Features of body response of students with health limitations to multidirectional physical loads

UDC 796.01:612

PhD, Associate Professor **V.A. Vishnevsky**[1]
Dr.Hab., Associate Professor **N.V. Peshkova**[1]
[1]Surgut State University, Surgut

Corresponding author: fizkult@teoriya.ru

Abstract

Objective of the study was to reveal the features of the body response of students temporarily exempted from physical education classes to multidirectional loads in the modified version of S.P. Letunov's functional test.

Methods and structure of the study. The study conducted at Surgut State University involved 16 first-year female students temporarily exempted from physical education classes. After setting up the equipment and a 5-minute rest, the female students sequentially performed an orthostatic test: 20 squats in 30 seconds, a 15-second run in place at a maximum pace, a 3-minute run at a pace accessible to the subjects (the rest intervals after loading were, respectively, 2, 3, 4, and 5 minutes).

The mobile COSMEDK5 and GuarkT12x systems were used to measure respiratory, metabolic and electrocardiogram parameters during testing. The following baseline values were recorded: oxygen consumption, carbon dioxide production, pulmonary ventilation, heart rate, blood pressure, energy consumption. Based on these data, the following parameters were calculated: respiratory coefficient, oxygen pulse, pulse cost and a number of other parameters.

Results and Results and conclusions. The study found that, in terms of a comprehensive body response, the most informative tests were 20 squats and 3-minute run. We detected a more significant increase in the respiratory parameters of the students compared to the hemodynamic ones. In this view, the determination of the type of body response to physical loads based exclusively on pulse and blood pressure does not fully reflect the real picture. The use of advanced mobile systems to assess physical load tolerance in the field provides the necessary information for dosing physical loads.

Keywords: *S.P. Letunov's test, body response to physical loads, students exempted from physical education classes.*

Background. Demographic problems and negative trends in the health of the younger generation have created the conditions for an increase in the proportion of students temporarily exempted from physical education classes [2, 3]. At the same time, the authors agree that exemption from sports for health reasons can only be temporary, and it is necessary to search for possible options to involve students in health and fitness activities [4]. It should also be taken into account that the studied group is extremely heterogeneous in terms of health condition. Thus, it was found [1] that when assessing the functional reserves of the body in response to an active orthostatic test, only 48% of students demonstrate a normal transient process and an adequate response, while 28% have an increased response range of the cardiovascular system, and 24% - a decreased one. This indicates that this group of students can engage in physical education but with strict dosing of physical loads, taking into account their individual characteristics. In this regard, there is a need to search for available and safe methods for determining physical load tolerance.

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Results and discussion. In the initial position, the studied group was characterized by tachycardia (92±16 bpm), rapid breathing (18±4, min), and low oxygen pulse (3.3±1.1 ml/min). The respiratory coefficient (0.85±0.07 c.u.) reflected the nature of the mixed diet (0.85-0.9). In general, the rates obtained at rest were typical for an untrained person. The transition of the subjects to a standing position (orthostatic test) did not cause serious changes in their body, there was only a tendency towards cardiac acceleration (up to 101 ± 15 bpm, by 9.8%) and an increase in oxygen consumption (up to 329 ± 87 ml/min, by 13%); however, the changes in these indicators were not statistically significant.

The second stage of the test caused a more significant body response (see Table). Upon performing 20 squats, we observed an increase in pulmonary ventilation, which reached its maximum in the 1st minute of recovery and remained significantly higher than the baseline values until the end of the 3rd minute. This was due to the depth of breathing (74.1%) rather than frequency (26.3%). Moreover, the respiratory rate was restored already in the 2nd minute after the test, and the respiratory volume remained elevated (53.7%) until the end of the 3rd minute of recovery.

Oxygen consumption in the subjects was found to increase when they performed physical loads and reached its maximum in the 1st minute of recovery (221%). The maximum carbon dioxide production occurred a minute later (254.2%). The maximum respiratory coefficient was even more inert and reached the highest values in the 3rd minute of recovery (150%), while its value exceeded the anaerobic threshold. This was probably due to the high concentration of hydrogen ions in the blood, which excited the respiratory center, caused increased carbon dioxide production, an increase in its concentration in the exhaled air ($FeCO_2$ in the second minute of recovery - 126.5%), and oxygen consumption in the 3rd minute of recovery dropped significantly.

Among the hemodynamic parameters, it was heart rate that was the most responsive. It reached its maxi-

Body response of female students to 20 squats during test

Indicators, M±σ	Time of recording				
	Baseline values	20 squats	1 min	2 min	3 min
Rf (per min)	19±4	22±5	24±5*	21±5	19±4
VT (l)	0,54±0,16	0,59±0,22	0,86±0,27*	0,94±0,25*	0,83±0,21*
VE (l/min)	9,8±2,8	12,5±3,7*	19,8±5,6*	19,2±5,6*	15,6±4,5*
IV(ml)	459±170	716±270	878±247	733±191	609±145
VO_2 (ml/min)	338±74	397±91*	747±222*	695±179*	438±104*
VCO_2 (ml/min)	264±65	334±88*	606±177*	671±214*	512±156*
RQ	0,78±0,05	0,83±0,58*	0,82±0,11*	0,98±0,14*	1,17±0,18*
VE/VO_2	24,8±4,2	27±4,8	25±4,2	26±5,5	33±6,5*
VE/VCO_2	31,6±4,2	32,3±4,7	30,3±3,5	26,8±3,3*	28,2±3,5
VO_2/kg (ml/min/kg)	6,2±0,9	7,3±1,6*	13,6±2,8*	12,7±2,4*	8,1±2,2*
METS	1,8±0,3	2,1±0,4*	3,9±0,8*	3,6±0,7*	2,3±0,6*
HR (bpm)	91±13	119±18*	117±14*	102±12*	97±13
VO_2/HR (ml/beat)	3,8±1,0	3,4±1,1	6,5±1,8*	6,9±2,0*	4,5±1,1*
FeO_2 (%)	16,8±0,6	17±0,6	16±0,6	16±0,6	17±0,6
$FeCO_2$ (%)	3,4±0,4	3,4±0,4	3,8±0,4*	4,3±0,5*	4,0±0,5*
SBP (mmHg)	122±15	-	135±15*	126±11	121±11
DBP (mmHg)	75±10	-	82±10*	78±9	75±8
PP (mmHg)	47±15	-	52±10	47±8	45±8
SV5 (mV/s)	1,00±0,39	1,01±0,71	1,62±0,62*	1,35±0,43*	1,08±0,43
SV6 (mV/s)	0,78±0,33	0,66±0,94	1,16±0,45*	1,01±0,34	0,85±0,44

* the changes are significant at $p<0.05$.

mum value during squats (130.8%) and fully recovered already in the 2nd minute of rest. Immediately after loading, we recorded the maximum values of the systolic (110.7%) and diastolic (109.3%) blood pressure, which did not differ significantly from the baseline values already in the 2nd minute of rest. Moreover, judging by the fact that the pulse pressure did not change significantly, it was the chronotropic effect of adaptation to physical loads that was mainly realized. A significant deepening of the S wave in V5 (162%) and V6 (148.7%) leads of ECG in the 1st and 2nd minutes of recovery also indicated low cardiac contractility.

There were no significant changes in the structure of correlation relationships during squats. Oxygen consumption still indicated a wide range of relationships: depth of breathing ($r=0.716$, $p<0.05$); pulmonary ventilation ($r=0.847$, $p<0.05$); carbon dioxide production ($r=0.960$, $p<0.05$); oxygen pulse ($r=0.725$, $p<0.05$); specific oxygen consumption ($r=0.578$, $p<0.05$); METS ($r=0.587$, $p<0.05$). At the same time, the heart rate values revealed a significant correlation with oxygen pulse only ($r=0.692$, $p<0.05$). Approximately the same situation persisted in the 1st minute of recovery, with the exception of pulse, which was found to correlate with the respiratory coefficient ($r=-0.549$, $p<0.05$).

Therefore, it can be argued that the body response to 20 squats of students exempted from physical education classes is characterized as imperfect. Taking into account the elevated diastolic pressure, the absence of an increase in pulse pressure, incomplete recovery of a number of indicators by the end of the 3rd minute, increase in the respiratory coefficient above the anaerobic threshold, the type of reaction to physical loads was deemed not normotonic (not optimal). It should also be emphasized that a more significant increase was observed in the respiratory parameters compared to the hemodynamic ones, which to a greater extent reflect the body response to physical loads and correlate with many other integral indicators of body state.

Given this fact, as well as the absence of broad correlation relationships between heart rate and blood pressure, it can be stated that the determination of the type of body response to physical loads based exclusively on pulse and blood pressure does not fully reflect the real picture. Nor can we assess the recovery of the body as a whole by heart rate and blood pressure only, since a number of other integral indicators of the body (oxygen consumption, carbon dioxide production, pulmonary ventilation, respiratory coefficient, and oxygen pulse) exceed the baseline values even by the 3rd minute of recovery.

The most significant body response was observed during the 3-minute run at a pace that the subjects considered optimal for themselves. The test results indicated that the trainees chose a rate of 145±17 bpm on average, with oxygen consumption of 261% of the baseline values, carbon dioxide production of 232% and respiratory rate of 0.93±0.09. This pace appeared to have been somewhat increased. This was evidenced by a significant increase in oxygen consumption (394%) and carbon dioxide production (382%), increase in diastolic blood pressure (13.5%), deepening the S wave in V5 (248.5%) and V6 (361.3%) leads of ECG in the 1st minute of recovery and further increase of respiratory rate to 1.20±0.14 by the 3rd-4th minute of recovery. At the same time, there were also some signs of increased efficiency in the body function (increase of oxygen pulse, pulse pressure, fuller utilization of oxygen from the inhaled air, decrease of ventilatory equivalent for carbon dioxide). Most of the indicators (except respiratory rate) recovered by the 3rd-4th minute of rest.

Conclusion. The use of advanced mobile systems to assess physical load tolerance in the field significantly enhances the insight into the adaptation mechanisms and provides the necessary information for dosing physical loads. Based on this, we have developed a physical education model for students temporarily exempted from physical education classes, which includes methodical-practical sessions devoted to the development of individualized health and fitness, rehabilitation programs and their subsequent implementation in practice.

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