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# On the normative values of the adaptive potential and their practical application

A.I. Bosenco[1], M.S. Topcii[1], L.A. Evtuhova[2]

In the practice of functional diagnostics, the use of adaptive potential is gaining popularity; however its normative values need to be clarified, especially when examining students. Studies were made of the adaptive capabilities of adolescents and young men involved in sports, using functional tests in the form of physical activities of a different nature, both under normal conditions and in conditions of increased motivation – sparring-partner competition. The correlation analysis of 80 criteria did not reveal high connections of the adaptation potential with physical working capacity and the state of the regulatory mechanisms of the cardiovascular and central nervous system of the schoolchildren and students surveyed. The experimental data obtained testify to the need to develop new normative tables for assessing the adaptive potential of students in the process, taking into account the age and level of physical readiness that are subject to functional diagnostics.
**Keywords:** adaptive potential, normative values, adolescents, young men, functional tests.

В практике функциональной диагностики приобретает популярность использование адаптационного потенциала, однако его нормативные значения нуждаются в уточнении, особенно при обследовании учащейся молодежи. Проведены исследования адаптационных возможностей подростков и юношей, занимающихся спортом, с использованием функциональных проб в виде физических нагрузок различного характера, как в обычных условиях, так и в условиях повышенной мотивации – спарринг-партнерского соревнования. Корреляционный анализ 80 критериев не выявил высоких связей адаптационного потенциала с физической работоспособностью и состоянием регуляторных механизмов сердечно-сосудистой и центральной нервной системы обследованных школьников и студентов. Полученные экспериментальные данные свидетельствуют о необходимости разработки новых нормативных таблиц оценки адаптационного потенциала учащейся молодежи с учетом возраста и уровня физической подготовленности, подлежащих функциональной диагностике.
**Ключевые слова:** адаптационный потенциал, нормативные значения, подростки, юноши, функциональные тесты.

**Introduction.** Evaluation of human adaptability is one of the archaic issues in a wide range of scientific and practical fields. During the period of development of functional diagnostics, a number of methods for determining them have been developed. Only in the study of physical performance, as an integral characteristic of functional capabilities, more than 100 techniques are proposed. Detailed analyzes of their scientific and practical significance are given in the works of I. Aulik [1], V. Karpman [2], E. Mikhalyuk [3]. There are three main methodological approaches to assessing the functional reserves of both individual systems and the whole human body: this control is not only in a state of relative muscle rest, but also under conditions of dosage and extreme physical exertion. The most complete and objective assessment, according to many scientists, is research using loads at the limit of the capabilities of the human body. The first two approaches give a significant error in the forecasting of functional reserves, the latter – a possible disruption of adaptation [4], [2], [3]. It is actual to estimate them without stress, according to the rest state. In recent years, the so-called index of functional changes (IFI) [5], [6], [7], [8], [9], [10], used by A. Bersenev [11] for the determination of adaptation levels by R. Baevsky [12], whose normative values are treated ambiguously, need to be clarified and harmonized, especially when examining children and adolescents.

**Objective:** to study the informative value of the functional change index in assessing the adaptive capabilities of students.

**Methods of research.** Monitoring of individual functional indicators of young athletes: a sport – football, was carried out in two stages during a training session with the performance on the bicycle ergometer of hard work for endurance: under normal conditions (DU) and in conditions of increased motivation (PM-sparring-partner competition). The load power in both cases was 70 % of the maximum and was 3.1 W per kg of body weight. The mean age (calculated according to the decimal system) of the examinees was 14.95 ± 0.10 years, length and body weight were 172.0 ± 0.9 cm, and 59.0 ± 0.9 kg, respectively. At the first stage, 38 adolescents (14–15 years) took part in the studies, and on the second stage 18 (the main team).

In the third series of studies using the closed-cycle dosed physical exercise (with the reverse), the students of the Faculty of Physical Education (n = 73), whose average age, length and body weight were 17.48 ± 0.03 years, 178 , 35 ± 0.98 cm, 70.05 ± 0.49 kg.

The set of techniques included: functional monitoring of physical performance, the state of the central nervous system by the time of a simple sensorimotor reaction and over the slow bioelectric activity of the brain, cardiovascular system according to the state of the mechanisms of regulation of the heart rhythm and respiratory system. The paper presents the results of a study characterizing the functional reserves in conditions of quiescence and their relationship with the test values with dosed and limit loads.

Statistical processing is carried out by conventional methods using correlation analysis (Spearman rank coefficient). The study was carried out in compliance with the main provisions of the Council of Europe Convention on Human Rights, the Helsinki Declaration of the World Medical Association on the ethical principles of conducting scientific medical research with human participation (1994–2008).

**Results of the study and their discussion.** In the calculation formula of the adaptive potential (AP), many authors use indicators of the cardiovascular system and physical development. However, there are still no clearly differentiated norms of the functional change index (API) by age, gender and physical fitness.

In the scientific literature, there are many approaches to assessing the adaptive potential of different age groups: children, adolescents, boys, in which different norms are used to characterize the same level of adaptation. The calculated AP formulas of many authors include different ages of the surveyed: in years, months, days. In our studies we used a decimal system, which allowed us to individualize the analysis of the data.

M. Antropova, T. Paranicheva [5], L. Kvashnina [9], I. Kalinichenko [8] carried out the first observations of the incorrect use of the existing normative values of the IFI and attempts to develop new normative tables taking into account specific requirements. However, the developed tables do not take into account the level of physical readiness, which narrows the range of their practical use.

The set of techniques included: functional monitoring of physical performance, the state of the central nervous system by the time of a simple sensorimotor reaction and over the slow bioelectric activity of the brain, cardiovascular system according to the state of the mechanisms of regulation of the heart rhythm, heart rate, systolic blood pressure, diastolic blood pressure and respiratory rate (Table 1).

All indicators are recorded in terms of limit values and in a state of relative muscle rest. The paper presents the results of a study characterizing the functional reserves in conditions of quiescence and their relationship with the test values with dosed and limit (Table 1).

Note that before testing with increased motivation (PM), a better state was recorded compared to the resting state under ordinary conditions. This is evidenced by the mechanosistolic index (CGS) and greater cardiac output – the minute volume of blood (IOC, $p > 0.05$) with a lower index of the intensity of regulatory mechanisms (IN, $p > 0.05$).

Exercise of significant training loads both under normal conditions and with increased motivation is accompanied by extreme extra- and intracardial shifts in the conditions of extreme stress of the mechanisms of regulation of cardiac activity, which was significantly less with increased motivation.

As a criterion of integral adaptation capabilities, the data of physical working capacity were used – time and volume of the work performed. As the data in Table 1 show, increased motivation stimulates efficiency, which is 51,84 % ($p < 0.001$).

It is logical to assume that in conditions of increased motivation, when the best adaptive capabilities were demonstrated, the IFI indicators will be correspondingly better.

Table 1 – Indicators of functional changes and adaptive potential of young athletes during the training microcycle

| Indicators | Before training, at rest ordinary conditions | | During training, the maximum values | |
|---|---|---|---|---|
| | ordinary conditions | high motivation conditions | ordinary conditions | high motivation conditions |
| Respiratory rate , cycles / min | 19,0 ± 0,5 | 18,0 ± 0,4 | 56,0 ± 1,6* | 56,0 ± 2,0* |
| Heart rate, beats / min | 80,0 ± 1,32 | 79,0 ± 2,97 | 189,0 ± 2,1* | 185,0 ± 3,5* |
| Systolic blood pressure, m.hg. | 119,0 ± 1,3 | 116,0 ± 1,3 | 171,0 ± 2,7** | 166,0 ± 1,6** |
| Diastolic blood pressure mm.hg. | 75,0 ± 1,28 | 78,0 ± 1,9 | 68,0 ± 1,9** | 64,0 ± 2,9** |
| IOC, l//min | 4,5 ± 0,13 | 4,8 ± 0,2 | 19,0 ± 0,75 | 24,4 ± 1,3♥ |

End of table

| | | | | |
|---|---|---|---|---|
| IN, conventional units | 86,8 ± 6,9 | 75,1 ± 10,8 | 4739 ± 403 | 4094 ± 411 |
| CGS, % | 35,7 ± 0,68 | 37,6 ± 1,8 | 45,5 ± 0,6 | 45,8 ± 1,1 |
| Time work, min | – | – | 36,01 ± 1,94 | 53,4 ± 3,81♥♥ |
| Công việc bị can, kgm / kg | – | – | 674,0 ± 45,3 | 1023,4 ± 78,6♥♥ |

*Note:* * – condition, apparent residual, ** – stable position? ♥ – $p < 0,05$, ♥♥ – $p < 0,001$

Table 2 presents the indices of functional changes and levels of human adaptation from the data of different authors. Our data show that IFI L. Kvashnina [9], developed to assess the adaptive capabilities of schoolchildren, is the most successful, but not fully can be used in surveys of young athletes after a 4-year training period.

Table 2 – Ratio of indexes of functional changes and the level of human adaptation, according to different authors

| Assessment of the level of adaptation | Index of functional changes, in points | | |
|---|---|---|---|
| | RM. Baevsky, 1997, 2009 | L.I. Arabadzhi, 2012; O.A. Baev 2012; V.M. Tsinker, D.V. Dugarova, 2011 | L. Kvashnina, 2010 |
| Satisfactory adaptation | up to 2,59 | ≤ 2,10 | 1,82–1,9 |
| Stress of adaptation mechanisms | 2,60–3,09 | 2,11–3,20 | 1,55–1,81<br>1,91–2,17 |
| Unsatisfactory adaptation | 3,10–3,49 | 3,21–4,30 | 1,29–1,54<br>2,18–2,44 |
| Disruption of adaptation | ≥ 3,50 | ≥ 4,3 | ≤ 1,28<br>≥ 2,45 |

The results of the conducted studies showed that only 13,16 % of the young players surveyed under normal conditions and 22,2 % in conditions of increased motivation can be attributed to the group with satisfactory adaptation, the majority of teenage football players (more than 50 %) should be assigned to the group with tension adaptation mechanisms.

And 22–26 % of young athletes should be characterized as individuals with an assessment of unsatisfactory adaptation (Table 3). It is impossible to assume that with such results young players were in optimal sports form and showed high physical efficiency, ability to mobilize functional reserves, especially in conditions of increased motivation (see Table 1).

The analysis of the correlation dependencies between the IFI, which characterizes the AP of adolescents and a number of functional criteria, did not reveal significant connections. There was a weak relationship between the adaptation potential and performance indicators (at the level of 0,26–0,29): AP and IOC (0,28–0,43); AP and SKG (0,45–0,57), AP and IN (0,35–0,62). The increased motivation contributed to the strengthening of functional interrelations, which is one of the mechanisms for the formation of a rational functional system for mobilizing the reserve capabilities of the organism of young athletes.

Table 3 – Indicators of the index of functional changes and assessment of the level of adaptation of young athletes in conditions of intense muscular activity in conditions of usual and increased motivation (%)

| Assessment of the level of adaptation | Normative values, points | Ordinary conditions | | High motivation conditions | |
|---|---|---|---|---|---|
| | | by levels | total | by levels | total |
| Satisfactory adaptation | 1,82–1,9 | 13,16 | 13,16 | 22,22 | 22,22 |
| Stress of adaptation mechanisms | 1,55–1,81 | 13,16 | 52,63 | 5,56 | 55,56 |
| | 1,91–2,17 | 39,47 | | 50,0 | |
| Satisfactory adaptation<br>Stress of adaptation mechanisms | 1,29–1,54 | 2,64 | 26,32 | 0 | 22,22 |
| | 2,18–2,44 | 23,68 | | 22,22 | |
| | ≤ 1,28 | 0 | 7,89 | 0 | 0 |
| | ≥ 2,45 | 7,89 | | 0 | |
| Total by levels, % | | 100 | 100 | 100 | 100 |

The third series of studies provided for a comparative assessment of the level of functionality of first-year students of the Faculty of Physical Education. The adaptation potential data were compared to the results of testing with a dosed physical load, in which the power changed in a closed cycle (with a reverse) – first increased from zero to a power that increased the heart rate to 150

bpm, and then decreased at the same rate (33 W / min) to the reference level. The technique allows to obtain about 30 indicators characterizing physical performance and gives a complex idea of the formation of a functional system of adaptation to these loads [13], [14], [15].

Presented in Table 4, the data on the physical performance of students indicate a high variability in performance even in persons with the same assessment of AP, while the total operating time (T), its volume (A), reversal power (Wrev) with PWC170 could be as in the middle the registered range of the IFI, and at its upper or lower limit. Similar dynamics was characteristic for the criterion (absolute and relative per kg body weight) of the maximum oxygen consumption (MIC) of the young men surveyed.

Table 4 – Selected indicators of the adaptive capabilities of students in physical load testing in a closed cycle, (%)

| Indicators, M±m / Assessment of the level of adaptation | T, min | A, kilojoule | Wrev, w | $PWC_{170}$, w | MIC, mil/ kg |
|---|---|---|---|---|---|
| | 14,49 ± 0,39 | 102,23 ± 5,41 | 233,33 ± 6,54 | 276,49 ± 9,22 | 64,15 ± 1,28 |
| | B:C:H | B:C:H | B:C:H | B:C:H | B:C:H |
| Satisfactory adaptation | 2,04:14,29:0* 4,08:93,88:2,04♥ | 2,04:14,29:0 4,08:95,92:0 | 2,04:14,29:0 4,08:93,88:2,04 | 0:16,32:0 2,04:97,96:0 | 0:14,29:2,04 2,04:93,88:4,08 |
| Stress of adaptation mechanisms | 2,04:63,27:2,04 0:0:0 | 2,04:65,31:0 0:0:0 | 2,04:63,27:2,04 0:0:0 | 2,04:65,31:0 0:0:0 | 2,04:63,27:2,04 0:0:0 |
| Satisfactory adaptation | 0:14,29:0 0:0:0 | 0:14,29:0 0:0:0 | 0:14,29:0 0:0:0 | 0:14,29:0 0:0:0 | 0:14,29:0 0:0:0 |
| Stress of adaptation mechanisms | 0:2,04:0 0:0:0 | 0:2,04:0 0:0:0 | 0:2,04:0 0:0:0 | 0:2,04:0 0:0:0 | 0:2,04:0 0:0:0 |

*Note:* the ratio of the students surveyed for the B – high, C – average, H – low level of the indicator of the adaptive potential * – in the numerator by [9], ♥ – in the denominator according to [12].

It should be noted that none of the IFI normative tables provides a fully objective assessment of the adaptive potential of the contingent we surveyed. So, according to the scale of adaptation potential L. Kvashnina [9] for schoolchildren 6–17 years old, does not take into account the level of physical preparedness. At the same time, our surveyed age group does not «fit» into the norms for adults [6], [7], [12]. For example, according to the indicator of the total time of work according to the table by Kvashnina [9], the ratio of young men of 17 years in terms of high, medium, low was 2,04:14,29:0 percent, and according to R. Bayevsky's table [12] – 4,08:93,88:2,04, which indicates the inconsistency of the norms and possible errors in the assessment of AP. A similar picture is evident in other criteria.

The conducted correlation analysis, which included more than 80 variables, also did not find high dependencies between AP and performance indicators. It is established that between the AP and the group of indicators of physical working capacity the correlation coefficient fluctuated in the range of 0,311–0,361. The AP was more closely connected with the energy level of the organism during the performance of physical work (r = 0,411–0,422). A weak positive dependence was noted only between the modal duration of cardiocycles and their variability, which indicates the individuality of the formation of the functional system of human adaptation [16].

Between the indicators of the general functional state of the brain (the functional level of the system, the stability of the reaction, the level of functional capabilities), both in relative muscle rest and in the period of urgent recovery after work, there are no reliable relationships with the adaptive potential, which indicates the need for further research: expansion of the contingent surveyed and the development of relevant regulatory tables [17].

**Conclusion.** The analysis of literary sources and materials of scientific research on the problem of assessing the functional capabilities of adolescents 13–15 and boys 17 years showed that in functional diagnostics several (at least three) normative tables are used to assess the adaptive potential, which differ significantly in their values and give different characteristic of the adaptive potential.

Adaptation potential according to the existing norms does not fully reflect the true functional state of trained adolescents and young men and their adaptive reserves, as evidenced by the data

from studies using metered and strained physical exertion. It is shown that persons with a strain of adaptation mechanisms or an unsatisfactory level of it exhibit high functional possibilities under conditions of increased positive motivation.

The analysis of correlation dependencies between the index of individual changes, characterizing the adaptation potential of trained adolescents and young men, and a number of functional criteria did not reveal significant connections.

The received experimental materials testify to the need to develop new normative evaluation tables of the index of individual changes that meet the requirements of an adequate assessment of the adaptation potential, taking into account the sex, age in the decimal system and the level of physical preparedness of persons subject to functional diagnostics.

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[1]South Ukrainian national Pedagogical University
named after K.D. Ushinsky

[2] Francisk Scorina Gomel State University

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