereshchenko, V.I. Uvarova, V.H. Chaika, V.D. Tsurkan, etc.).

The disproportions between different adaptative mechanisms form a significant “price of adaptation” (Meierson, 1981; Kaznacheiev, 2000; Ahadzhanian, Nykytiuk, Polunin, 1996; Ahadzhanian, Polunin, 1998; Ahadzhanian, Baievskyi, Bersenieva, 2000; Ahadzhanian, 2002; Nykytiuk, 2002).

People have adapted to physical load over a long period of time. Over a significant period of the development, physical activity has been the most characteristic feature of human way of living. This contributed to the harmonious development of the main physiological systems providing the maintenance of homeostasis and the achievement of the beneficial adaptation result (Anokhin, 1998; Sudakov, 2000, 2002, 2005). Modern human is characterized by hypodynamia which results in serious inconsistencies in functioning of the vital systems such as the cardiovascular system, the respiratory system, the musculoskeletal system.

The development of morphofunctional disproportions between these systems actualizes further search for both complex criteria for evaluating their state and the methods of overcoming functional disorders.

The study of the adaptive capacity of the circulatory system and the adaptive reserves at the organism level is of great practical relevance. It should be considered that dysregulation disorders are associated with the disorders of autonomic homeostasis (Baievskyi, Bersenieva, 1997; Sytdykov, Shaikhelislamova, Valieiev, 2001; Kryzhanivskyi, 2002; Kotelnikov et al., 2003; Zemtsovskyi et al., 2004; Myronova, Myronov, 2006; Ferrari, 1990; Mapo, 1990; Shannahoff-Khalsa, 1991).

The nervous system which regulates the functioning of body systems and organs plays a key role in maintaining homeostasis. Due to this, self-regulation of physiological functions occurs maintaining the conditions necessary for the existence of life in the body.

Interacting with the environment, the individuals show different physiological reactions to an identical stimulus. Due to general somatic properties of physiological adaptation, the body can adapt or develop immunity to various external factors. All people are able to express the necessary phenotypic plasticity in response to changes in external conditions. The adaptation helps maintain a stable internal environment of the organism when the parameters of some environmental factors exceed the optimal ones [32].

The adaptation depends on the effects of environmental factors as well as individual reactivity of every organism. The criterion for measuring the degree of adaptation is the maintenance of homeostasis, regardless of the duration of the effect of factors to which the adaptation has been formed. In case of a disease, compensation occurs, i.e. the fight of the organism to maintain homeostasis with auxiliary defense mechanisms resisting the development and progression of the pathological process being involved. If there are danger signals and there are not enough necessary mechanisms being involved, stress-related diseases typical for our civilization occur.

The individual adaptation to new conditions of existence develops due to changes in metabolism, the maintenance of internal stability of the organism (homeostasis); immunity, i.e. the insusceptibility of the body to infectious and non-infectious agents and substances entering the body from the outside or being formed in the body under the influence of some factors; regeneration, i.e. the restoration of the structure of damaged body organs or tissues (wound healing, etc.); adaptive unconditioned and conditioned reflex responses (adaptive behavior).

In the human body, the dynamic stereotype with the maintenance of healthy person’s homeostasis that has been developed in the process of evolutionary development under environmental conditions is formed. Both human health and homeostatic maintenance can be preserved even if some environmental factors changed. Such effect causes corresponding biological changes in the human body; however, due to the adaptation processes in the healthy person’s body, environmental factors allow, to a certain extent, preserving health.

If the organism is able to provide a stable internal environment using adaptative mechanisms and responses in case of changes in the external environment, its state can be defined as health. If the intensity of environmental factor effect dominates over adaptive capabilities of the organism, its state can be defined as the pathology or disease that is an opposite to health.

The adaptation is, broadly speaking, a property of the organism to adapt to the effects of environmental factors.

The concept of physiological adaptation was first formulated by a famous American physiologist Walter Bradford Cannon as a complex of functional responses of the body to unfavorable environmental effects aimed at the maintenance of homeostasis [2].

Nowadays the adaptation is considered as the formation of adaptive responses of the body not only when it is exposed to the action of unfavorable environmental factors or stressors but also when it is exposed to the action of favorable environmental factors.

Biological mechanisms of adaptation have not been sufficiently studied yet. Any adaptive responses in the body are controlled by the central nervous system due to the formation of special adaptation systems which include cortical and subcortical brain regions and the endocrine glands.

The pituitary gland and the adrenal gland play a special role in the formation of defense responses of the body under stress conditions as they synthesize so-called “adaptive hormones”. The activities of the endocrine glands are controlled by subcortical brain region, namely the hypothalamus and the pituitary gland which form a single functional system.

Canadian scientist Hans Selye, professor and director of the Institute of Experimental Medicine and Surgery at the Université de Montréal (Canada) was the first person to describe adaptive mechanisms [15].

Syndrome turned out to be caused by both the introduction of purified hormones (adrenaline, insulin), and physical factors (cold, heat), trauma, hemorrhage, pain or intense muscular activity. Any of these agents could trigger a non-specific reaction that was termed “general adaptation syndrome” and the term “harmful agent” was changed to “stress” which was defined as “overstrain”. The words “distress” and “strain” were often associated with the word “stress”. Distress was defined as severe pain episodes, exhaustion [20].

The adaptation is a complex of physiological responses forming the basis of adapting to constantly changing conditions of existence and aiming at the maintenance of homeostasis. Adaptive responses provide homeostasis, working capacity, the maximum possible prolongation of life under certain conditions, reproductivity. Adaptive capabilities of the body are widely used to determine the level of individual health. Therefore, the study of the specifics of adaptation and physiological mechanisms of the adaptive capacity, the management of the adaptation processes and their correction are mandatory for disease prevention.

The complex process of adaptation was described by V.P. Kaznacheiev according to various criteria:

1. according to thermodynamic criteria, the adaptation is a process of maintaining an optimal level of biological system balance under adequate and inadequate environmental conditions which provides the maximum effect of external work and is aimed at the preservation and the prolongation of the given system life;
2. according to cybernetic criteria, the adaptation is a process of self-preservation of the functional level of self-regulating system under adequate and inadequate environmental conditions. There is also a choice of functional strategy that provides an optimal implementation of the final goal.
3. according to biological criteria, the adaptation is a process of preserving and developing biological properties of a species that provides the progressive evolution of systems under adequate and inadequate environmental conditions;
4. according to physiological criteria, the adaptation is a process of maintaining the functional state of homeostasis that provides the preservation of an organism, the development, working capacity and the maximum life

expectancy under changed environmental conditions [19].

The internal environment of the organism is characterized by the following parameters:

1. the regulation of blood circulation;
2. the regulation of blood gas composition;
3. the regulation of energy substance concentration in the blood;
4. the regulation of blood temperature;
5. the regulation of osmotic blood pressure.

The analysis of physiological and biological studies allows us to define the adaptive capacity as a quantitative expression of the level of the functional state of the organism and its systems, that characterizes its ability to adequately and reliably respond to the complexes of unfavorable factors and dynamics of their parameters using functional reserves sparingly without leading to prenosological or premorbid health disorders. The levels of the adaptive capacity are approximately the same as those of homeostatic capacity. However, the criteria are more developed (e.g. strain index, the Garkavi test, etc.) [30, 35, 40].

The decrease in the level of adaptive responses to physical load is primarily associated with the limited capacity of the cardiovascular system. This is due to myocardial deconditioning, cardiac rhythm disturbances, abnormalities in the conduction system, abnormal development, myocarditis, ischemic heart disease, hypertension (Zaleskyi, Dynnik, 2005). Almost all the aforementioned diseases are characterized by cardiac rhythm disturbances resulting in the failure of the whole cardiovascular system. Among the arsenal of the modern methods of diagnosing cardiac rhythm, computer appliances which allow analyzing cardiointervalogramms are of special interest. This method provides insight into the central and peripheral mechanisms which affect the process of cardiac rhythm formation. Despite the vast knowledge and research available, there is still no consensus on this issue (Baievskyi, 2001; Kotelnikov et al., 2002). Hence, further study of the central and peripheral regulatory mechanisms affecting cardiac rhythm in various functional states is of special interest [5].

The ultimate goal of the respiratory system is to maintain proper levels of oxygen and carbon dioxide in the blood and to create a certain environmental response (Breslava, Hlibovske, 1981; Uest, 1988; Safonov, Myniaiev, Polunin, 2000). During physical activity, metabolites accumulate in the body and respiratory homeostasis is disturbed. The increase in the amount of metabolic carbon dioxide in the blood and tissues may significantly affect the state of physiological systems. However, hypercapnia should not be considered as a negative component of muscular activity. Carbon dioxide is a versatile regulator of a considerable number of physiological processes.

At the same time, its role in the body has not been fully determined yet. Hence, the study of the effect of carbon dioxide on the formation of cardiac rhythm is of special interest [13].

The musculoskeletal system is the main morphofunctional formation resisting constantly acting gravitation. Scoliosis, kyphosis, congenital defects and traumas of the spine have a negative effect on anti-gravitational responses and hemodynamics, respiratory processes, regulatory mechanisms of autonomic functions (Mironov et al., 2006; Verikhov, Ustinova, Zaitseva, 2007). Lateral curvature of the spine may affect the central and peripheral divisions of the nervous system and cardiac function in a different way depending on its severity and the direction the curve bends. The character and mechanism of these effects have not been fully studied yet. Hence, the study of the effect of lateral curvatures of the spine on the formation of cardiac rhythm is of great practical relevance.

The adaptation is a complex body response to the factors of extreme environments, the intensity and extensity of which disturb the constancy of the internal environment.

The adaptation is a continuous process having the multi-level and dynamic nature. The most important sign of adaptation is the ability to carry out all the types of social and biological activities.

From the perspective of modern cybernetic ideas of constructive properties of living organisms, the human body can be considered as a harmonious integration of many functional systems where some systems determine dynamic stability of homeostasis and others determine the adaptation to the external environment (Pavlov, 1951, Anokhin, 1998; Sudakov 2000; Sudakov, Uryvaiev, 2004; Karpov, 2005).

The formation of dominant functional system, the beneficial result of which is the restoration of disturbed homeostasis is the basis of adaptation. The multi-level principle of functional systems in an integral organism provides the involvement of both the somatic and autonomic nervous systems in the adaptation processes. It should be noted that the initial reactivity which relates to the morphofunctional state of the organism and determines, to a large extent, the future response to the effects of adaptogens plays an exceptional role. The determination of the initial reactivity or so-called “readiness for adaptation” is important to predict the corresponding response of the organism under new conditions (Iliukhina, Zabolotskikh, 2000; Kaznacheiev, 2000; Kazin et al., 2001; Baboshko et al., 2004; Kryzhanivskiy et al., 2004, Van-Lenthe, Snel, Twisk, 1988).

One of modern health determining concepts is the adaptation concept proposed by V.P. Kaznacheiev and R.M. Baievskiy which states that the adaptive capacity of a person is his/her ability to maintain normal life activity under inadequate environmental conditions. Therefore, the authors have proposed to make prenosological diagnosis depending on the degree of adaptive mechanism strain. According to this concept, the following states - satisfactory adaptation, functional strain of adaptive mechanisms, unsatisfactory adaptation and its failure,

characterize, to a certain extent, individual health [4, 5, 20].

R.M. Baievskiy and A.P. Bersenieva believe that the parameters which characterize adaptive capabilities of the organism and its compensatory homeostatic properties serve as the main criteria to differentiate health from prenosological state, pre-disease from disease.

One of the promising approaches to solving the problem being discussed in this article is the use of the principles and methods of prenosological diagnosis which is a relatively new field of applied physiology and medicine dealing with study of the functional states of the organism in health and disease (P.M. Baievskiy, V.P. Kaznacheiev, 1978). Prenosological states are considered as the result of a decrease in adaptive capabilities of the organism which precedes the development of the pathology (P.M. Baievskiy, 1979, 1987). Among the methods of prenosological diagnostics, a simple but highly informative method of measuring the adaptive capacity is worth special attention (P.M. Baievskiy, A.P. Bersenieva, N.R. Palie, 1987). The effectiveness of this method in mass health examinations was proven by A.P. Bersenieva (1991).

Based on the analysis of theoretical knowledge of adaptive mechanisms and the methods of calculating the adaptive capacity of the human organism, we have developed the method of evaluating the adaptive capacity of students of higher medical institutions. According to this method, the level of physical health was determined using the method of quantitative rapid assessment of the level of somatic health (H.L. Apanasenko) [63]. To assess medical students' biological age, a battery of tests for the determination of the biological age was applied (according to V.P. Voitenko). Quantitative assessment of efficient functioning of the cardiovascular system was conducted using the methods proposed by M.Ya. Domracheva, L.A. Mykhailova, O.A. Domrachev [6].

The adaptive capacity of an individual was assessed according to the method proposed by L.O. Konevskiykh [6]. To estimate oxygen consumption, there was used the indirect estimation method of human oxygen consumption proposed by A.B. Diomin [6]. The state of physical health in medical students was determined according to the method of assessing health reserves and working capacity of the population proposed by V.O. Orlov [6]. Total endurance of medical students' organism was calculated according to the method of simultaneous determination of the level of maximal oxygen consumption and total endurance of the organism proposed by M.F. Sautkin [6]. The level of oxygen intake at the level of the aerobic-anaerobic threshold was determined using the indirect method of determining the anaerobic threshold of physical working capacity of an individual proposed by A.V. Diomin [6].

2. Conclusions

Thus, the adaptive capacity of students of higher medical institutions depends on a wide range of general physiological patterns and is associated primarily with self-regulation of multicomponent functional systems. According to the WHO,

the adaptation is characterized as a real adaptation of the organism to varying environmental conditions that does not lead to any alterations in the given biosystem and increase in homeostatic capabilities of its response. The adaptation manifests itself at different levels: from cell biochemistry and the behavior of individual organisms to the structure and functioning of communities and ecological systems.

According to modern concepts, all individual functions are formed and changed in close interaction of the organism and environment. Accordingly, the adaptive nature of organism functioning in different age periods is determined by two most principal factors, namely morphofunctional maturity of physiological systems and the adequacy of the effect of environmental factors on the functional capabilities of the organism.

The main mechanisms of forming the adaptive capacity at the organism level were found to be: 1) biochemical mechanisms which manifest themselves in the intracellular processes, e.g. the change in enzyme activity or their number; 2) physiological mechanisms, e.g. increased sweating as the body temperature rises; 3) morphofunctional mechanisms, i.e. the features of body structure and functions which are associated with lifestyle; 4) behavioural mechanisms – e.g. the creation of comfortable living conditions, etc.; 5) ontogenetic mechanisms, i.e. the acceleration of individual development or its slowdown contributing to the survival when conditions change [35]. Although its final effect, namely the increase in the resistance of the system to environmental factors is preserved at each level. The adaptation includes an effective, economical and adequate adaptive response of the organism to the effect of various factors.

There are two opposite features of adaptation. On the one hand, these are distinct changes that, to some extent, affect all the systems of the body; on the other hand, it is the maintenance of homeostasis, the transition of the organism to a new level of functioning with a mandatory maintenance of dynamic equilibrium.

3. Prospects for further research

A detailed diagnosis of all physiological criteria for the formation of the adaptive capacity of students of higher medical institutions is promising.

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