Development of Professionally Important Physical Qualities in Engineering Students

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Abstract: The purpose of the article is to theoretically substantiate, develop and test the author's program of professionally applied physical training of students of technical specialties in order to increase the efficiency of the process of physical training of specialists in accordance with modern production requirements. Based on the purpose of the study, the following tasks have been formulated: to identify the professionally applied features of physical training of specialists in the field of agricultural engineering, to develop a method of professionally applied physical training for junior specialists and to experimentally test the effectiveness of its use in the process of physical education of students. The following research methods were used to accomplish these tasks: methods of theoretical analysis and generalization of data of scientific and methodological literature, pedagogical observations, physical fitness test, pedagogical experiment, methods of mathematical statistics. Participants. The study involved the students of specialty 208 Agroengineering of the Kropyvnytskyi College of Mechanization of Agriculture, from which experimental (n=23) and control (n=21) groups of young people of 16–17 years old, belonging to the main health group, were formed. The main results of the study were: determination of professionally important physical qualities of agricultural engineers, experimental verification of the effectiveness of the author's program of complex development of professionally important physical qualities in future specialists of technical profile; a significant increase in the results of testing on the special fitness of the boys of the experimental group. Conclusions: the conducted research showed that the experimental program of special physical training of students of specialty agricultural engineering, the content of educational material of which corresponds to the peculiarities of future professional activity, provides the development of physical professionally important qualities and allows to make the choice of adequate forms, methods, tools aimed at achieving full professional potential of future specialists.

Keywords: *professionally applied physical training; students; level of fitness; testing; professional physical qualities.*

How to cite: Chernii, V., Shevchenko, O., Nievorova, O., Melnyk, A., Kramarenko, A., & Nikonenko, T. (2020). Development of Professionally Important Physical Qualities in Engineering Students. *Revista Romaneasca pentru Educatie Multidimensionala*, 12(1Sup1), 93-105. <https://doi.org/10.18662/rrem/12.1sup1/225>

1. Introduction

The educational process in modern educational institutions is carried out taking into account the possibilities of information technologies of training and is focused on the formation of an educated, harmoniously developed personality, capable of continuous updating of scientific knowledge, professional mobility and rapid adaptation to changes in sociocultural sphere, system of management and organization of work market economy (Protsenko et al. 2019). As Khalaidzhi (2009) proved, an extremely important factor in the formation of professional competencies of future specialists is the special physical fitnesslevel of a person for a specific type of professional activity, namely professionally applied physical training.

The analysis of the scientific literature indicates that the problem of organizing the process of professionally applied physical training of students has been investigated in the works of many authors (Pylypei, 2009; Salatenko, 2012; Ostapenko, 2015). The studies of specialists in physical education and sports (Kashuba & Golovanova, 2018) highlight the theoretical, methodological and applied aspects of constructing the process of professionally applied physical training of students. The study by Ahmadi et al. (2020) developed and evaluated machine learning algorithms to predict children's physical activity category using raw accelerometer data. The study by McEntyre et al. (2020) produced a quantified negotiation profile for the preservice sport education teacher. Scientific research by Kashuba & Golovanova (2018) is devoted to the study of increase in efficiency of professionally applied physical training of students based on application of informational and methodical systems. Karagodina et al. (2018) considered the development of professionally applied physical qualities of building specialties students. Shkola at al. (2019) investigated the influence of professional-applied physical training on the formation of the personality of vocational school students. Studies by the scientists Krutsevich et al. (2019) prove that the general physical training of specialists cannot completely solve the problems of qualitative preparation of a young specialist for future professional activity, since modern highly skilled physical work requires a certain profile of physical education according to the peculiarities of the profession.

Modern agro-industrial production requires the education system to search for new effective techniques for training modern technicians, able to withstand prolonged physical exertion on the musculoskeletal system, muscular system without work decrement. Therefore, the development of an effective methodology of professionally applied physical training for junior

specialists in technical specialties, its use in the process of physical education of students is an urgent problem and requires thorough study at the theoretical and practical levels.

2. Material and methods

The study was conducted during the 2017–2019 academic year. The study involved the students of the specialty 208 Agroengineering of the Kropyvnytskyi College of Mechanization of Agriculture, from which experimental and control groups of young people aged 16–17 years old, belonging to the main health group, were formed. Physical education of the students of the experimental group (hereafter group E with a total of 23 persons) was carried out in accordance with the experimental program developed by us. The students of the control group (hereafter group C with a total of 21 persons) were engaged in the current physical training program “Physical Education for Students of Professional and Technological Education” (confirmed on August 28, 2017). All participants of the experiment were placed on equal terms in the number and duration of sessions per week.

The analysis of educational qualification characteristics in this specialty, professigrams of agrarian production engineer allowed to determine the leading physical qualities and peculiarities of professional activity of workers in accordance with National Classifier of Ukraine (2010).

Therefore, on the basis of a differentiated approach to the choice of teaching aids and taking into account the specifics of professional activity of a specialist in the field of agricultural engineering, in the educational and training work the leading method, which we have determined, is the organization of the educational process of students in action, and the main means – a system of practical tasks. We have developed the author's program of special physical training "Professional and applied training for students of technical specialties" (on the example of specialty: 208 Agroengineering), aimed at increasing the level of professionally important physical qualities of junior specialists. The content of the training process according to the author's program was divided into six stages. The annual cycle of the training process under the suggested program was divided into six stages. The first stage involved the process of accumulating (communicating) relevant experience at the empirical level. The second stage involved the diagnosis of the level of students' development of a particular skill by teachers by means of control and diagnostic tasks (performance of test physical exercises on the level of development of special motor

qualities). The third stage required the students to develop self-motivation and interest in mastering motor activity. The motivational sphere was enhanced by the introduction of functional music, game technologies, and methods of interactive learning into the educational process of students. At the fourth stage, there was an explanation of the procedure and method of action and a sample of the activity. The fifth stage is the organization of the collective activity of students according to the model. At this stage, it is important to keep students confident in the compulsory success of their new job, striving for increased effort and continuing the training process. At the last stage of skills development, the teacher, while developing a system of practical tasks, changed the conditions of activity. These conditions varied in part or in full, depending on the level of fitness. Practical material of the program is represented by complexes of exercises that promote the development of professionally important physical qualities, namely: manual dexterity, static and dynamic endurance of the hands, strength and static endurance of the muscles of the legs, shoulder girdle, trunk, balance, general endurance. The main means of professionally-applied physical training of students have been selected: exercises with dumbbells, medbol, rubber shock absorbers, on a gymnastic bench and wall-bars exercises, throwing balls, grenades, shot put, elements of sports games, exercises on accuracy and dexterity of movements, attention games, elements of gymnastics, outdoor games.

In order to check the effectiveness of the developed program of special physical training of students, we conducted a study that allowed us to investigate the dynamics of the indicators of the level of physical fitness and the development of special physical qualities in future specialists of the technical profile.

To assess overall (cardio-respiratory) endurance, we used the Eurofit program, which offers a 20-meter fixed-speed shuttle run (Tomkinson et al. 2017).

Researchers (Krutsevich et al. 2019) have noted a weak relationship between the strength level of different muscle groups. This is especially important for testing the level of physical fitness of future specialists in the technical field. As the predominant types of the activity of a specialist in the agro-industrial complex are the management of machines, apparatus, installation, maintenance and repair, the static work posture is predominant, which is often uncomfortable. During the production activity of the mechanic considerable load falls on the musculoskeletal system, the muscular system (especially the muscles of the back, arms and legs). That is why the tests for the determination of muscle force are selected

comprehensively and are aimed at measuring explosive, dynamic, static force and endurance, to assess the development of dynamic strength endurance of the legs, static strength endurance of the muscles of the arms and shoulder girdle, the development of the explosive force of the shoulder girdle hands (Catley & Tomkinson, 2011).

The specificity of professional activity of a mechanic, an installer, an adjuster requires fast, precise movements of fingers, coordination and dexterity of hands and feet, sensorimotor coordination. That is why, we have included a hit the planktest under Eurofit (Adam et al.1993) to determine the speed of movement of the upper extremities.

To assess agility, we used a 4x9 m shuttle run. The coordination skills were determined by using tests of throwing a tennis ball for accuracy and running a basketball while running 10 m, avoiding obstacles.

Balance is considered to be professionally one of the most important qualities that are characteristic of this specialty of the technical direction. In fact, the better the balance is, the faster it recovers and the smaller is the amplitude of the oscillation of the body. To assess the balance of the students, we used the Flamingo test suggested by Eurofit (Adam et al.1993).

To compare averages, we used Student's t-criterion for dependent and independent samples based on Microsoft Excel computer software. To evaluate the validity of the experimental data at the beginning of the study, we used an unrelated (unpaired) t-criterion to determine the differences between the scores obtained from the testing of both groups of students. At the end of the study, we conducted paired comparisons of the averages of the two related samples by modifying the Student's t- criterion (comparing test figures of students' fitness in each group before and after the experiment).

To establish the scientific reliability of the results, the studies used the following algorithm: checking the normality of data distribution in the samples of the control and experimental groups; verification of the equality of dispersions of independent samples (the beginning of the experiment); calculation of the t-criterion; comparison of the empirical value of the t-criterion obtained with the critical table value and the conclusion about the confirmation (at the beginning of the experiment) and the refutation/confirmation (at the end of the experiment) of the null hypothesis of no differences.

3. Results

The results of statistical processing of the initial data showed that the value of t-calculation for all analyzed indicators of special fitness is less than

t-critical ($p>0.05$), indicating that there are no statistically significant differences between the control and experimental groups before conducting the experiment (Table 1).

Table 1. Comparative characteristics of testing indicators of special fitness of the control (C, $n=21$) and experimental (E, $n=23$) group of young men before and after the experiment

Name of the test	Group	Before experiment			After experiment		
		$\bar{X} \pm m$	t	p	$\bar{X} \pm m$	t	p
Shuttle running on 20-meter sections, number of sections	C	37.1 $\pm$ 4.34	0.12	>0.05	38.2 $\pm$ 3.29	1.57	>0.05
	E	37.2 $\pm$ 4.02			49.3 $\pm$ 3.22	13.21	<0.05
3000-meters race, m, s	C	14.4 $\pm$ 1.76	0.61	>0.05	14.0 $\pm$ 1.13	1.60	>0.05
	E	14.1 $\pm$ 1.39			13.3 $\pm$ 0.85	3.94	<0.05
Standing long jump, cm	C	21.3 $\pm$ 5.71	0.46	>0.05	226.5 $\pm$ 3.38	6.12	<0.05
	E	20.6 $\pm$ 4.4			227.6 $\pm$ 2.97	8.64	<0.05
Pull-ups on a high crossbar, rep.	C	7.4 $\pm$ 1.62	0.17	>0.05	7.8 $\pm$ 1.57	1.20	>0.05
	E	7.3 $\pm$ 1.43			8.7 $\pm$ 1.52	5.97	<0.05
Holding the angle up or down, s	C	8.2 $\pm$ 1.33	0.16	>0.05	8.4 $\pm$ 1.25	1.28	>0.05
	E	8.1 $\pm$ 1.08			9.9 $\pm$ 1.02	8.20	<0.05
Bent suspension, s	C	33.2 $\pm$ 2.00	1.59	>0.05	35.6 $\pm$ 4.44	1.99	>0.05
	E	34.3 $\pm$ 2.33			45.1 $\pm$ 2.00	22.91	<0.05
Squatting on one leg with support on the other (left+right), rep.	C	17.2 $\pm$ 1.85	0.26	>0.05	17.7 $\pm$ 1.91	1.53	>0.05
	E	17.1 $\pm$ 1.95			18.9 $\pm$ 1.53	4.35	<0.05
Benchsit-up in 30 s, rep.	C	21.7 $\pm$ 1.36	0.76	>0.05	24.9 $\pm$ 2.35	6.09	<0.05
	E	22.0 $\pm$ 1.43			25.3 $\pm$ 2.08	8.59	<0.05
Dip up, rep.	C	22.6 $\pm$ 2.40	0.22	>0.05	23.1 $\pm$ 0.35	2.49	>0.05
	E	22.8 $\pm$ 2.34			31.9 $\pm$ 0.52	3.01	<0.05
Retention on the wrist dynamometer force 50% of the maximum, s	C	24.7 $\pm$ 2.03	0.18	>0.05	25.1 $\pm$ 1.51	0.77	>0.05
	E	24.8 $\pm$ 2.08			32.7 $\pm$ 2.22	13.58	<0.05
Tapping frequency, s	C	10.3 $\pm$ 0.48	1.15	>0.05	10.1 $\pm$ 0.72	0.64	>0.05
	E	10.5 $\pm$ 0.60			9.3 $\pm$ 0.68	8.41	<0.05
Throwing a tennis ball from a sitting position, cm	C	02.1 $\pm$ 1.5	0.55	>0.05	100.8 $\pm$ 1.51	1.86	>0.05
	E	02.2 $\pm$ 1.5			94.6 $\pm$ 1.42	22.25	<0.05
Dribbling a basketball while running 10 m, avoiding obstacles and changing direction, s	C	10.2 $\pm$ 0.91	0.20	>0.05	9.9 $\pm$ 1.11	0.88	>0.05
	E	10.1 $\pm$ 1.08			9.3 $\pm$ 1.11	3.23	<0.05
Shuttle running 4x9 m, s	C	9.8 $\pm$ 1.01	0.65	>0.05	9.6 $\pm$ 0.14	1.00	>0.05
	E	9.6 $\pm$ 1.01			9.1 $\pm$ 0.14	1.10	<0.05
Flamingo rep.	C	10.1 $\pm$ 0.83	0.55	>0.05	9.9 $\pm$ 1.20	0.69	>0.05
	E	10.3 $\pm$ 0.96			8.1 $\pm$ 0.95	12.92	<0.05

Note: n is the number of young men in the control and experimental groups

The results of the initial testing and their analysis give grounds to claim that the students under this system of assessment do not meet the age normative requirements. According to Table 1, at the beginning of the experiment, there was no significant difference between the results of the testing of the overall endurance of the “shuttle running on 20-meter sections” of the control and experimental groups of students ($p>0.05$). Most young men of both groups were found to be underdeveloped (Table 1). Concerning the indicators of development of special endurance (running at 3000 m), the test results of students of both groups reached the average level of readiness (Table 1). The results of complex testing of muscle force revealed that the indicators of tests for the determination of the explosive force of the shoulder girdle and arms (benchsit-up in 30 s), static force endurance of the muscles of the arms and shoulder girdle (holding on the wrist dynamometer of 50% of the maximum effort, bent suspension) and development of dynamic strength endurance of legs (squatting on one leg with support on the other (left+right)) of students of both groups are on average level of readiness and there is no significant difference between indicators ($p>0.05$) (Table 1). The average result of pull-ups at the high bar in the control and experimental group of adolescents was 7.4 ± 1.62 and 7.3 ± 1.43 respectively, i.e. at the low level of readiness (Table 1). Concerning the performing of the power test “dip up”, its results did not reach the limits of the average level of readiness of students of both groups (Table 1). The analysis of the results of the tests of agility, coordination and balance showed that the students correspond to the average level of physical fitness of young people (Table 1).

Following the introduction of the pedagogical experiment, we observed statistically significant changes in the experimental group ($p<0.05$) compared to the control group, which indicates the effectiveness of the applied teaching method (Table 1, Figure 1).

Figure 1. Graph of increase of special physical qualities of students of control (C) and experimental (E) groups before and after the experiment, %

During the analysis of the results, the test results for the overall endurance test ($p < 0.05$) in the experimental group were more likely than at the beginning of the experiment. Instead, no significant changes occurred in the control group ($p > 0.05$) (Table 1). Positive dynamics of indicators of general endurance can be explained by the use of specially-jogging exercises: uniform and interval running; running along the obstacle course and the like. In the course of the analysis of the study materials, indicators of special endurance in the experimental group ($p < 0.05$) were found to be probable compared to the beginning of the academic year; however, we did not find a statistically significant difference in the rates of development of special endurance in the control group ($p > 0.05$) (Table 1). The positive dynamics of the “standinglongjump” test results for both group C and group E boys is noteworthy: the improvement in speed and power in group E is 3.2%, and in group C this indicator increased by 2.4%, which indicates the possibility of a targeted impact also on the development of this motor quality (Figure 1).

The results of comprehensive testing of muscle strength of students indicate a positive change in group E, so the indicators of the test “pull-ups on a high crossbar” improved by 19.2%, and the test “bent suspension” – by 31.5%, and in group C it is 7.2% (Figure 1). Regarding the results of the “benchsit-upin 30 s” test, they significantly improved in both study groups during the academic year, but a larger increase was observed in group E

(15%), slightly smaller in group C (14.8%) (Figure 1). Positive dynamics of performing testing of the young men of the experimental group (“dip up”, “retention on the wrist dynamometer force 50% of the maximum”) also indicates a significant difference ($p < 0.05$), whereas in the control group there was no statistically significant difference in the indicators of the development of power abilities ($p > 0.05$), and the result improved only by 2.2% and 1.6% (Table 1, Figure 1).

The improvement of certain indicators of muscular strength of the students in the experimental group is associated with the application in the program of training exercises with dumbbells, a medball, rubber expanders, throwing balls, grenades, downhill running. In our opinion, this is what caused such a high increase in these capabilities. In addition, taking into account the peculiarities of the professional activity of agricultural production engineers, in the developed experimental program we intentionally developed this quality.

The data obtained after the experiment indicate that the students of the experimental group have significantly ($p < 0.05$) higher rates of development of agility, coordination and balance compared to the initial stage (Table 1). Students who enrolled in the program developed statistically higher results of testing the speed of upper limbs on the test “hit the planks” (an increase of 11.4%) (Figure 1). Also, we observed statistically significant changes in all of the studied E group of boys under the test “dribbling a basketball while running 10m, avoiding obstacles and changing direction” ($p < 0.05$) (Table 1). The results in group E are 9.3 ± 1.11 s, and in group C – 9.9 ± 1.11 (Table 1). The improvement rates in Group E were 7.9%, and in Group C this indicator improved only by 2.9% (Figure 1). According to the Flamingo test, the results of the boys in Group E increased to 21.4%, which is 19.4% more than in Group C (Figure 1).

Thus, the conducted research showed the adequacy of the developed program of complex development of professionally important physical qualities of students of technical specialties, as evidenced by the reliable improvement of the test results on the special physical fitness of the boys of the experimental group.

4. Discussion

The results of the study confirm the data on the low level of physical fitness of students by Pichurin (2014); Krutsevich et al. (2019); Leuciuc (2019) and point to the need for the use of innovative methods of physical education.

In the course of the research it has been revealed that for the complex development of professionally important qualities of specialists working in agrarian industry, it is necessary to develop a special program that is fully consistent with the research of Pylypei (2009).

The novelty of the scientific search is to determine the leading physical qualities of agricultural engineers, which include: manual dexterity, static and dynamic endurance of the hands, strength and static endurance of the muscles of the legs, shoulder girdle, trunk, as well as balance. Data on the specificity of employment in the field of agricultural engineering have been expanded.

For the first time it was theoretically substantiated, developed and experimentally tested the author's program of special physical training of students of agricultural engineering specialty, the content of educational material of which corresponds to the peculiarities of future professional activity, provides the development of physical professionally important qualities and allows the choice of adequate forms, methods and tools aimed at revealing professional potential of future specialists.

Data on physical fitness of students of higher education institutions and knowledge on ways of optimization and correction of the state of physical fitness of young people have been further developed.

5. Conclusion

1. A detailed analysis of scientific works in the field of physical culture and sports, made it possible to conclude that the optimization of professionally applied physical training of students of technical profile is possible only through the implementation into the educational process tools, methods and technologies, taking into account the specific professional activity of future specialists.

2. The analysis of scientific researches, scientific and methodical works, qualification characteristics of the engineer of agrarian production allowed to determine the leading physical qualities and peculiarities of professional activity of workers of technical profile. It has been found out that the leading physical qualities of a specialist include manual dexterity, static and dynamic endurance of hands, strength and static endurance of leg muscles, shoulder girdle, trunk, balance, general endurance.

3. The results of the initial testing and their analysis give grounds to claim that the results of the students of the control and experimental groups do not meet the age normative requirements.

4. An experimental program of professionally applied physical training for students of specialty 208 Agroengineering has been developed, which ensures the development of professionally important physical qualities. The effectiveness of the suggested experimental program was tested in a pedagogical experiment. The results of testing the professional and applied readiness of the students of the experimental group are statistically significantly better compared to the results of the students of the control group ($p < 0.05$).

5. The conducted researches have shown that the author's program of special physical training, use of physical exercises of professional orientation, analysis of the results of the research allow to recommend the presented program in educational institutions in order to improve the quality of training of future specialists of technical profile.

6. The study does not examine all aspects of the problem. Further studies require the issues of professionally applied physical training to optimize the functional status of students of technical specialties.

Conflicts of interest

The authors declare that there is no conflict of interests.

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