Discriminant analysis: peculiarities of impact of sports specialization on 3rd-year female students' functional and motor fitness

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Abstract

Background and Study Aim The objective of the study was to determine the peculiarities of impact of sports specialization on 3rd-year female students' functional and motor fitness.

Material and Methods The study involved 3rd-year female students of the Donbas State Engineering Academy in Kramatorsk, who practiced badminton (n = 43), aerobics (n = 43), and callanetics (n = 43). To solve the tasks set, the following research methods were used: analysis of scientific literature, pedagogical observation, pedagogical testing; index method and medical-biological methods. Pedagogical methods were used to study the peculiarities of students' functional state of the body and motor abilities; for data processing discriminant analysis was used. Sectional classes were held in groups according to the schedule – twice a week.

Results The study revealed the peculiarities of impact of attending badminton, aerobics, and callanetics sports sections on the level of 3rd-year female students' functional and motor fitness. The female students who play badminton show better results in the 100-meter dash and the Standing long jump. In the exercise "Push-ups", better results are shown by the female students who do aerobics.

Conclusions The results of classification of students by the level of motor and functional fitness and the analysis of multidimensional averages (centroids) point to the peculiarities of dynamics of female students' state depending on sports specialization. The results of the following tests are most important for differentiated assessment of the state of motor and functional fitness at the first level: Romberg test (r = 0.662), 100-meter dash (r = 0.491), Push-ups (r = 0.491). At the second level – Stange test (r = 0.417), Standing long jump (r = 0.412).

Keywords: students, badminton, aerobics, callanetics, discriminant analysis.

Introduction

Recently, there has been a noticeable deterioration in the state of health and a decline in motor fitness of students throughout the country, which causes concern among physical education specialists [1-3].

Decreased physical activity and motivation to exercise among adults, as well as children and young people is a global phenomenon [4-6]. Sigmundová et al. [4] point out that 69% of female students and 74% of male students of Czech universities meet the 10,000 steps daily criterion on four or more days per week; Cachón-Zagalaz et al. [5] focus on using the method for identifying professionally important qualities as components of a student's competency levels and their physical activity levels; Doroshenko et al. [6] indicate that taking into account female students' motor age during recreational aerobics classes ensures optimal motor activity and increases the level of physical fitness.

A number of studies are aimed at studying the dynamics of motor fitness [7-9], the influence of predominant orientation means on students' motor and functional fitness [10-12], methods of fundamental movement

screening [13-15].

Much less research focuses on studying the functional peculiarities of the cardiovascular and respiratory systems, motor fitness of student youth under the influence of sports [1, 16, 17].

Multidimensional methods of mathematical statistics, such as factor and discriminant analysis are effective methods of studying the peculiarities of functional and motor fitness [18, 19, 20]. Discriminant analysis is used to assess both the results of sports training [21-23] and recreational classes [24-26].

The objective of the study was to determine the peculiarities of impact of sports specialization on 3rd-year female students' functional and motor fitness.

Materials and methods

Study participants

The study involved 3rd-year female students of the Donbas State Engineering Academy in Kramatorsk, who practiced badminton (n = 43), aerobics (n = 43), and callanetics (n = 43). The study started after the approval of the Research Ethics Committee of the Academy.

Study organization

To solve the tasks set, the following research methods

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were used: analysis of scientific literature, pedagogical observation, pedagogical testing; index method and medical-biological methods. Pedagogical methods were used to study the peculiarities of students' functional state of the body and motor abilities; for data processing discriminant analysis was used. Sectional classes were held in groups according to the schedule – twice a week.

Testing procedure

The testing program included well-known tests proposed by Serhiyenko [27]: Standing long jump (cm), 100-meter dash (s), Push-ups (times), Romberg test.

The Ruffier index, the Stange test, the Genchi test were used to assess the functional state [28, 29].

Ruffier-Dickson index. The test was used to assess cardiovascular performance during exercise.

Equipment: Stopwatch, tonometer, a device for measuring blood pressure.

Testing procedure. After 5 minutes of sitting calmly, the number of pulses was counted for 15 seconds (P1). Then 30 squats were performed for 45 seconds, using a metronome. Immediately after squatting, the pulse was measured for the first 15 seconds (P2) and the last 15 seconds (P3) of the first minute after the end of exercise.

Testing evaluation. The results are evaluated by an index determined by the formula: $\text{Ruffier index} = (P3 + P2 - P1 - 70)/10$. Ruffier index: 0–5 - good cardiovascular performance; 5.1–10 - average result; 10.1–15 - satisfactory (moderate heart insufficiency); 15.1–20 - bad (significant heart insufficiency).

Stange test. The test was used to assess the functional state of the respiratory system.

Equipment: Stopwatch.

Testing procedure. In a sitting position, the subject inhales deeply and exhales, then inhales again (approximately 80% of the maximum), closes the mouth and simultaneously pinches the nose with fingers, holds breath (timing begins when inhale finishes and stops when exhale starts).

Testing evaluation. Breathhold: up to 35 s - fatigue; for 40–55 s - healthy untrained; for 60–90 s - healthy trained.

Genchi test. The test was used to assess the functional state of the respiratory system.

Equipment: Stopwatch.

Testing procedure. The Genchi test involves breath-holding after exhalation. It was conducted not earlier than 5–7 minutes after the Stange test.

Testing evaluation. Breathhold: up to 20 s - fatigue; for 25–30 s - healthy untrained; for 40–60 s - healthy trained.

Romberg test. The test is used to assess static balance.

Equipment: Stopwatch.

Testing procedure. The participant stands with the feet on one line, one in front of the other, eyes closed, arms forward. Timing begins at the moment when a steady position is assumed, the test stops when the steady position is lost.

Result. The time of holding a steady position in seconds is recorded.

Testing evaluation. Normally, balance should not be lost for 30 seconds.

Statistical analysis

The study results were processed by the method of mathematical statistics. The following parameters were calculated: arithmetic mean ($\bar{x}$), error in calculating the arithmetic mean (s); significance of difference between means (t). The significance of difference between statistical indicators (t) was evaluated using the Student's t -test. Discriminant analysis created a prognostic model for group membership. This model builds a discriminant function (or, for more than two groups, a set of discriminant functions) in the form of a linear combination of predictor variables, which provides the best discrimination between the groups. These functions are developed from a sample of cases for which their group membership is known. These functions can be further used for new cases with known values of predictor variables and unknown group membership. For each variable, the following values are calculated: means, standard deviations, one-way ANOVA (Box's M test, within-group correlation matrix, within-group covariance matrix, covariance matrices for separate groups, total covariance matrix). For each canonical discriminant function: eigenvalue, percentage of variance, canonical correlation, Wilks' Lambda, Chi-square. For each step: prior probabilities, Fisher's function coefficients, unstandardized function coefficients, Wilks' Lambda for each canonical function.

Results

Tables 1–2 show the results of analysis of the motor and functional fitness of 3rd-year female students attending badminton, aerobics, and callanetics sports sections. It was found that by the level of fitness the female students of the three groups differ statistically significantly both at the beginning of attending the section and after a year of training. According to the Ruffier index, the female students have a satisfactory level of heart performance. According to the indicators of the Stange test, they are assessed as healthy untrained. According to the Genchi test – as healthy trained. According to the Romberg test indicators, the female students show below normal results.

The female students who play badminton show better results in the 100-meter dash and the Standing long jump. In the exercise "Push-ups", better results are shown by the female students who do aerobics.

Discriminant analysis was conducted to identify the peculiarities of the female students' motor and functional fitness. The first canonical function explains 53.5% of the variation of results, the second function – 34.1%, which indicates their high informativeness ($r_1 = 0.619$; $r_2 = 0.532$) (see Table 3). The materials of analysis of the canonical functions show a statistical significance of the first, second, and third canonical functions ($\lambda_1 = 0.384$; $p_1 = 0.001$; $\lambda_2 = 0.623$; $p_2 = 0.001$; $\lambda_3 = 0.870$; $p_3 = 0.002$). The first, second, and third functions have a high discriminative ability and value in interpretation of the general population (Table 4).

Tables 5 and 6 show the standardized and structure canonical discriminant function coefficients. The results of the following tests are most important for differentiated

Table 1. Group Statistics

Indicators	Badminton				Aerobics				Callanetics			
	pre-test		post-test		pre-test		post-test		pre-test		post-test	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Ruffier index	14.7	5.1	14.3	4.2	14.3	4.2	12.0	3.4	12.9	3.1	12.6	2.9
Stange test, s	55.1	17.2	64.0	31.8	44.8	9.8	49.8	11.7	38.6	12.1	44.1	12.9
Genchi test, s	43.5	10.7	41.4	15.0	31.0	7.6	35.3	8.1	32.5	10.1	40.1	12.4
Romberg test, s	7.0	4.2	5.7	2.7	10.9	7.4	13.3	6.1	4.7	3.4	6.6	5.2
100-meter dash, s	16.2	1.7	15.8	1.7	17.7	1.2	17.2	1.0	17.6	1.2	17.3	1.1
Standing long jump, cm	198.3	31.1	208.8	32.5	179.1	14.2	184.8	14.0	179.3	15.6	180.4	30.3
Push-ups, times	15.7	6.8	16.9	7.3	18.8	5.3	22.3	4.1	16.6	6.7	17.1	6.3

Table 2. Tests of Equality of Group Means

Indicators	Wilks' Lambda	F	df1	df2	Sig.
Ruffier index	.937	3.387	5	252	.006
Stange test, s	.816	11.381	5	252	.000
Genchi test, s	.844	9.290	5	252	.000
Romberg test, s	.734	18.218	5	252	.000
100-meter dash, s	.784	13.925	5	252	.000
Standing long jump (cm)	.822	10.919	5	252	.000
Push-ups, times	.890	6.240	5	252	.000

Table 3. Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.621 ^a	53.5	53.5	.619
2	.396 ^a	34.1	87.6	.532
3	.087 ^a	7.5	95.1	.283
4	.054 ^a	4.6	99.7	.226
5	.003 ^a	.3	100.0	.058

Table 4. Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 5	.384	239.511	35	.000
2 through 5	.623	118.447	24	.000
3 through 5	.870	34.967	15	.002
4 through 5	.946	14.016	8	.081
5	.997	.845	3	.839

assessment of the state of motor and functional fitness at the first level: 100-meter dash ($r = 0.586$), Standing long jump ($r = -0.493$). At the second level – Romberg test ($r = 0.614$), at the third level – Genci test ($r = -0.803$).

The analysis of multidimensional averages (centroids) shows different levels of motor and functional fitness of the female students according to pre-test and post-test results. There are peculiarities of dynamics of the female students' state depending on sports specialization (Table 7, Fig. 1).

Discriminant analysis of the three groups. Post-test

To clarify the impact of specialization on the 3rd-year female students' functional and motor fitness, the study conducted a discriminant analysis of post-test results in

groups practicing badminton, aerobics, and callanetics. The first canonical function explains 66.4% of the variation of results, the second function – 33.6%, which indicates their high informativeness ($r_1 = 0.689$; $r_2 = 0.560$) (Table 8). The materials of analysis of the canonical functions show a statistical significance of the first and second canonical functions ($\lambda_1 = 0.360$; $p_1 = 0.001$; $\lambda_2 = 0.686$; $p_2 = 0.001$). The first and second functions have a high discriminative ability and value in interpretation of the general population (Table 9).

Tables 10 and 11 show the standardized and structure canonical discriminant function coefficients. The results of the following tests are most important for differentiated assessment of the state of motor and functional fitness at

Table 5. Standardized Canonical Discriminant Function Coefficients

Indicators	Function				
	1	2	3	4	5
Ruffier index	-.345	.401	.311	.696	.000
Stange test	-.236	.537	.321	-.200	.835
Genchi test	-.372	-.254	-.889	.276	.108
Romberg test	.526	.668	-.219	.440	-.171
100-meter dash	.435	-.062	.308	.089	.534
Standing long jump	-.073	.478	.438	-.169	-.377
Push-ups	.236	.257	-.126	-.570	-.033

Table 6. Structure Matrix

Indicators	Function				
	1	2	3	4	5
100-meter dash	.586*	-.373	.183	.266	.520
Standing long jump	-.493*	.386	.053	-.329	-.443
Romberg test	.558	.614*	-.410	.286	-.080
Genchi test	-.446	.100	-.803*	.054	.204
Ruffier index	-.205	.109	.378	.665*	.007
Push-ups	.347	.295	-.202	-.456*	.040
Stange test	-.412	.537	-.081	-.285	.624*

Table 7. Functions at Group Centroids

1, 3, 5 – pre-test; 2, 4, 6 – post-test	Function				
	1	2	3	4	5
1.00	-.863	.151	-.205	.302	-.070
2.00	-1.113	.545	.220	-.239	.042
3.00	.788	.280	.346	.308	.043
4.00	1.000	.698	-.263	-.217	-.036
5.00	.193	-.963	.287	-.161	-.060
6.00	-.005	-.710	-.386	.007	.080

Table 8. Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.905	66.4	66.4	.689
2	.458	33.6	100.0	.560

Table 9. Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	.360	125.654	14	.000
2	.686	46.381	6	.000

the first level: Romberg test ($r = 0.662$), 100-meter dash ($r = 0.491$), Push-ups ($r = 0.491$). At the second level – Stange test ($r = 0.417$), Standing long jump ($r = 0.412$).

The analysis of multidimensional averages (centroids) shows different levels of motor and functional fitness of the female students according to post-test results. There are peculiarities of dynamics of the female students' state depending on sports specialization (Table 12, Fig. 2). The results of classification of the female students by the level of motor and functional fitness show that 71.3% of the students were classified correctly (Table 13).

Discussion

The study assumed that on the basis of discriminant analysis it is possible to determine the peculiarities of the functional and motor fitness of female students attending badminton, aerobics, and callanetics sports sections. The testing of discriminant functions revealed that they have a high discriminative ability and value in interpretation of the general population.

The data presented add up to the results of the study by Ivashchenko [18, 30], Chernenko et al. [19] on the effectiveness of discriminant analysis in assessing

Fig. 1. Indicators of female students' fitness depending on sports specialization: 1, 2 – badminton; 3, 4 – aerobics; 5, 6 – callanetics

Table 10. Standardized Canonical Discriminant Function Coefficients

Indicators	Function	
	1	2
Ruffier index	-.502	.462
Stange test	-.276	.507
Genchi test	-.164	-.481
Romberg test	.577	.542
100-meter dash	.476	-.119
Standing long jump	-.044	.675
Push-ups	.286	.388

Table 11. Structure Matrix

Indicators	Function	
	1	2
Romberg test	.662*	.453
100-meter dash	.491*	-.396
Push-ups	.377*	.309
Ruffier index	-.281*	.094
Genchi test	-.214*	-.114
Stange test	-.302	.417*
Standing long jump	-.396	.412*

Table 12. Functions at Group Centroids

1 – badminton; 2 – aerobics; 3 – callanetics	Function	
	1	2
1.00	-1.171	.448
2.00	1.131	.498
3.00	.040	-.945

Fig. 2. Indicators of female students' fitness depending on sports specialization: 1 – badminton; 2 – aerobics; 3 – callanetics

Table 13. Classification Results

		1 – badminton; 2 – aerobics; 3 – callanetics	Predicted Group Membership			Total
			1.00	2.00	3.00	
Original	Count	1.00	32	1	10	43
		2.00	5	31	7	43
		3.00	8	6	29	43
	%	1.00	74.4	2.3	23.3	100.0
		2.00	11.6	72.1	16.3	100.0
		3.00	18.6	14.0	67.4	100.0

a. 71.3% of original grouped cases correctly classified

students' functional and motor fitness.

The findings show that the 3rd-year girls most significantly differ in the results of coordination fitness testing. According to the Romberg test, the female students show below normal results. The data confirm that the third year is a problematic period in physical education of students [19]. The findings complement the information on the need for additional introduction of more intensive forms of classes into the system of physical education of students [2, 11, 31], on the importance of motor activity in the educational process of students [32-34].

An important conclusion is that the results of the following tests are most significant for differentiated assessment of the state of motor and functional fitness at the first level: Romberg test ($r = 0.662$), 100-meter dash ($r = 0.491$), Push-ups ($p = 0.491$). At the second level – Stange test ($r = 0.417$), Standing long jump ($r = 0.412$). The results complement the data on pedagogical control in physical education of students [6, 35].

Thus, to assess functional and motor fitness, the first discriminant function and the function value in group

centroids can be used, as the results of classification of the female students by the level of motor and functional fitness show that 71.3% of the students were classified correctly.

Conclusions

The results of classification of students by the level of motor and functional fitness and the analysis of multidimensional averages (centroids) point to the peculiarities of dynamics of female students' state depending on sports specialization. Female students who play badminton show better results in the 100-meter dash and the Standing long jump. In the exercise "Push-ups", better results are shown by female students who do aerobics.

The results of the following tests are most important for differentiated assessment of the state of motor and functional fitness at the first level: Romberg test ($r = 0.662$), 100-meter dash ($r = 0.491$), Push-ups ($r = 0.491$). At the second level – Stange test ($r = 0.417$), Standing long jump ($r = 0.412$).

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