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CARDIAC ACTIVITY INDICATORS IN FEMALE STUDENTS OF NIZHNEVARTOVSK DEPENDING ON PHYSICAL ACTIVITY LEVEL

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ПОКАЗАТЕЛИ ДЕЯТЕЛЬНОСТИ СЕРДЦА У СТУДЕНТОК г. НИЖНЕВАРТОВСКА В ЗАВИСИМОСТИ ОТ ОБЪЕМА ДВИГАТЕЛЬНОЙ АКТИВНОСТИ

Abstract. Physical inactivity as a serious health threat to students is exacerbated in the North by extreme environmental and climatic conditions. The aim of the study was to assess the state of the circulatory system at rest and during graded physical exercise in female students of a northern university, depending on the volume of their organized physical activity. The study involved female students from the Faculty of Physical Culture and Sports (PCS) (n=37) and the Faculty of Ecology and Engineering (EE) (n=51) of Nizhnevartovsk State University (NVSU). The parameters were obtained using volume-compression oscillometry with the APKO-8-RITs-M device at rest and during a test with graded muscle exercise (20 squats in 30 seconds). Results and Discussion. In female students with higher volumes of organized physical activity (OPA) (Faculty of Physical Culture and Sports), significantly lower values were observed at rest for: systolic blood pressure (SBP, mm Hg); cardiac output (CO, L/min); cardiac index (CI, L/(min. m²)); stroke volume (SV, mL); stroke index (SI, mL/m²). Following the exercise test, female students from the Faculty of Ecology and Engineering demonstrated higher values for SBP, diastolic blood pressure (DBP), CO, CI, SV, and SI. Conclusion. The study results indicate a pronounced economization of hemodynamic function in females with a higher volume of habitual motor activity, both under resting conditions and during a physical load test with limited duration and muscle group involvement. This economization may be attributed to a partial redistribution of the load from the cardiac muscle to the skeletal musculature, which maintains good functional status due to adequate OPA volume.

Keywords: students, northern regions, cardiac output, stroke volume, heart rate, blood pressure.

Аннотация. Серьезной угрозой здоровью студенческой молодежи выступает гиподинамия, усугубляющаяся на севере экстремальными природно-климатическими условиями. Цель исследования – оценить показатели системы кровообращения в покое и при дозированной физической нагрузке у студенток северного вуза в зависимости от объема организованной двигательной активности (ОДА). Обследованы студентки факультетов физической культуры и спорта (ФКиС) (n=37), экологии и инжиниринга (ЭиИ) (n=51) НВГУ. Показатели получены методом объемной компрессионной осциллометрии при помощи АПКО-8-РИЦ-М в покое и с дозированной физической нагрузкой (проба Мартине-Кушелевского). Результаты и обсуждение. У девушек с бо̀льшим объемом ОДА (студентки факультета ФКиС) в условиях мышечного покоя были значимо ниже величины систолического АД (САД, мм рт. ст.), сердечного выброса (СВ, л/мин.), сердечного индекса (СИ, л/(мин. м^2)), ударного объема (УО, мл), ударного индекса (УИ, мл/м2). После выполнения нагрузки, у студенток факультета ЭиИ были выше показатели САД, ДАД, СВ, СИ, УО и УИ. Заключение. Результаты исследования свидетельствуют о выраженной экономизации гемодинамической функции у девушек с бо̀льшим объемом привычной ОДА в условиях двигательного покоя и в пробе с физической нагрузкой, ограниченной по времени выполнения и вовлеченности мышечных групп. Экономизация может быть обусловлена частичным перераспределением нагрузки с сердечной мышцы на скелетную мускулатуру, имеющую хороший функциональный статус за счет достаточного объема ОДА.

Ключевые слова: студенты, север, сердечный выброс, ударный объем, частота сердечных сокращений, артериальное давление.

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Introduction. National security largely depends on the health status of the population. "Human health is a most important indicator and condition for the development of an individual, the society, and the economy" [14, p. 142]. From an ecological perspective, human health may be negatively affected by adverse environmental factors [5, pp. 8-9]. In northern regions, these include low air temperatures, altered photoperiod, and abrupt weather changes [8]. Adaptation of the human organism to extreme environmental conditions is largely determined by the state of the cardiovascular system (CVS). In turn, the CVS functioning depends on the level of adaptation to various influences, primarily physical exercise, which has a beneficial effect on its function, overall endurance, skeletal muscle condition, and psychological status [1; 10]. Maintaining the optimal level of physical activity is particularly important in northern territories, where during the prolonged cold season people spend considerable time indoors, spontaneous physical activity decreases, and as a result hypoxia is aggravated, "motor deficiency" increases, and skeletal muscle function deteriorates [9, p. 62].

Reduced physical activity negatively affects students' well-being [20]. Among acquired risk factors for cardiovascular diseases, physical inactivity is one of the most significant [13], and its prevalence increases during the period of university education [11]. The combined effect of these negative influences leads to a deterioration in the health status of modern students. For example,

only one quarter of male students and a half of female students examined at the health centre of Stavropol State Medical University demonstrated favorable hemodynamic status, normal blood pressure values, and normal vascular wall stiffness [12]. For the students of northern regions, the daily volume of habitual physical activity is limited by climatic and weather conditions that hinder walking and outdoor activity. Adverse trends in the health status of student youth highlight the urgent need for continuous monitoring of cardiovascular system function, while "studies addressing cardiovascular risk factors … in this social group remain clearly insufficient" [11, p. 24]. Exercise tests with graded physical load are widely used to assess the functional state of the circulatory system [19].

Based on the above, the aim of the study was to assess cardiac function parameters at rest and during graded physical exercise in female students of a northern university, depending on the level of organized physical activity.

Materials and Methods. The study was conducted at the Laboratory of Human Physiology and Ecology of Nizhnevartovsk State University (NVSU). Female students from the Faculty of Physical Culture and Sports (PCS) (n = 37) and the Faculty of Ecology and Engineering (EE) (n = 51) were examined. According to the curricula and class schedule, these groups differed in the volume of organized physical activity (OPA): the students of the PCS faculty had at least 8-10 academic hours of in-class physical education per week, whereas the students of the EE faculty had 4 academic hours of physical education per week. Cardiac function parameters were assessed by using the APKO-8-RITs-M device (oscillometric circulatory parameter analyzer, Russia) [2]. The method of volume compression oscillometry provides high reliability in the estimation of circulatory system parameters. The measurements were obtained under resting conditions and during a graded physical exercise test (Martinet–Kushelevsky test), in accordance with standard methodological recommendations [16]. The following cardiovascular parameters were assessed: *heart rate* (HR, beats/min); *systolic blood pressure* (SBP, mm Hg); *diastolic blood pressure* (DBP, mm Hg); *cardiac output* (CO, L/min); *cardiac index* (CI, L/min·m²); *stroke volume* (SV, mL); and *stroke index* (SI, mL/m²).

The study was conducted in accordance with the principles of the World Medical Association Declaration of Helsinki (2013 revision) and was approved by the Local Ethics Committee of Nizhnevartovsk State University (Protocol No. 1 dated 12.09.2024). Statistical analysis was performed by using Microsoft Excel 2010. Normality of the data distribution was assessed through the Kolmogorov-Smirnov test. Comparison between two independent samples was performed via the non-parametric Mann-Whitney U test [4]. Descriptive statistics are presented as mean (M), median (Me), and interquartile range (Q1–Q3). Differences were considered statistically significant at $p \leq 0.05$. Probability values with more than four zeros after the decimal point were reported as $p < 0.0001$.

Results and Discussions. In female groups with different volumes of organized physical activity (OPA), circulatory system parameters were compared under resting conditions (Table 1) and during graded muscle exercise (Table 2). Heart rate is one of the most important characteristics

of hemodynamic function, representing the integrated outcome of multilevel regulatory mechanisms. As shown, resting heart rate (HR, beats/min) did not differ significantly between the compared groups, and in at least 50% of examined participants (Q1–Q3) it remained within the normal range [2]. After physical exercise, a tendency toward higher HR values was observed in female students of the Faculty of Physical Culture and Sports (PCS).

Table 1

Cardiac function parameters in female students of NVSU with different levels of organized physical activity under resting conditions

Parameters	Students of the Faculty of Ecology and Engineering (n=51)	Students of the Faculty of Physical Culture and Sports (n=37)	P
	M/Me (Q_1-Q_3)	M/Me (Q_1-Q_3)	
HR, beats/min	79.5/77.0 (68.0-89.0)	73.6/75.0 (71.0-80.0)	0.101
SBP, mm Hg	124.8 /125.0 (120.0-130.0)	109.5/107.0 (101.0-120.0)	<0.0001
DBP, mm Hg	57.4/58.0 (49.0-64.0)	54.3/54.0 (49.0-58.0)	0.079
Cardiac output, L/min	5.53/5.60 (4.90-6.10)	4.29/4.30 (4.10-4.80)	<0.0001
Cardiac index, L/(min·m²)	3.34/3.30 (3.00-3.80)	2.76/2.90 (2.60-3.20)	0.00009
Stroke volume, mL	74.4/72.0 (61.0-83.0)	57.7/55.0 (53.0-62.0)	<0.0001
Stroke index, mL/m²	45.98/46.00 (36.00-57.00)	36.89/37.00 (32.00-41.00)	0.003

Note: p – Mann-Whitney U test.

Table 2

Cardiac function parameters in female students of NVSU with different levels of organized physical activity during a graded muscle exercise test

Parameters	Students of the Faculty of Ecology and Engineering (n=51)	Students of the Faculty of Physical Culture and Sports (n=37)	P
	M/Me (Q_1-Q_3)	M/Me (Q_1-Q_3)	
HR, beats/min	92.7/94.0 (77.0-106.0)	98.6/100.0 (89.0-103.0)	0.089
SBP, mm Hg	128.2/127.0 (118.0-136.0)	117.1/117.0 (108.0-123.0)	0.0001
DBP, mm Hg	56.6/56.0 (51.0-62.0)	50.2/50.0 (47.0-55.0)	0.0002
Cardiac output, L/min	5.8/5.8 (4.7-6.8)	4.9/5.1 (4.3-5.5)	0.0003
Cardiac index, L/(min·m²)	3.5/3.4 (3.1-4.0)	3.1/3.1 (2.9-3.5)	0.006
Stroke volume, mL	65.9/65.0 (55.0-75.0)	50.8/54.0 (42.0-57.0)	0.00001
Stroke index, mL/m²	40.9/41.0 (30.0-48.0)	32.6/34.0 (29.0-37.0)	0.0008

Note: p – Mann-Whitney U test.

The results of studies on cardiovascular responses to physical exercise are often contradictory and may depend on several factors, including the characteristics of the load itself – duration, intensity, involvement of muscle groups, etc. – as well as the functional state of the organism. Published data on trained individuals indicate that "during standard exercise, trained subjects have a lower heart rate in absolute values, while in relative terms it may be higher than in untrained individuals" [7, p. 103-104].

Among blood pressure parameters, systolic blood pressure (SBP) reflects the cardiac component of hemodynamics; it corresponds to the maximal blood volume ejected into the vascular bed and largely depends on myocardial contractility. Under both resting conditions and during the exercise test, SBP (mm Hg) was significantly higher in female students with a lower volume of OPA. Diastolic blood pressure (DBP), measured at the end of diastole, is determined by blood outflow through the capillary network and heart rate [2]. This is considered to be a so-called vascular component of blood pressure. At rest, a tendency toward lower DBP values was observed in students with a higher volume of OPA; after exercise, the trend became more pronounced and reached statistical significance. According to clinical definitions, *optimal*, *normal*, and *high-normal* blood pressure levels are defined as follows (mm Hg): SBP < 120 and/or DBP < 80; SBP 120-129 and/or DBP 80-84; SBP 130-139 and/or DBP 85-89 [15]. At rest, SBP values in at least 25% of students from the EE faculty corresponded to *high-normal* blood pressure, whereas in 75% of students from the PCS faculty they fell within the *optimal* range. The DBP values in both measurements were within the optimal range according to the 2024 Clinical Guidelines [15], and corresponded to normal values according to the device software (50–71 mm Hg) [2], while the elevated DBP is generally considered to be a more unfavorable indicator than the increased SBP. Such DBP values may be associated with the optimal functional state of the vascular wall in female students, regardless of the volume of organized physical activity.

There is evidence that, depending on the characteristics of physical work, "blood pressure in the brachial artery increases less in trained athletes, but in some cases may also increase more than in untrained individuals," as "in active regions of the body arterial pressure increases less in trained subjects than in untrained ones, while in inactive regions it may be somewhat higher" [7, p. 104]. During the squat test, the main load is imposed on the large muscles of the lower limbs, resulting in a redistribution of blood flow. Female students of the Faculty of Physical Culture and Sports (PCS) demonstrate a better adaptation to muscular load due to a higher volume of habitual organized physical activity (OPA). Lower indices of central hemodynamics, including systolic and diastolic blood pressure and heart rate, in athletes compared to non-athletes are considered an "advantage in cardiovascular system function" [3, p. 25]. Both components of blood pressure depend on vascular stiffness; therefore, it was suggested that "assessment of vascular stiffness should be included in cardiovascular health screening programs for young people" [11, p. 21]. Cardiac output (CO), defined as the volume of blood ejected by the heart into the main vessels per minute, characterizes the pumping function of the heart. This parameter depends on circulating blood volume and blood flow velocity; additional influencing factors include age, sex, body mass,

and others. Normal CO values are considered to be 5.0 ± 1.5 L/min [2]. At least a half of the female participants in both groups demonstrated CO values within the normal range. At rest and after the squat test, cardiac output was higher in students with a lower level of OPA. Thus, even under a low-intensity physical load, an intensification of cardiovascular function is observed, indicating reduced adaptation and insufficient readiness of the organism to perform such a load. The *cardiac index* (CI) is defined as cardiac output normalized to body surface area. The CI is an individual characteristic of the circulatory system and normally equals 3.0 ± 1.0 L/(min·m²) [2]. At rest, the CI values in both groups were within normal limits; however, after exercise, 25% of students from the EE faculty exceeded the upper normal threshold. In both resting and post-exercise conditions, the CI was higher in students with a lower level of OPA.

The myocardial contractile strength defines the *stroke volume* (SV), a volume of blood ejected with each heartbeat into the great vessels; its normal value is 70 ± 20 mL. At rest, normal SV values were observed in female students regardless of the level of organized physical activity (OPA). After the squat test, at least 25% of students from the Faculty of Physical Culture and Sports (PCS) showed the SV values below the lower limit of normal. In both resting and post-exercise conditions, the SV was higher in students from the Faculty of Ecology and Engineering (EE).

The stroke volume normalized to body surface area is defined as *stroke index* (SI), with normal values considered to be 40 ± 10 mL/m² [2]. At rest, the SI in at least 25% of students from the EE faculty exceeded the upper limit of normal values; after exercise, almost a quarter of the PCS faculty students demonstrated the SI values below normal. In both measurements, higher SI values were observed in female students with a lower level of OPA.

Conclusion

Lower values of HR, SBP, DBP, and other functional cardiovascular parameters in females with a higher level of physical activity are considered to be a sign of functional economization and better adaptation [6]. The reduced demand placed on the circulatory system in individuals adapted to physical exercise is explained by "a relatively lower oxygen demand and more efficient oxygen utilization by body tissues" [7, pp. 103-104]. Insufficient physical activity among students leads to a reduction in the functional capabilities of the cardiovascular system and contributes to increased regulatory strain under resting conditions [17; 18, p. 76].

Thus, the results of the study indicate increased regulatory strain of the cardiovascular system in female students with a low level of habitual organized physical activity, and pronounced economization of hemodynamic function in those with a higher level of activity, both at rest and during a limited in duration and in the involvement of muscle groups exercise test. This economization may be attributed to a partial redistribution of workload from the cardiac muscle to the skeletal musculature, which maintains a good functional status due to an adequate level of physical activity. In northern environmental conditions, the improvement of cardiovascular function can be achieved through an increase in students' physical activity via feasible, systematic, low-intensity exercise programs.

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