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Adaptation to university studies affects on functional state of freshmen

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ABSTRACT. According to different researches, 30% of university graduates have a low level of health, and studying at university is one of the factors of its deterioration, besides the first year is considered critical. The purpose of research is to study the dynamics of physical development, physical fitness and functional state of young men during the first year of university studies. For the survey we used standard measurements and index calculations for 11 indicators of physical development, 9 indicators of physical fitness and 15 indicators of functional status. We calculated the arithmetic mean (M), the standard error of the mean (m), then evaluated differences by the Student criterion (t) for independent samples and considered them as reliable atp < 0.05. It is shown that during the first year of studies, young men have an increase in the Erismann index, the corpulence (Rohrer's) index, the body mass index and a decrease in the Pignet index. There is also an increase in the coefficient of endurance, adaptive capacity and diastolic pressure, while vital capacity of the lungs, the vital index, time of hanging on the bar and the speed of running 1000 m decrease. The dynamics of physical development is expressed in a change in mass-growth indices and indicates an increase in body weight. The dynamics of physical fitness is expressed in a decrease of the time of hanging on the bar and the speed of running 1000 m. The dynamics of the functional state is expressed in a decrease of vital capacity of the lungs, vital index, increase in the coefficient of endurance, adaptive capacity and diastolic blood pressure.

Keywords: dynamics of physical development; functional state of young men; motor skills.

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Introduction

Students is a special social group characterized by specific living conditions and the need to adapt to constantly emerging new factors. To observe young students is important, as at this age they can play significant social roles, including military service and starting a family. The country's defense ability and the health of future generations largely depend on their health.

Studying at university is one of such factors; it is accompanied by high mental and psycho emotional stresses, forced frequent violation of the work and rest regime, nutrition. All this can cause tension of the compensatory-adaptive systems of the body and have a negative impact on health (Torshin, Yakunina, Severin, Zheludova, & Batotsyrenova, 2012). Now there are some researches focused on problems of students' adaptation to university, where students' health is considered in the aspect of adaptation (Litvinova, Kazin, & Lurie, 2011).

Students' adaptation depends not only on physiological compensatory-adaptive mechanisms, but also on the personality and psycho physiological characteristics of a person (Litvinova, Kazin, & Lurie, 2011). In some cases, prolonged psycho emotional stress, which is one of the main links in mobilizing the body's reserve capabilities, in combination with metabolic changes, causes the development of maladaptation, progression of somatic diseases and formation of chronic emotional stress (Mayorga-Vega, Bocanegra-Parrilla, Ornelas, & Viciana, 2016).

According to researches, adaptation to studying at university affects the physical development, physical fitness and functional state of young men.

A large number of researches are devoted to the study of freshmen's physical development. Examination of Belgian students (n = 172) showed that during the first 1.5 years at the university, young men had an increase in the body weight (by 2.7 kg), body mass index (BMI) by 0.7 kg m^{-2} and waist circumference (2.1 cm) (Deliens, Deforche, De Bourdeaudhuij, & Clarys, 2015). European freshmen (n = 101) gained about 1 kg of weight after 1 semester, but their waist circumference did not change (Deliens, Clarys, Van Hecke, De

Bourdeaudhuij, & Deforche, 2013). Spanish students (n = 132) demonstrated a decrease in the physical activity, an increase in the body's fat content, and BMI did not change significantly (Pullman et al., 2009; Sukhanova & Maksimov, 2015). Belgian students (n = 291) gained 4.7 kg of weight over the period from the last year of school to the second year of university (Deforche, Van Dyck, Deliens, & De Bourdeaudhuij, 2015). North American students (n = 108) gained 3 kg in weight, together with an increase in BMI and waist during the period from admission to the end of the 2nd semester (Ramírez-Vélez, Meneses-Echavez, González-Ruíz, & Correa, 2014).

Some studies are also devoted to studying the effect of adaptation on physical fitness and functional state. So, Belgian freshmen (n = 172) demonstrated that over the year the physical fitness indicators did not change significantly, only the strength of the hand press increased significantly (Deliens et al., 2015). Hungarian freshmen (n = 123) showed statistically significant differences in the strength of the hand press and the time of hanging on the bar (Kaj, Tékus, Juhász, Stomp, & Wilhelm, 2015). The study of 108 students showed that indicators of speed decreased, while indicators of strength, flexibility and endurance did not change (Ramírez-Vélez et al., 2014). Testing of students' physical fitness showed the ambiguity of speed, speed-strength qualities and endurance results (Artemenkov, 2012). When studying the dynamics of students' functional state and adaptation processes, there was an increase in the tension of the heart rate regulation mechanisms after the third year of study (Karpenko, 2012).

7.6% of Samara students (n = 770) demonstrated tension and disruption of adaptation processes (Kretova, Belyaeva, & Shiraeva, 2014).

It is important to note that there are no complex studies on the effect of adaptation on freshmen's state. Moreover, the regional student portrait based on the results of the first year at university is of interest, as each territory has a unique set of geographical, climate and socio-cultural factors. Such studies are being conducted in the region for the first time. The data obtained can be useful for conducting a comparative analysis with other regions of Russia and for comparing Russian and foreign freshmen.

The purpose of the research is to study the influence of adaptation on the dynamics of physical development, physical fitness and functional state of young men during the first year at university.

Therefore, the tasks of the research are: 1) to study the dynamics of the physical development of young men during the first year at university, 2) to study the dynamics of physical fitness of young men during the first year, 3) to study the dynamics of the functional state of young men during the first year.

Material and methods

We conducted an analytical research on the basis of Vyatka State University (Kirov) with students of the first and second years of study and tested them during the first and third semesters in September and October. We conducted an observational comparative, non-randomized, single-center pilot study. The study was carried out in 2018-2019 at the Vyatka State University (Kirov, Russian Federation). At the first stage, students of the first semester of study were tested (September 2018). At the second stage of the study, the same students were tested in the third semester (October 2019). The sample size was not calculated. All participants provided informed consent to participate in the experiment. We examined 78 full-time students (males). The sample was created in a simple random way. The average age of young men was 18.51 ± 0.10 years in the first year and 20.43 ± 0.12 years in the second year of studies. Students had no complains about their health, all students gave voluntary consent to participate in the test. We examined 35 indicators: 11 indicators of physical development, 9 - physical fitness and 15 - functional state.

Physical development. To assess physical development, we measured length (cm), body weight (kg), circumference of the chest (CC, cm) and calculated weight-growth indices. The Pignet Index (PI) = BL - BW - CC, where BL - body length (cm), BW - body weight (kg), CC - chest circumference (cm). Rohrer's index (RI, kg m^{-3}) = BW: BL, where BW is body weight (kg); BL - body length (m). Body mass index (BMI, kg m^{-2}) = BW: BL^2, where BW is body weight (kg); BL–body length (m^2). Erismann index (EI, cm) = CC - BL / 2, where CC - chest circumference (cm), BL - body length (cm).

Physical fitness. To determine physical fitness, we assessed the level of development of basic motor skills in accordance with the sample program of the discipline 'Physical culture' (Russian Federation, 2000). At the end of each semester, students had a test, which included basic physical exercises in a gym and at a stadium: running 30 and 100 meters (speed), long jump (speed force), crunches on a bench from a standing position (flexibility), push ups, hanging on the bar, abdominal crunches (strength endurance), 1000 and 3000 m running (total endurance).

Functional state. The flexion muscle strength (kg) of the right and left hands was measured by the wrist dynamometry method. Then we calculated the power index, i.e. muscle strength to body weight.

To assess the state of the cardiovascular system (CVS) we measured heart rate (HR), systolic (SBP) and diastolic (DBP) blood pressure (mm Hg) at rest.

To assess the state of the respiratory system, we measured the vital capacity of the lungs (VCL, l), respiratory rate, conducted a Stange test and Genchi test. VCL was measured by a portable spirometer and the vital index (VI) was calculated as the ratio of VCL to body weight (mL kg^{-1}). In a Stange test a student in a standing position took a breath, then exhaled deeply and again inhaled, 80-90% of the maximum, and the breath holding time was noted. In a Genchi test a student was holding his breath as long as possible after a normal exhalation.

We assessed the tone of the autonomic nervous system on the basis of the Kerdo index, which was calculated by the formula: $KI = \left(1 - \frac{D}{p}\right) \times 100$, where D isdiastolic pressure (mm Hg), P - pulse (heart rate), b min^{-1}.

The blood circulation efficiency factor (CEF) was calculated by the formula: CEF = (SBP - DBP) • Heart rate, where SBP is systolic blood pressure (mm Hg), DBP - diastolic blood pressure (mm Hg), heart rate – frequency of heart rate (b min^{-1}.).

The coefficient of endurance (CE) was determined by the Kvass formula: CE = (10 • HR): PP, where HD is the heart rate (b min^{-1}.), PP is the pulse pressure (mm Hg). PP was calculated as the difference between SBP and DBP.

Adaptation to studying was evaluated by the value of adaptive capacity (AC): AC = 0.011 • HR + 0.014 • SBP + 0.008 • DBP + 0.09 • M - 0.009 • L + 0.014 • A - 0.27, where M is the body weight in kg, L - height in cm, A - age in years.

The results of the study were statistically processed by parametric statistics methods in the licensed Microsoft Excel software package on an Intel Pentium computer. Quantitative data were checked for the normality of the distribution in several ways: we estimated the symmetry of the sample by the histogram and used the Kolmogorov-Smirnov method. We found out that all data, with the exception of VCL and DBP, obeyed the law of normal distribution. For the latter, we used the method of nonparametric statistics - the Mann-Whitney criterion.

Then, we calculated the arithmetic mean (M) and the standard error of the mean (m), and expressed them in the text and tables asM ± m. Differences were evaluated by Student's criterion (t) for independent samples and were considered reliable at $p < 0.05$ («*» in text).

Results and discussion

Analyzing 35 indicators, we found statistically significant differences for 11 indicators (Tables 1, 2 and 3). In the study of physical development, we did not find differences in absolute indicators (weight, body length, etc.). Relative indicators (weight-growth) changed. It means there is a tendency to increase the body mass of young men during the first year of studies.

Table 1. Physical development of sudents.

Parameters	Group 1			Group 2		
	n	M	m	n	M	m
Body length, cm	64	174.95	0.78	67	176.54	0.78
Body weight, kg	71	68.36	1.00	70	69.62	1.06
Body-mass index (BMI)	64	383.94	5.45	60	400.87	6.41
Chest circumference at rest, cm	78	91.50	0.93	67	93.10	0.90
Chest circumference inhale, cm	78	96.61	0.91	67	99.05	1.40
Chest circumference exhale, cm	78	88.16	0.94	67	90.44	1.12
Chest excursion	69	8.39	0.32	67	8.62	0.57
Erismann index	58	2.72	1.00	59	5.97* p = 0.018	0.92
Rohrer index	64	12.36	0.20	59	13.20* p = 0.010	0.27
Pignet index	64	17.49	1.75	59	11.38* p = 0.023	2.03
Body weight index	64	21.77	0.32	60	22.99* p = 0.016	0.40

Note: * - significant differences, $p < 0.05$.

As for the indicators of physical fitness, the time of hanging on the bar and the speed of 1000 m running decreased. It indicates a deterioration in the physical fitness of students during the first year of studies.

Table 2. Physical fitness of students.

Parameters	Group 1			Group 2		
	n	M	m	n	M	m
Run 1000 m, min.	50	3.57	0.08	52	3.80*	0.08
Run 3000 m, min.	58	13.96	0.76	57	13.64	0.79
Run 100 m, sec.	56	14.3	0.21	56	14.3	0.21
Run 30 m, sec.	54	4.49	0.14	57	4.46	0.07
Long jump from a place, m	60	2.26	0.03	62	2.25	3.37
Push-ups, times	60	41.03	1.58	65	41.16	1.77
Abdominal crunches per 30 sec., times	60	27.2	0.58	63	29.1	0.66
Hanging on the bar, sec.	60	41.94	3.66	56	33.08*	2.24
Forvard bend, cm	58	5.54	1.20	49	6.97	1.80

Note: * - significant differences, $p < 0.05$.

Table 3. The functional state of students.

Parameters	Group 1			Group 2		
	n	M	m	n	M	m
vitalcapacityofthelungs (VCL, mL)	60	4091.68	76.75	64	3856.26*	70.44
the vital index (VI): the ratio of VCL to body weight (mL kg^{-1})	58	60.00	1.18	64	55.67*	0.95
Breathing rate, times per min.	78	17.63	0.48	65	16.66	0.46
Stange test, sec.	74	64.09	2.37	65	60.36	2.62
Genchi test, sec.	62	34.96	1.72	66	37.22	1.36
Kerdo index	73	10.92	1.80	60	8.22	2.56
Blood circulation efficiency factor	73	4242.74	116.72	60	4063.4	156.89
Endurance ratio	73	14.18	0.47	60	15.85*	0.52
Adaptivecapacity	62	2.07	0.03	60	2.20*	0.04
Heart rate (HR), beats per min.	75	75.86	1.48	66	77.63	1.34
Systolicbloodpressure (SBP), mm Hg	75	121.30	2.17	64	121.70	1.52
Diastolicbloodpressure (DBP)mm Hg	75	66.41	1.48	64	70.20*	1.17
The flexion muscle strength (kg) of the righthand, kg	74	43.19	0.85	63	43.47	1.14
The flexion muscle strength (kg) of the lefthand, kg	74	40.32	0.82	63	40.77	1.23
Power index	63	64.28	1.20	62	62.37	1.54

Note: * - significant differences, $p < 0.05$.

As for the indicators of the functional state, VCL and vital index decreased. The coefficient of endurance, adaptive capacity, diastolic blood pressure increased. It indicates a deterioration in functional state.

The study established a number of statistically significant differences in physical development, physical fitness, students' functional state in the process of adaptation to studying at university. Weight-growth indices, coefficient of endurance, adaptive capacity, diastolic blood pressure increased. VCL, vital index, hanging time on the bar and speed of 1000 m running decreased.

Physical development: We found out differences in weight and height indices, including BMI. Our data on the increase in BMI during a year are consistent with data on the increase in BMI of young men during the first year of studies (Ramírez-Vélez et al., 2014), during the first 1.5 years at the university (Deliens et al., 2015), during the first semester (Deliens et al., 2013). In our study BMI changed by 1.09 kg m^{-2}, in in the study (Deliens et al., 2015) - by 0.7 kg m^{-2}, and in the study (Pullman et al., 2009) BMI changed slightly.

The increase in weight and growth indices indicates a tendency to increase the body mass of young men during the first year of studies. Since weight and growth indices are recalculated relative indicators, they are more likely to show statistically significant differences than absolute indicators.

It is known that the ratio of body weight to length (in particular BMI) reflects adaptation to various environmental conditions at the population level, which forms a regional somatotype (Agadzhanyan, 2011).

Physical fitness and functional state: The results of our study of physical fitness are consistent with the research data of freshmen in Chelyabinsk (Ushakov, Nenasheva, & Kleschenkova, 2014). Our data on the decrease in the time of hanging on the bar and speed of 1000 m running are confirmed by the researches (Artemenkov, 2012). In our opinion, the non-physiological course of the adaptation process causes the deterioration of physical fitness.

The state of the cardiorespiratory system of young men in the process of adaptation also underwent a number of changes. In particular, there was a decrease in VCL and vital index, which confirmed the literature (Sukhanova, Maksimov, & Vdovenko, 2013). Deterioration of the state of the external respiration system is an alarm signal, indicating the tension of the compensatory-adaptive reactions of the body (Efimova & Popova, 2012).

The cardiovascular system also plays a leading role in the formation of an adequate level of metabolism (Sukhanova et al. 2013). Our data on an increase in diastolic blood pressure are confirmed by the literature. So, in the process of adaptation, students observe an increase in diastolic blood pressure (Zaccagni, Barbieri, & Gualdi-Russo, 2014) and a tendency to hypertension (Litvinova, Kazin, & Lurie, 2011). It should be noted that all the studied parameters of the cardiovascular system are within the physiological norm, but adaptive capacity and coefficient of endurance tend to the upper limit. An increase in these indicators means a weakening of the cardiovascular system and the tension of adaptation mechanisms. It is also known that adaptive capacity reliably characterizes the level of adaptation of the body and is a sensitive indicator of the state of adaptive mechanisms (Zinker & Dugarova, 2011).

Therefore, we consider the process of studying at university as a factor which negatively affects the health of young men. A negative effect is observed during the period of adaptation in reducing stamina and worsening the state of the cardio-respiratory system. In our research we obtained a full picture (physical development, physical fitness and functional state) of young students in the process of adaptation to studying. The data obtained require clarification using hardware methods for examining the cardiorespiratory system and continuing the research until the 3rd year of university.

Conclusion

As a result we came to the following conclusions:

1. The dynamics of physical development is expressed in a change in mass-growth indices and indicates an increase in body weight.
2. The dynamics of the functional state is expressed in a decrease in VCL, vital index, increase in coefficient of endurance, adaptive capacity and diastolic blood pressure.
3. The dynamics of physical fitness is expressed in a decrease in the time of hanging on the bar and speed of 1000 m running.

The results can be used to develop guidelines for optimizing the healthy environment at university and practical recommendations for improving students' health and development.

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