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The Effect of Programed Physical Activity Measured with Levels of Body Balance Maintenance

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Data Collection B
Statistical Analysis C
Data Interpretation D
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Background: The aim of the research was an evaluation of 2 training programs covering the same standard physical activity in the initial stage (warm-up) and the main (motor exercises) as well as a separate end part in Program A of stretching and in Programme B of vibration training designed to improve the level of body balance.

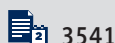
Material/Methods: We tested 40 randomly chosen students of the Academy of Physical Education and Sport in Gdansk, subsequently divided into two 20-person groups: C (average age 21.3 ± 1.2), and E (average age 21.8 ± 1.1). The training of body balance was conducted for 8 weeks: we used in Group C Program A and in group E Program B. The evaluation of body balance was done 3 times: at the beginning, at midway point, and at the end of the experiment. The stabilographic tests with posture-graphical method and the task of 1-leg balance standing with eyes closed was used.

Results: It was found that in the first examination both groups did not significantly differ in terms of the tested parameters of balance. During the training process we obtained increased time of maintaining balance on 1 leg. This difference was significant between tests 1 and 2 both for Group C ($p=0.0002$) and for E ($p=0.0034$), while between the tests 2 and 3 in Group E ($p=0.0213$) only.

Conclusions: The training Program B is more effective to maintain balance on 1 leg when compared to Program A.

Keywords: **Motor Skills • Posture-Graphic • Vibration Platform**

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Background

Body balance is defined as the organism's ability to maintain the body's position without the aid of another person, excluding uncontrolled falls [1]. In the evaluation of body balance various methods and testing instruments are used, including the observation of oculovestibular reflexes, vestibulospinal reflexes, and tests using posturography [2,3]. In academic research in general the sensitivity in the behavior of the analyzer of balance in various conditions of an external and internal environment has been touched on [4].

Far less often is there an evaluation of exercise programs that aim to stimulate the forming of the abilities to maintain the balance carried out [5]. It is known that better body balance allows one to obtain better results in sport. This is linked to the necessity to find methods of stimulation and training programs that would increase this ability. At present we know standard training programs for body balance but we also know that the effectiveness of these programs is not always satisfactory, hence also the global search for new forms of body balance stimulation. Recent years have seen new solutions, in which a vibration platform has been utilized allowing for a stimulation of the system of balance. Academic reports allow one to speculate on an appropriate program of vibration exercises influencing the shaping of the ability to maintain body balance [6,7]. Such a program may be prepared through using a vibration platform sports training [8]. The vibration platform creates muscle-nerve stimulation through mechanical vibration at an appropriate frequency (Hz) and amplitude (mm). The vibration brought about by this device causes a natural contraction of the muscles in all the parts of the body involved in the training program. The use of mechanical vibrations in training leads to an increase in the gravitational burdening for the muscles. In addition, this leads to the occurrence of reflex tension of the muscle in reaction to vibration [9]. The vibrations that are the consequence of vibration training influence, by means of proprioceptors, the stimulation of the circumferential and central nerve system. At the same time it leads to a weakening in the mechanism of braking caused by the antagonistic muscles. The alternating mechanism of arousal and braking leads, as a consequence, to the generation of greater values of muscle strength.

Testing the effectiveness of the action of the vibration platform amongst competitive professionals and amateurs in a vertical jump test showed an improvement in the value of the maximum strength of the skeletal muscles [10,11]. Issurin [12] has observed that as a result of standard training the increase in the value of maximum strength of the skeletal muscles was 16%, while as a result of applying a vibration platform the increase in the strength value was 50%. In addition, he observed an improvement in the mobility of joints as well as a change

in the composition and mass of the body [13,14]. There were also noted metabolic changes in the form of a reduction in the uptake of oxygen by 50% in the test of maximum physical exertion (the so-called "test until refusal to continue the effort") [15]. In addition, there was an increase in the volume of blood within the working muscles, and even changes in the concentration of testosterone and the growth hormone [16,17].

The aim of the research was an evaluation of 2 training programs covering the same standard physical activity in the initial stage (warm-up) and the main (motor exercises) as well as a separate end part in Program A of stretching and in Program B of vibration training designed to improve the level of body balance.

Material and Methods

The tests were administered to 40 women (randomly chosen female students of the Academy of Physical Education and Sport in Gdansk). They were divided into 2 equal 20-person groups: control group (C) and experimental group (E). The physical characteristics of those tested are presented in Table 1. This takes into consideration the age of the participants, the body mass, the BMI indicator [kg/m^2], and the Rohrer indicator [g/m^3].

The students in each group were of a similar average age and body height: for the students from Group C the average value of this feature was 167.20 ± 5.4 cm, while for students from Group E it was 168.89 ± 4.91 cm. The body mass of the students from Group C formed on the mean level 57.14 ± 9.14 kg, while in the Group E it was 55.7 ± 9.16 kg. We found a similar dependence in the BMI indicator, where its average value in students from the C Group did not exceed 21.68 ± 2.36 kg/m^2 , while for students from Group E it was 20.61 ± 2.11 kg/m^2 . There was no greater divergence in the case of the minimum and maximum values. A statistical analysis of the results obtained for age, height, and body mass show that there is an absence of significant differences between Group C and E, which means that the tested groups are homogeneous in this respect.

Training procedure

The impact of the programmed motor exercises on the level of the female student body balance was evaluated in a carefully programmed experiment involving an 8-week training program, 3 times a week, for 60 minutes according to the 2 programmes A and B. These programs had a joint introductory and main part though with a different finish. The initial stage lasted 15 minutes and entailed a warm-up preparing the participant for the increasing main part, which lasted 30 minutes and covered balance exercises, exercises shaping the muscle strength of the lower limbs, the abductors and adductors of the lower limbs,

Table 1. Somatic features of the tested women (students).

Feature	Women (students)					
	Group C			Group E		
	Min.–max.	X	SD	Min.–max.	X	SD
Age [years]	19–23	21.3	1.2	20–24	21.8	1.1
Body height [cm]	156–180	167.20	5.41	157–179	168.89	4.91
Body mass [Kg]	45–70	57.14	9.14	45–71	55.7	9.16
BMI indicator [kg/m ²]	16.38–27.21	21.68	2.36	17.12–23.57	20.61	2.11
Rohrer indicator [g/m ³]	1.01–1.58	1.25	0.16	1.06–1.58	1.23	0.15

Table 2. Mean values and standard deviation of the standard field of the developed surface [mm²] in test with open eyes in the students tested in relation to the methods of motor training used.

Successive test	Test 1	Test 2 (after a month)	Test 3 (after 2 months)	Test 1	Test 2 (after a month)	Test 3 (after 2 months)
	E			C		
\bar{x}	253.7	365.5	257.5	236.0	295.5	231.8
SD	133.7	220.3	100.5	153.6	125.5	102.6

Table 3. Analysis of the variants for the repeated measurements – variable Field of developed surface [mm²].

Effect	SS	Df	MS	F	P
Training	195969	2	97984	8.2858	0.0006
Training*/group C and E	15873	2	7936	0.6711	0.5141
Error	898746	76	11826		

and exercises shaping the stomach muscles and those of the extensors and flexors of the shoulders in supporting exercises [4]. The end part lasting 15 minutes involved a standard program: A) stretching and in the experimental programme B) exercises on a vibration platform. The frequency of the vibrations was increased every 2 weeks, starting from 5 Hz (for the first 2 weeks) to 20 Hz (for the final 2 weeks). The amplitude of the vibrations was increased from 3 to 10 mm. Such a regulation was dictated by the safety and effectiveness of the exercises carried out with limited scopes of the parameters above [10,18]. The intensity of the motor exercises was directed by means of music utilizing a Beat Per Minute (BPM) device. In the initial stage 130–140 BPM was used, while in the main part 130–150 BPM was used.

In the end part of the training on the vibration platform 120–130 BPM was used. Relaxing music was used for the stretching. Students from Group C exercised according to program A, while those from Group E according to program B.

Evaluation of the ability to maintain body balance was carried out by means of tests:

1. A stabilographic tests with posture-graphical method
 - a. In its basic form with eyes open in which the field of developed surface is defined (mm²);
 - b. After completing 7 turns in the longitudinal axis of the body in conditions of having the eyes open.
2. The balance posture on 1 leg test, with closed eyes. The examined person had to stand on only the right leg and maintain balance for the longest possible period of time.

The tests were conducted 3 times: the first test was carried out prior the experiment, the second after a month, and the third test after 2 months of the experiment's duration.

To verify the significance of the differences between the groups C and E, in which various forms of programmed exercises were employed, variants of the ANOVA System instrument analysis were used with repeated measurements. The assumptions of

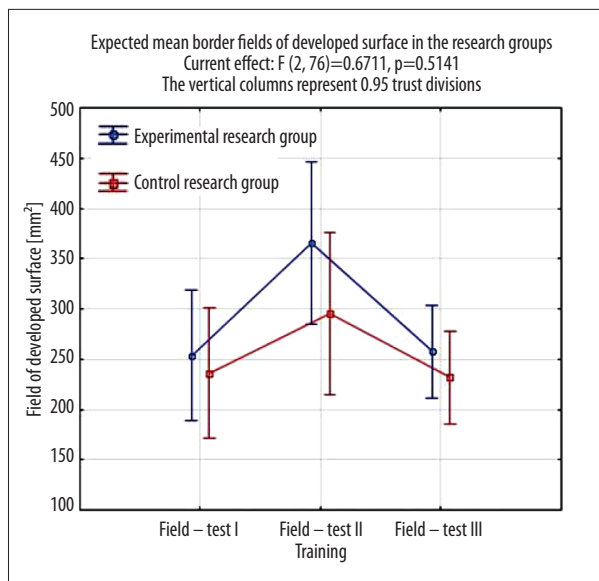


Figure 1. The mean, minimum, and maximum values of the developed surface field in the test groups.

a model on the uniformity of variants and configurations were verified by means of the tests of Cochran et al. [19]. The effect of repeated measurements was given the name Training* and related to their change in state prior to the commencement of the experiment, to the states after 1 and 2 months of its duration.

Table 4. The mean values of the variable *Field of developed surface [mm²]* in the subsequent tests in the categories of affiliation to test groups. In the column (6) are given the values of the testing function (F) and the test probability (p) for comparisons of the planned *Field of developed surface [mm²]* between the group C and the group E in the tests that successively occurred.

No. (1)	Test group (2)	Successive tests (3)	Mean (4)	N (5)	Planned comparisons (6)
1	Group E	Test 1	253.7	20	F=0.1511; p=0.6996
2	Group C		236.0	20	
3	Group E	Test 2	365.5	20	F=1.5247; p=0.2245
4	Group C		295.5	20	
5	Group E	Test 3	257.5	20	F=0.6402; p=0.4286
6	Group C		231.8	20	

Table 5. The mean values and standard deviation of the field of developed surface [mm²] in a test following seven turns in the categories of the tested groups in relation to the various methods of motor training employed.

Successive test	Test 1	Test 2 (after a month)	Test 3 (after 2 months)	Test 1	Test 2 (after a month)	Test 3 (after 2 months)
	E			C		
$\bar{\chi}$	1547.7	1581.6	1136.9	1436.8	2162.3	1211.8
SD	534.8	774.8	766.4	709.9	1345.5	818.6

Analysis of the research results

1. Analysis of the values of the developed surface field [mm²] in the testing of the experimental and control group in the test with open eyes

In Table 2 are presented the mean values and standard deviation of the developed surface [mm²] in the test with open eyes in the test group categories with regard to various methods of motor training.

Analysis of the variants of the ANOVA system of repeated measurements for the field of changed developed surface [mm²] showed the existence of a statistically significant effect of training in relation to both groups (Table 3).

The interesting effect from the point of view of the aim of this work is that the interaction of the type of training applied in relation to the various research groups (Figure 1) did not turn out to be statistically significant (p=0.5154).

In Table 4 are presented the mean values of the variable field of developed surface [mm²] in the successive tests in the categories of affiliation to the research test groups. In the column (6) are given the values of the testing function (F) and the tested probability (p) for the planned comparisons of the

Table 6. Analysis of the variance for repeated measurements – varied Field of developed surface [mm²] following the completion of seven turns.

Effect	SS	Df	MS	F	p
Training	9759095	2	4879548	8.4341	0.0005
Training*/group C and E	2561820	2	1280910	2.2140	0.1163
Error	43969758	76	578549		

field of developed surface [mm²] between the group C and the group E in the successive tests that occurred.

It was found that the group C and the group E do not significantly differ in terms of the values of the field of developed surface in test 1 preceding the commencement of the training cycle. The comparison of the group after a month of training (test 2) equally did not show significant differences in the values of the field of developed surface between group C and the group E. Requiring analysis is the fact of a statistically significant regression ($p=0.0030$) in the results between the first and second stage of the testing both in the control group as in the experimental group. The testing in the third test again did not show significant differences between the group C and the group E for the end of the training cycle; but the fall in the value of the field of developed surface in the experimental group between tests 2 and 3 ($p=0.0055$) was significant.

2. Analysis of the value of the field of developed surface [mm²] in the testing of the experiment and control groups in a test following the completion of 7 turns

The mean values and standard deviation of the field of developed surface [mm²] in a test following 7 turns in the categories of the tested groups in relation to the various methods of motor training employed are presented in Table 5.

Analysis of the variance of the ANOVA system of repeated measurements for the varied developed field surface [mm²] in a test following 7 turns showed the existence of a statistically significant effect of the training concerning both of the test groups are presented in Table 6.

The interesting effect in relation to the aim of the work – the interaction of the applied form of training with regard to the various test groups (Figure 2) – did not turn out to be statistically significant ($p=0.1163$).

Table 7 presents the mean values of the variable field of developed surface [mm²] in the test after turns in the successive tests in the categories of affiliation to test groups. Column (6) gives the values of the testing function (F) and the test probability (p) for the planned comparisons of the Field of developed

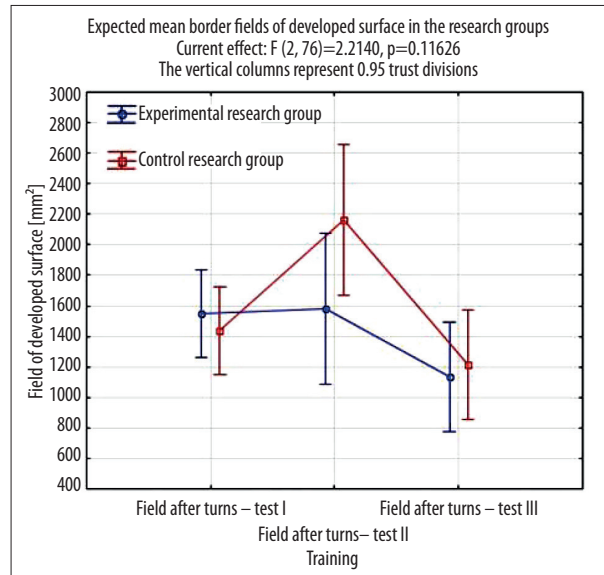


Figure 2. The mean, minimum, and maximum values of the surface field in the test after turns.

surface [mm²] in the test after turns between the control and experimental groups in the successively conducted tests.

The results of the analysis showed that the group C and the group E did not differ significantly in relation to the value of the field of developed surface after turns in the first test that preceded the commencement of the training cycle.

Comparison of the groups after a month of training – test 2 – equally did not display significant differences in the values of the field of developed surface between the group C and the group E. We cannot therefore talk of the appearance of an experiment effect, although the actual increase in the value of the field of developed surface in the control group between tests 1 and 2 turned out to be statistically significant ($p=0.0076$).

Test 3 again did not show significant differences between the group C and the group E at the end of the training cycle. However, the fall in the value of the field of developed surface in the control group noted between tests 2 and 3 ($p=0.0005$) was significant.

Table 7. The mean values of the variable *Field of developed surface [mm²]* in the test after turns in the successive tests in the categories of affiliation to the test groups. In the column (6) given are the values of the testing function (F) and the test probability (p) for the planned comparisons of the *Field of developed surface [mm²]* in the test after turns between the groups C and E in the successively conducted tests.

No. (1)	Test group (2)	Successive tests (3)	Mean (4)	N (5)	Planned comparisons (6)
1	Group E	Test 1	1547.7	20	F=0.3140; p=0.5801
2	Group C				
3	Group E	Test 2	1581.6	20	F=2.7971; p=0.1026
4	Group C				
5	Group E	Test 3	1136.9	20	F=0.0892; p=0.7668
6	Group C				

Table 8. The mean values and the standard deviation for the time balance was maintained on the right lower limb in the closed eyes test in the test group categories relating to the application of various methods of motor training.

Successive test	Test 1	Test 2 (after a month)	Test 3 (after 2 months)	Test 1	Test 2 (after a month)	Test 3 (after 2 months)
Group	E			C		
\bar{x}	23.3	33.1	42.1	25.5	38.6	41.2
SD	16.5	17.6	18.8	16.9	15.2	19.6

3. Analysis of the value of the time of maintaining balance with eyes closed on the right leg in the experimental group and control group

In Table 8 are presented the mean values and the standard deviation for the time balance was maintained on the right lower limb in the closed eyes test in the test group categories relating to the application of various methods of motor training.

Analysis of the ANOVA system variance of repeated measurements for the variable Time maintained on the lower right extremity in the eyes closed test showed the existence of a statistically significant effect of the Training for both test groups (Table 8).

Of interest from the view point of the aim of this work is that the effect of interaction of the applied form of training in relation to the various test groups (Figure 3) did not turn out to be statistically significant ($p=0.4817$).

In Table 9 are presented the mean values of the variable Time maintained on the lower right extremity [s] in the closed eyes test in the successive tests in the categories of affiliation to the test groups. Column (6) gives the values of the testing function (F) and the test probability (p) for the planned comparisons between the group C and the group E in the successive tests.

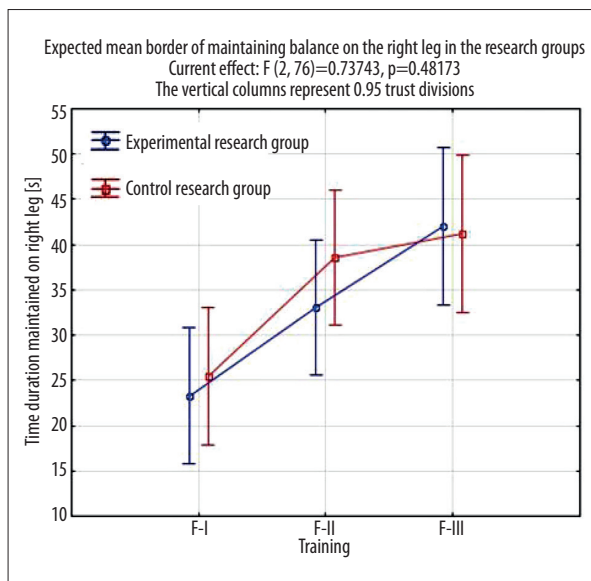


Figure 3. The mean, minimum, and maximum values of time of balance maintained on 1 lower limb.

The results of the analysis showed that the group C and the group E did not differ significantly in relation to the time maintained on the lower right extremity in Test 1, which preceded the commencement of the training cycle.

Table 9. Analysis of the variance for repeated measurements – the variable *Time maintained on the lower right extremity in the eyes closed test.*

Effect	SS	Df	MS	F	p
Training	6158.6	2	3079.3	22.7110	0.0000
Training*/group C and E	200.0	2	100.0	0.7374	0.4817
Error	10304.7	76	135.6		

A comparison of the groups after a month's training – test 2 – equally did not show significant differences in the values of time maintained on the lower right extremity between the group C and the group E. We cannot therefore speak of the appearance of an experiment effect, although there was noted a significant increase in the time value maintained on the lower right extremity between tests 1 and 2 both in the control group ($p=0.0002$), as equally in the experimental group ($p=0.0034$).

The analysis in test 3 again did not show any significant differences between the group C and the group E at the end of the training cycle; however, there was found a significant increase in the values of time maintained on the lower right extremity but only in the experimental group and this being between tests 2 and 3 ($p=0.0213$).

Discussion

Body balance, as has been shown by many academics worldwide, is a genetically conditioned ability [2,6], which may be developed particularly during the early stages of biological development [4,7]. During the later stage the development of this ability is inherently hampered by the fact that the brain already is in possession of a completely formed and appropriately 'cut' neurological set of connections [20–22]. Equally, the motor abilities are already formed [8]. However, the level of these abilities, including that of balance, may be unsatisfactory for those who engage in sports. As a result there exists the need to develop a set of programed exercises to aid development or maintain these abilities along with the possibility for a further verification of the effectiveness of training [4,12].

We have evaluated in our experiment the effectiveness of a sports training program in which there has been utilized a vibration platform emitting mechanical vibrations to the whole body or parts of it. In the subject literature there exist reports and studies that indicate the time a stimulus acts as well as the frequency of these vibrations may bring about various effects. A lot of discussion has also been devoted to the question of the impact of vibrations on the development of motor abilities. Most works were devoted to the question of muscle strength and body balance. Some authors emphasize the

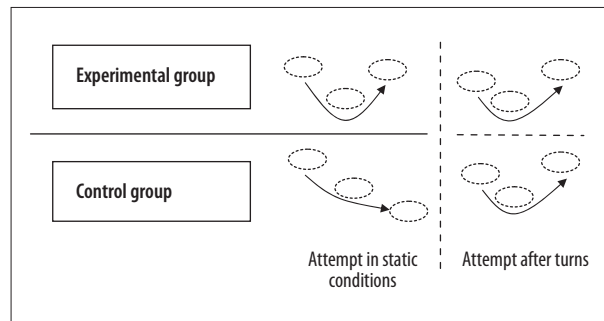


Figure 4. The directions of changes displaying the body balance ability level depending on the type of motor activity for the tested group in the posture-graphical evaluation in static conditions and following kinetic arousal.

absence of an influence on the part of vibrations on the shaping of muscle strength and also force directed into a vertical jump [23,24]. Others present a different position [25]. Similarly, the impact of vibration on body balance develops in 2 different directions. Certain authors did not observe significant changes following the application of vibration exercises in relation to body balance [18,25]. The phenomenon of fatigue impact through mechanical vibrations is emphasized and even a connecting of the effectiveness of vibration exercises with the duration of their application [18]. This is also maintained by the results obtained in our experiment, where the application of a short vibration training time duration did not result in statistically significant changes in the level of body balance amongst the female students.

There equally exist works where the effectiveness of vibration exercises in effective body balance is linked to the frequency of these vibrations. Damjan [26] has claimed that under the influence of applied vibrations of a low frequency there is observed a significant change in the nerve-muscle coordination and that of static balance. The presented effects are often identified with changes occurring in the muscle structure, as well as the bone, but first and foremost these concern the broad spectrum of nerve-muscle conductivity and the higher structures of the nervous system [27–29].

An evaluation of the training effects measured by the manifested level of ability to maintain balance is also not unequivocal

in meaning, the symptoms of which may be discerned in the present work (Figure 4).

The changes noted after the elapse of the first 4-week period in the experiment and control group were deterioration in the results characterizing an increase in the mean field of the centre of body mass deflections. The fact of the negative impact of a programme of physical activity in the standard model A realized in the control group and in particular in the experimental model B realized in the experimental group on the system of the body balance of exercising female students is undoubtedly something in need of further observation.

After a subsequent 4 weeks of the experiment the evaluation of effectiveness for the body balance system, in the test under static conditions, brought a different characterization of the effects than the evaluation in the test following kinetic arousal. The mean measurement value for the experimental group gained the initial level, while for the control group there was noted a subsequent lowering in the maintenance of the body balance level.

A different direction in relation to training effects may result from positive stimulation by means of exercises on a vibration platform, accelerating the eradication of fatigue processes. However, the test after kinetic arousal allowed one to see in both groups a heightened level of ability for the balance system. It is also important to note in this test an almost constant measurement value for 75% of those tested in the experimental group (I test $Q_3-Q_1=1171 \text{ mm}^2$; II test $Q_3-Q_1=1122 \text{ mm}^2$; III test $Q_3-Q_1=1001 \text{ mm}^2$) and significant changes in the control group, which again may point to the manifestation of fatigue effects (I test $Q_3-Q_1=885 \text{ mm}^2$; II test $Q_3-Q_1=2288 \text{ mm}^2$; III test $Q_3-Q_1=1122 \text{ mm}^2$).

The absence of unequivocal tendencies for the changes to end at a level of balance ability after 8 weeks of the experiment

raise the question as to whether it should not be continued until the training effects have been established. Simultaneously, it seems necessary to conduct the evaluation of the impact of mechanical vibrations on the ability to maintain body balance with consideration of the time used for stimulation in the training process, the time duration of a single stimulus, and the frequency of the vibrations.

The application dimension

A sizeable part of the experiments conducted are based on the testing of the effects of regaining the ability to maintain body balance, following multi-dimensional vibration stimulation to the whole body, for individuals with illness syndromes handicapping the ability to maintain stability and locomotion [4,30–32]. The results obtained by us in the testing of healthy female students of the Academy of Physical Education and Sport may be used as a model for the testing and training of the above-mentioned individuals suffering from these disease syndromes.

Conclusions

It has been shown that the obtained results in relation to body balance by students from the group C in which Program A was administered together with stretching displayed only a slightly worse set of results than those obtained by the examined students from group E in which Program B was implemented together with exercises on a vibration platform. Therefore, we were unable to confirm the hypothesis of the effectiveness of a vibration platform with regard to the ability to maintain body balance in female students studying physical education. However, there exists a significant difference in the testing of maintaining balance on a single lower limb in the group of female students training under the Program B when compared to those following Program A.

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