THE ASSESSMENT OF PHYSICAL FITNESS AND MORPHOFUNCTIONAL STATE OF FEMALE FIRST-YEAR STUDENTS IN NON-LINGUISTIC HIGHER EDUCATION INSTITUTIONS

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Accepted for Publication: September 20, 2020
Published: September 25, 2020

DOI: 10.17309/tmfv.2020.3.05

Abstract
The purpose of this research paper is to study physical fitness and functional state of female first-year students in Prydniprovska State Academy of Civil Engineering and Architecture.

Materials and methods. The study involved 100 female first-year students of general group aged 17-18, all after medical examination and obtaining doctor’s approval: the age group was 18 years old (n = 100). To meet the goals set, the following research methods were used: theoretical analysis and generalization of data in specialized scientific and methodological literature, pedagogical testing, anthropometric research methods, functional methods of cardiorespiratory system investigation and methods of mathematical statistics for processing the results of the research.

Results. The conducted study proved the hypothesis on the necessity to improve the system of physical education in technical higher educational institutions, which is connected with the low level of physical fitness among students.

Conclusions. The study revealed the low level of physical fitness among the investigated students in terms of speed and strength endurance indicators (with 83%), explosive physical force of the lower limbs (with 82%) and strength endurance of the upper limbs (with 68%), as well as reduced functional characteristics: resistance to hypoxia (according to the results of the Shtange test with 46% and the Gench test with 49%), workability (with 71%) and efficiency of cardiovascular system (with 55%). Low physical fitness levels among the tested girls necessitate the additional introduction of more intensive training. The high variability of the physical fitness indicators among the students requires personalization of the training process, as well as the obligatory use of express testing methods for the physical state of each student during a workout.

Keywords: students, physical education, physical state, functional indicators, physical fitness.
the fitness level of girls and young women was lower than the fitness level of boys and young men of the same age.

All that necessitate a more thorough study and analysis dedicated to the issue of physical fitness and functional state among young people in Ukraine.

Analysis of research and publications. Studies of physical fitness and functional state of students is a crucial issue of national importance, which can be evidenced by a large number of publications devoted to this issue. Most experts in both physical education and health care have been making efforts to increase the levels of young people's physical fitness.

The analysis has shown that the main reasons for low physical fitness levels among youth are as follows:

- Decline in motor activity of the population related to universal automation and modernization of life (Osipov, Kudryavtsev, Iermakov, Yanova, Lepilina, Plotnikova, & Dorzhieva, 2017);
- Lack of motivation to do sports or work out (Anikieiev, 2015; Jaakola, Yli-Piipari, Barkoukis, & Liukkonen, 2017; Sulz, Temple & Gibbons, 2016);
- Lack of a differentiated approach while selecting the load level at physical education classes (Nagovitsyn, Osipov, Manurov, Zhuikov, & Vershinina, 2019);
- Reduction of mandatory hours on physical education in non-specialized universities and transfer of these classes to an optional or elective form (Kashuba et al., 2019; Gryban, 2014);
- Deterioration of ecological environment (Lebedinskiy, Koipysheva, Rybina, Kudryavtsev, Iermakov, Osipov, & Sidorov, 2017; Palienko, 2017; Trotksa, Homlia, & Kovalenko, 2018).

The researchers offer a range of measures to increase the youth’s fitness levels. Thus, Aghyppo, Tkachov, and Orlenko (2016) recommend promotion of a healthy lifestyle as the main objective of physical education in schools and universities. Gryban (2014) believes that it is possible to change the existing situation by improving the educational process at physical education classes and increasing the quality of education by enhancing teacher’s performance. Kozina, Ol’khovyj, and Temchenko (2016) suggest computer technologies as an important component aimed at enhancing the quality and effectiveness of PE classes. Puzdymir (2019) and Vaskevich (2019) offer to prioritize physical training and purposeful development of physical skills as the main component of physical education programme. Butenko, Goncharova, Saienko, and Tolchieva (2017) recommend promoting tourism with the aim of increasing students’ interest, and Yarmak, Galan, Hakman, Dotsyuk, and Blagii (2017) and Skurikhina, Kudryavtsev, Kuzmin, and Iermakov (2016) advise including fitness technologies in physical education programme.

Other experts consider it necessary to focus efforts on improving the physical fitness of those categories of youth who already suffer a decrease in this indicator. Kuzmina, Lebedinskiy, and Kudryavtsev (2018), Prosvirina, Kolokoltsev, Koltchanova, Cieslicka, and Stankiewicz (2015) and Skurikhina et al. (2016) investigate the issue of organizing educational process in groups with special health needs. Kuzmin, Kopylov, Kudryavtsev, Galimov, and Iermakov (2015) research the issue concerning students who lack physical fitness. Adyrkahev (2016) works on the methods of physical education improvement for disabled students. Kashuba, Kolos, Rudnytskyi, Yaremenko, Shandrogy, Dudko, and Andrieieva (2017) substantiated the technology of the female students’ body state improvement with the use of wellness fitness means.

The problem of weight control is also addressed by a group of scholars: Osipov, Kudryavtsev, Gruzinky, Kramida, and Iermakov (2017) point out the issue of obesity prevention, whereas Kolokoltsev, Iermakov, and Jagiello (2018) study underwater health risks.

Thus, the undertaken analysis of academic literature proves the topicality of the problem stated and conditions the necessity of doing a complex research into youth’s physical fitness and morphofunctional state.

The purpose of this research paper is to identify the level of physical fitness and morphofunctional state among the female first-year students at SHEI "Prydniprovska State Academy of Civil Engineering and Architecture".

Materials and methods

Participants of the research

The study involved 100 female first-year students of general group aged 17-18, all after medical examination and obtaining doctor’s approval: the age group was 18 years old (n = 100). All students gave permission to process their personal data.

Organization of the research: to meet the goals set, the following research methods were used: theoretical analysis and generalization of data in specialized scientific and methodological literature, pedagogical testing, anthropometric research methods, functional methods of cardiorespiratory system investigation and methods of mathematical statistics for processing the results of the research.

The investigation into the girls’ anthropometric indicators was conducted by comparing them with the average indicators within their gender and age group. Their body length, weight and girth body dimensions were studied, which were measured with a rubber-modified tape measure to within 0.5 cm (the length of the tape was calibrated according to a metal standard mould after every 20th measuring).

Moreton and Morley (2011) and Shulga (2019) justify the need for assessing students’ physical fitness using the index method.

The body mass index (BMI), which is used to assess the correspondence between person’s weight and height, is calculated by formula (1).

\[
\text{BMI} = \frac{m \text{ (kg)}}{L \text{ (m)}^2} = \frac{kg}{m^2}.
\]  

where \(m\) is body weight; \(L\) is body length.

According to the World Health Organization, the BMI scale is as follows: normal body weight corresponds to BMI indicator between 18.5 and 24.99; indicators of 16-18.4 mean that a person is underweight; figures 25-30 show that a person is overweight; BMI of more than 30 indicates obesity.

To assess the proportionality and the correspondence of particular segments with the basic anthropometric parameters, the proportionality index (PI) was calculated by dividing the values of different parts of the body girth measurements (cm) by the body length figures (cm) and comparing them to actual and guideline values, provided in table 3.

Tests and standards, which are used during the annual assessment of Ukrainians’ physical fitness level, were included...
into the scheme of testing to assess physical fitness levels (Prontenko, Griban, Medvedeva, Aloshyna, Bloshchynskyi, Bezpalyi, Bychuk, Mudryk, Bychuk, Radziyevsky, Filatova, & Yevtushok, 2019). The criteria of these tests are stated in Table 1.

The corresponding number of points was awarded for each of the results. In the end, the scores for each of the tests were summed. The assessment of the physical fitness level was carried out depending on the total number of points.

Such cardiorespiratory indicators as heart rate (HR), systolic and diastolic blood pressure (SBP and DBP respectively) and respiratory rate (RR) were measured at rest according to standard methods in order to assess the functional state of the students. Yarmak et al. (2017) and Kozhokar, Vaskan, Palagniuk, Zavgorodnia, Strazhnikova, Kyselytsia, Balatska, and Yarmak (2019) recommend using such tests, based on breath holding to determine the resistance to hypoxia, as Shtange and Genchi timed inspiratory capacity tests, performed according to standard methods. Standard heart rate for a healthy person at rest is 60-80 beats per minute, SBP is between 100 and 120 mmHg; DBP is between 60 and 80 mmHg; RR at rest is 16-18 respiratory acts per minute, the result of the Shtange test for untrained people is 40-50 seconds, the Genchi test is 25-30 seconds.

The Rufier cardiovascular endurance test, which was also performed in compliance with standard methods, allows to assess workability (capability to endure dynamic load). Before the test starts, the subject is given an opportunity to rest: they sit still for 5 minutes. Then their pulse is taken for 15 seconds (P1). Afterwards 30 deep squats are done within 45 seconds. Immediately after the load the pulse is taken again in the standing position for 15 seconds (P2). After the first minute of recovery the pulse is taken again in the sitting position for 15 seconds (P3). The Rufier index is calculated by formula (2):

\[ \text{Rufier index} = \frac{4 \times (P1 + P2 + P3) - 200}{10} \]  

(2);

the results were evaluated by the index guidelines: less than 3 means excellent performance; 4-6 means good performance; 7-9 is average performance; 10-14 is satisfactory performance, and above 15 is poor performance.

Additional indicators showing circulatory system performance were calculated for a more detailed study of physical fitness levels:

- **Circulation efficiency factor (CEF)** was calculated by formula (3):
  \[ \text{CEF} = (\text{SBP-DBP}) \times \text{HR} \]  

(3);

normally the factor is 2400-2600 conventional units; it can increase because of fatigue, overexertion or overtraining.

Furthermore, adaptive potential (AP), which was introduced by R. M. Baevsky in order to predict prenozology within a mass screening, was assessed to determine female students' adaptive capacity. The level of adaptive potential is determined by formula (4):

\[ \text{AP} = 0.011 \times \text{HR} + 0.014 \times \text{SBP} + 0.008 \times \text{DBP} + 0.009 \times M + 0.001 \times 4^*A - 0.009 \times L - 0.27, \]  

(4);

where \( M \) is body weight (in kg); \( A \) is age (in years); \( L \) is body length (in cm).

The adaptive potential points can be interpreted as follows: figures under 2.1 indicate sufficient adaptive potential; the score of 2.11-3.2 demonstrates some strain of adaptation mechanisms; the total of points between 3.21 and 4.3 reflects insufficient adaptation; the result less than 4.31 reflects adaptation failure.

In order to evaluate myocardium metabolic and energy processes, the Robinson’s Index, which characterizes cardiovascular system regulation and is determined by formula (5), was used.

\[ \text{Robinson’s Index} = \frac{\text{HR} \times \text{SBP}}{100} \]  

(5).

Myocardium metabolic and energy processes can be interpreted relative to the Robinson’s index as follows: the index of less than 69 demonstrates high level of energy metabolism, the rate of 70-84 is higher than average, the score 85-94 indicates an average level of processes, 95-110 points show lower than average rates, the total of more than 111 reflects poor myocardium energy metabolism.

### Statistical analysis

The results obtained were processed using descriptive statistics of the licensed Excel package. In order to analyze the sample for each variable, the mean value (X), the mean error (m), standard deviation (S) and the coefficient of variation (V) were determined. In order to statistically test the hypothesis regarding the reliability of the differences, the Student’s T-test was applied.

### Results

The results of studying the main anthropometric characteristics in comparison with the benchmarks of physical
Table 2. The main anthropometric indicators among first-year female students (n = 100)

| Anthropometric indicators | X     | S     | V     | Average parameters of physical fitness level for girls aged 18* |
|----------------------------|-------|-------|-------|-------------------------------------------------------------|
| Body length, cm            | 166.6 | 5.332 | 3.2   | 160.4-167.0                                                |
| Body weight, kg            | 58.12 | 8.669 | 14.92 | 56.5-65.3                                                  |
| Chest circumference, cm    | 83.45 | 5.49  | 6.58  | 80.8-86.4                                                  |

Note: * – according to the assessment of physical fitness with the population of central (Kuts, 1993).

Table 3. Anthropometric indicators of first-year students (n = 100)

| Indices, CU | X     | S     | V | Guideline intervals | Number of students, % |
|-------------|-------|-------|---|----------------------|-----------------------|
| BMI         | 20.932| 2.852 | 13.62 | 18.5-24.99         | < N: 18, N*: 76, > N: 6 |
| Chest PI    | 0.507 | 0.032 | 6.39 | 0.5-0.55           | < N: 2, N*: 93, > N: 5 |
| Waist PI    | 0.402 | 0.040 | 9.90 | 0.35-0.4           | < N: 4, N*: 83, > N: 13 |
| Pelvis PI   | 0.582 | 0.041 | 7.08 | 0.54-0.62          | < N: 11, N*: 72, > N: 17 |
| Thigh PI    | 0.340 | 0.030 | 8.76 | 0.32-0.36          | < N: 17, N*: 62, > N: 21 |
| Shin PI     | 0.215 | 0.017 | 7.92 | 0.21-0.23          | < N: 25, N*: 63, > N: 12 |
| Shoulder PI | 0.162 | 0.026 | 16.24 | 0.16-0.18         | < N: 42, N*: 48, > N: 10 |

Note: N*: N - indicators within the norm

The results of statistical verification of the hypothesis concerning the credibility of the diversity of the physical fitness level indicators, which were calculated using different tests clusters, are presented in Table 5.

The study of variability indicators for functional state revealed the high level of variability for functional tests and CEF, as well as the average level of variability for HR and RR at rest, the indices of blood pressure, AP and the Robinson’s index (Table 6).

Thus, according to the results of such tests as steady running for 2000 meters, long standing jump and sprint for 100 meters, about 80% of the girls have low physical fitness level (83%, 82% and 80% respectively). The investigation into the sample variation revealed a low level of variability for the results of such tests as shuttle running and spring 100 m, such tests as steady running 2000 m and long standing jump showed the average variability, whereas the variability for such tests as push-ups and forward bend from a seated position was high.

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Table 4. The indicators of physical fitness among first-year students (n = 100)

| Tests               | X     | S     | V     | Number of students, % |
|---------------------|-------|-------|-------|-----------------------|
|                     | high  | sufficient | average | low | poor |
| Steady running 2000 m. | 13.356 | 1.594 | 11.93 | 3 | 3 | 11 | 12 | 71 |
| Push-ups            | 13.55 | 6.844 | 50.51 | 10 | 3 | 19 | 14 | 54 |
| Long standing jump  | 168.65 | 17.633 | 10.46 | – | 6 | 12 | 50 | 32 |
| Sprint 100 m.       | 17.175 | 1.073 | 6.25  | 2 | 5 | 13 | 25 | 55 |
| Shuttle running 4 x 9 m. | 10.508 | 0.521 | 4.96  | 50 | 32 | 9 | 6 | 3 |
| Forward bend from a seated position | 16.02 | 7.015 | 43.79 | 33 | 19 | 12 | 17 | 19 |
| Fitness level*      | 11.58 | 3.856 | 33.30 | 2 | 15 | 47 | 31 | 5 |
| Fitness level**     | 11.98 | 3.875 | 32.53 | 2 | 18 | 44 | 31 | 5 |

Note: * – by the sum of points taking into account the result of long standing jump
** – by the sum of points taking into account the result of push-up test
Discussion

According to the results of comparison of the body length, body weight and chest circumference indicators among female first-year students in Prydniprovska State Academy of Civil Engineering and Architecture with the standard indicators within their gender and age group, the investigated students have the average level of physical fitness (see Table 2). The correction of the minor insufficiency with the girths (see Table 3) of the shoulder (42% of the girls investigated) and shin (25%) is possible with the implementation of strength exercises with the aim of increasing the upper limbs strength and flexibility demonstrates the necessity to divide the girls into subgroups while developing the corresponding physical features.

In the course of the research, there were confirmed the findings by Maslyak et al. (2016), Kozhokar et al. (2017) and Fotynyuk (2017) regarding the Rufier index; the findings by Druz et al. (2016), Kozhokar et al. (2019) concerning the indices of body length and weight; as well as variations from the standard indices of the cardiorespiratory system (see Table 6). Thus, according to the results of the Shtange and the Genchi tests, the reduced indicators were revealed with 46% and 49% of the girls investigated, respectively. The excess of CEF was observed with 55% of students, and the excess of heart rate and RR at rest was found with 36% and 29%, respectively. According to the Rufier test results, the reduced indicators were observed with 71% of girls investigated. The decreased indices of the cardiorespiratory system performance and workability necessitate the use of additional breathing exercises and the exercises aimed at developing endurance.

According to the results of running for 2000 meters, sprint for 100 meters and the push-up tests, 71%, 54% and 55% of girls (respectively) were not able to meet even the standard approved for low fitness level (see Table 4). Students’ poor physical fitness test results condition using the means and methods aimed at the development of speed and strength endurance and the upper limbs strength in further activities for students showing low physical fitness levels as well as the implementation of additional self-training, aimed at the development of the corresponding physical features.

The statistical verification of the hypothesis on the reliability of differences between the values of physical fitness indicators, determined by the sum of points scored on the results of 5 tests, taking into account the long steady jump test or the push-ups test, confirmed the feasibility of complementing the physical exercises, selected to determine the level of physical fitness among female students (see Table 5).

The study of functional state revealed insufficient resistance to hypoxia with a significant number of girls tested, as well as variations from the standard indices of the cardiorespiratory system (see Table 6). Thus, according to the results of the Shtange and the Genchi tests, the reduced indicators were revealed with 46% and 49% of the girls investigated, respectively. The excess of CEF was observed with 55% of students, and the excess of heart rate and RR at rest was found with 36% and 29%, respectively. According to the Rufier test results, the reduced indicators were observed with 71% of girls investigated. The decreased indices of the cardiorespiratory system performance and workability necessitate the use of additional breathing exercises and the exercises aimed at developing endurance.

At the course of these studies of female students’ functional state there were confirmed the findings by Maslyak et al. (2016), Kozhokar et al. (2019) regarding blood pressure; as well as the findings by Kozhokar et al. (2019) and Fotynyuk (2017) regarding the Rufier index; the findings by Druz et al. (2017) and Kozhokar et al. (2018) concerning the Robinson’s index; as well as the findings by Yarmak et al. (2017) and Kozhokar et al. (2019) concerning the Genchi test.

According to the study, the functional characteristics of most students tested are on the border between the norm and pathology, which justifies the need to prevent their further deterioration by increasing the amount of physical activity through the introduction of new forms of training and improving the students’ physical fitness level by means of physical education.

Thus, despite the fact that the anthropometric characteristics of the investigated girls are mostly within the norm, most female students have reduced physical fitness levels in terms of speed and strength endurance, explosive physical force of the lower limbs and strength endurance of the upper limbs, which confirms the findings of other studies. The low level of physical fitness, as well as reduced indicators of the functional state among the tested students necessitate

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**Table 5.** The comparison of physical fitness level indicators, calculated using different tests clusters

| Tests considered | Long standing jump | Push-ups |
|------------------|--------------------|----------|
| X<sub>1</sub>    | m<sub>1</sub>       | exterity  |
| S<sub>1</sub>    | X<sub>2</sub>       | m<sub>2</sub>       |
| S<sub>2</sub>    | t calc.            |           |
| 11.58            | 0.386              | 3.857     |
| 11.91            | 0.388              | 3.875     |
| 0.604*           |                     |           |

Note: * the discrepancy between the samples is unreliable, because t calc. < t of the criterion (p = 0.001)

**Table 6.** Assessment of first-year students’ functional state of (n = 100)

| Indices               | X     | S     | V     | Normative intervals | Number of students, % |
|-----------------------|-------|-------|-------|----------------------|-----------------------|
|                       | < N   | N     | > N   |
| HR at rest, bpm       | 78.61 | 13.82 | 17.58 | 60-80                | 1 63                 | 36                |
| SBP, mmHg             | 107.66| 11.08 | 10.29 | 100-120              | - 98                  | 2                 |
| DBP, mmHg             | 71    | 7.61  | 10.72 | 60-80                | - 98                  | 2                 |
| RR at rest, times     | 16.9  | 4.10  | 2.24  | 16-18                | 34 37                 | 29                |
| The Shtange test, sec | 43.68 | 13.71 | 31.39 | 40-50                | 46 27                 | 27*                |
| The Genchi test, sec  | 26.74 | 11.09 | 41.48 | 25-30                | 49 24                 | 27*                |
| The Rufier index, CU  | 12.725| 5.317 | 41.78 | 0-14                 | - 66                  | 34                |
| CEF, CU               | 2896.88| 823.74| 28.44 | 2400-2600            | 31* 14                | 55                |
| AP, CU                | 1.718 | 0.30  | 1.70  | < 21.11              | - 89                  | 11                |
| The Robinson’s index, CU | 85.076| 19.70 | 23.16 | < 111                | - 88                  | 12                |

Note: * - the value of the indicator is better than the norm
the improvement of the system of physical education at the technical higher education institution. The high variability of physical fitness indicators requires obligatory taking into consideration the students' individual characteristics during the selection of exercises and calculation of training load.

Conclusions

The study revealed the low level of physical fitness among the investigated students in terms of speed and strength endurance indicators (83% according to the 2000 meters running test and 80% according to the 100 meters running test), explosive physical force of the lower limbs (82% for the results of the long steady jump test) and strength endurance of the upper limbs (68% according to the push-ups test), as well as reduced functional characteristics: resistance to hypoxia (according to the results of the Shtange test with 46% and the Gench's test with 49%), workability (71% according to the results of the Rufer test) and efficiency of cardiovascular system (55% according to the circulation efficiency factor). Low physical fitness levels among the tested girls necessitate the additional introduction of more intensive training, and the reduced cardiorespiratory system performance and workability condition the need to use breathing exercises and exercises aimed at developing endurance. The high variability of the physical fitness indicators among the students requires personalization of the training process, as well as the obligatory use of express testing methods for the physical state of each student during a workout, especially during exercising at maximum capacity.

Prospects for further research: improving the system of physical education in Prydniprovska State Academy of Civil Engineering and Architecture in connection with the low level of physical fitness among first-year students.

Conflict of interest

The authors declare no conflict of interest.

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Мета дослідження – визначити рівень фізичної підготовленості та морфо-функціонального стану студенток першого курсу ДВНЗ ПДАБА.

Матеріали та методи. У дослідженні взяли участь студентки основної групи І курсу ДВНЗ ПДАБА, вік 18 років (n = 100). Для вирішення поставлених завдань було використано: теоретичний аналіз і узагальнення даних спеціальної науково-методичної літератури, педагогічне тестування, антропометричні методи дослідження, функціональні методи дослідження кардіореспіраторної системи та методи математичної статистики обробки результатів дослідження.

Результати. Проведене дослідження підтвердило гіпотезу про необхідність удосконалення системи фізичного виховання у закладі вищої освіти технічного профілю у зв’язку з низьким рівнем фізичного стану студентів.

Висновки. Під час дослідження виявлено низький рівень фізичної підготовленості обстежених студенток за показниками швидкісно-силової витривалості (у 83%), вибухової сили нижніх кінцівок (у 82%) та силової витривалості верхніх кінцівок (у 68%), а також знижені функціональні характеристики: стійкості організму до гіпоксії (за результатами проб Штанге у 46% та Генчі у 49%), роботоздатності (у 71%) та ефективності системи кровообігу (у 55%). Низька фізична підготовленість обстежених дівчат обумовлює необхідність додаткового впровадження більш інтенсивних форм заняттів. Велика варіативність показників фізичного стану контингенту вимагає індивідуалізації тренувального процесу, а також обов’язкового використання методів експрес-контролю за фізичним станом кожного студента.

Ключові слова: студентки, фізичне виховання, фізичній стан, функціональні показники, фізична підготовленість.