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Research article

The influence of curricular physical activities on the values of body balance indices in university students

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ABSTRACT: The investigation analyzes the effect of specific motor structures on the indicators of the static and dynamic balance of the students of Dunărea de Jos University in Galați (99 boys aged = 20.29 years, body weight = 84.17 kg, height = 180.08 cm, respectively 96 girls aged = 20.09 years, mass bodyweight = 60.88 kg, height = 164.73 cm. The members of the tested group have no concerns related to performance sports or physical activities as a lifestyle. The application of the experimental program was made during the 28 weeks of the academic year 2018-2019, with 3 distinct moments: T1 / initial at the beginning of the 1st semester, T2 / intermediate before the winter break, T3 / final at the end of the academic year. The battery of tests included 7 tests: One leg standing test with eyes closed (sec), Stork test (sec), Flamingo test (number of attempts), Bass test (points), Functional reach test (cm), Walk and turn field sobriety test (errors) and Fukuda test (degrees). The results of the Anova parametric test with repeated measurements revealed statistically significant values of F associated with critical thresholds ($p < 0.05$), and the values of Partial eta squared (η^2_p) indicate strong influences of the proposed program on test performance in most cases, both at the level of the whole group and also for each gender. It should be noted that the performance improvements are greater in the first part of the study (differences between initial and intermediate tests, with $p < 0.05$), compared to those in semester 2 (differences between intermediate and final tests), which can be explained by the adaptation to the planned and applied stimuli, so modifying or changing their dosage is necessary in order to have a better chance of improving the results. Significant differences are confirmed for most tests of both genders ($p < 0.05$), with exceptions being the Walk and turn field sobriety test for boys (at the level of the difference between intermediate and final testing) and the Fukuda test for both genders (for differences between initial and intermediate testing). However, the results should be viewed with caution, the low level of physical training and sedentary behavior of most students providing the premises for such progress, even with a single weekly physical activity.

Keywords: *students, balance, postural stability, physical exercise, progress, motor skills*

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INTRODUCTION

The vestibular, visual and proprioceptive systems play a major role in the manifestation of static and dynamic balance, affecting these senses / analyzers generating poor performance of postural stability (1). As we age, a good interaction between the visual and vestibular systems must be harnessed to maintain balance. There is a suppression of the soleus H reflex by the vestibular system, but for the elderly the visual input is necessary for suppression, according to (2).

A study made on a group of Chinese children (3-6 years old) in Beijing showed that static, dynamic balance and proprioception have different values at different ages, and static balance and proprioception are also different depending on gender. Static and dynamic equilibrium are positively and significantly correlated with GMD / gross motor development, but no significant associations are found between BMI and balance, according to (3). Cervical proprioception provides additional information in addition to those provided by vestibular and auditory analyzers. The research conducted by (4) finds associations between kinesthetic information at the level of the neck and the balance on the non-dominant / non-preferred leg of Taekwondo fighters, as an adaptation that is not present in the untrained people.

The center of pressure (CoP) provides important data in assessing the postural stability, being the point at which the resulting GRF / ground reaction force is applied to the body. The antero-posterior component (AP) of GRF is more involved in maintaining balance in young people than in the elderly, according to (5).

The quantification of balance problems for people who have suffered from subacute stroke through the Fukuda test is done by (6,7). The instrumented version of this test can be used for anyone with postural deficiencies, not just those who have suffered a stroke. The response of stroke patients with balance problems to challenging virtual environments is analyzed by (8). Static and dynamic posturography testing, with eyes closed and open, showed that the dynamic variant (in more difficult conditions) generated greater posture disorders in those with stroke, than in the case of healthy people.

Balance problems are reported in subjects with type 2 diabetes, postural control being affected by stimulation of the vestibular system and disruption of the proprioceptive system. Anterior-posterior / AP balance is significantly altered by open-eyes unstable surface and stable closed-eyes testing, according to (9). Musculoskeletal problems (especially with the manifestation of scoliosis) are reported in 50% of patients with type 1 neorofibromatosis (FB1), according to (10), and melatonin has a therapeutic role in visual analyzer disorders in the elderly people (11).

Investigating balance values can provide information about the presence of CLBP / chronic low back pain. Those diagnosed with these problems have lower scores on the static / one leg standing balance assessment tests and higher CoP / center of pressure oscillations for dynamic balance (12). Balance is also influenced by postural deviations. The study conducted by (13) identifies these problems chronologically (students in the range of grades 1-5), head, spine, shoulders, chest, abdomen and lower limbs.

The effects of trazodone (medicine for anxiety and depression) on balance through the Field sobriety test are being studied by (14). Even if the mean test performance values do not decrease significantly after 2 hours after trazodone administration, there are individual cases of poorer results in the evaluated group.

The effectiveness of physical exercise in alleviating the problems caused by type 2 diabetes is highlighted by (15). Active women have lower BMI and high cardiovascular resistance, and the deterioration of the tiptoe dynamic balance impairments is associated with the presence of inflammatory conditions, poor glycemic control and hypercoagulation phenomena. The role of motor structures associated with physical therapy and physical education in improving joint problems, rehabilitating motor deficiencies, increasing the range of motion and installing well-being are highlighted by (16–20).

Impaired static and dynamic balance for young athletes (18-25 years old) with a history of chronic ankle sprain injuries, involved in athletic sports (track and field sports) are reported by (21), the same problems being identified for foot proprioception. The warning on the neglect of the process of developing the balance, through programs specific to the different branches of sports (football) is made by (22). The balance is decisive in the execution of the complex technique and the avoidance of potential injuries, and its optimization educates the sensorimotor skills necessary for top performance.

Correct posture in sports has the role of maintaining static and dynamic balance, and an objective and fast postural assessment, through video rasterstereography, for athletes and sedentary people is proposed by (23).

The need for balance differs depending on the specifics of each sport, but the values of static and dynamic balance between those who do individual sports and those involved in team sports (team and individual athletes) are still statistically insignificant, according to (24). The balance in the pubertal stage, correlated with the dominance of the cerebral hemispheres has a role in guiding children in various tests in athletics (25,26), and the assimilation and application of technical procedures in volleyball requires a good balance (27). Balance problems are a factor that can lead to injuries and poor performance in sports (football), according to (28). The author does not find significant differences between genders for static and dynamic balance tests, but they are significant between football and sedentary groups at the level of university students, so involvement in physical activities optimizes the values of balance.

The types of tasks influence the balance of the body. For healthy seniors, it has been found that dual motor task with cognitive demands have caused static balance disturbances due to the focus on solving challenging dual motor tasks or dual motor task with cognitive demands. (29). The balance is also affected by obesity. Physical activity in school curricula alone is not enough to effectively combat this problem, according to (30). The declining involvement of young people in Montenegro (8th grade) in physical activity, with major problems in BMI values, is reported by (31), which finds that 37.1% of the girls and 34.2% of the boys are overweight and obese. Sports activities contribute to the social integration of the participants, and body balance is also important in the sports activities of people with disabilities, for example in the game of wheelchair tennis (32,33)

People with forward head posture have higher movements and swinging speed both in the closed and open eyes position, on a hard surface and on an unstable surface/sponge. The position generates significant differences only for the evaluation of the static balance, not for the dynamic one, according to (34).

The importance of the visual analyzer in maintaining static and dynamic balance for young ballet dancers in Poland is highlighted by (35). The performance on the static balance test (30 sec) was reduced for the closed-eyed version, and the older ones (18 years old) have superior performance and are more stable than the 14-year-olds. No differences were found for dynamic equilibrium in rotational motion when the support base is low.

The usefulness of the one leg standing, as a test for assessing balance and diagnosing symptoms associated with musculoskeletal disabilities, for the elderly is highlighted by (36). The short time to maintain balance signals and predicts negative events and problems: illness, falls, decreased involvement in daily activities, fragility, etc.

MATERIAL AND METHOD

The aim of the research is the progressive improvement of the indicators of static and dynamic balance, at the level of university students, by using specific motor structures, within the physical education lessons.

Working hypotheses:

H1: We assumed that the implementation of the experimental program will generate significant improvements of the equilibrium values, at the level of the whole group.

H2: We consider that they are prerequisites for obtaining significant differences between the initial, intermediate and final tests, separately by gender (male and female).

Participants

The investigated subjects are 195 students of the University of the Lower Danube in Galați, of which 99 boys (age = 20.29 years, body weight = 84.17 kg, height = 180.08 cm) and 96 girls (age = 20.09 years, body weight = 60.88 kg, height = 164.73 cm) (with various specializations: Dentistry, Computer Science, Automation, Applied Electrical and Electronic Engineering), all included in years 1 and 2 of study / license. None of the study participants are engaged in high-performance physical activities, so the dynamics of the results on the applied test battery cannot be influenced by this aspect. All participants had favorable medical recommendations regarding the availability of physical effort exertion and were instructed about the purpose of the research.

Procedures

The research took place during the 2018-2019 academic year, before the onset of the Covid 19 pandemic. Subjects were tested with a set of 7 static and dynamic balance assessment tests at 3 distinct times: at the beginning of semester I (initial testing), before winter break (intermediate testing), and at the end of semester 2 (final testing). The tests used are: One leg standing with eyes closed (sec), Stork (sec), Flamingo (number of attempts), Bass (points), Functional reach (cm), Walk and turn field sobriety (errors) and Fukuda (degrees), their description and quantification being analyzed by the sources (37–39). The whole group participated in the physical activities related to the physical education lessons (28 weeks x 1 activity of 2 hours per week). The duration of the application of the structures intended to influence the balance parameters varied between 15-25 minutes in each lesson, and the efforts were individualized, in accordance with the individual motor availability. The variants proposed in the experimental syllabus and applied during the lessons are summarized in Table 1, separately for static and dynamic balance. The students who did not regularly attend classes were excluded from the study in order not to negatively influence the results. The current study presents the performances of the whole group, but also the dynamics of the performances at the 3 tests, separately for girls and boys. No comparative statistical analyzes of gender or BMI performance have been performed, and these data will be presented in future papers.

The rules for organizing scientific research and academic writing have been observed, according to (40).

The statistical – mathematical analysis:

The statistical calculation was performed using SPSS software (version 24). Anova parametric techniques with repeated measurements, Maucly's Test of Sphericity with Greenhouse-Geisser correction factors (for $\varepsilon < 0.75$) and Huynh-Feldt (for $\varepsilon > 0.75$), calculation of F values, significance thresholds (p / sig.) and a Partial eta squared (η^2_P). At the level of the whole group and separated by genres, the indicators of the central trend for the 3 test moments were calculated, highlighting the differences between them and the related significance thresholds, using the Bonferroni correction factor (41–44). The dynamics of the average values of the whole group, for all these tests and the comparison between the average results by genres were represented graphically with the help of Microsoft Excel and Microsoft Word.

RESULTS

The processed data were summarized in Tables 2-5, and the average values in the balance tests (for the whole group and comparative by gender for each of the 3 test moments) were represented in Graphs 1-8.

The results of the Anova test with repeated measurements at the level of the whole group show for all 7 tests significant values of F ($p < 0.05$), according to table 2. The results of Partial eta squared (η^2_P) indicate a strong influence of the proposed program on the test values, with very high values for Functional reach test (where 71% of the variance is attributed to the independent variable / experimental program), Stork test (where 59.5% of the variance is explained by the influence of the program), respectively Flamingo test and Bass test (at both 50.9% of variance is due to the applied program). The least influence of the applied exercises is found for the Fukuda test (only 4.5% of the variance is due to the planned physical activities).

Table 3 analyzes the results of the Anova test with repeated measurements for each genre. Only statistically significant values of F ($p < 0.05$) are found in total. The strongest influences of the proposed program are for Functional reach test in boys (82.6% of the variance is attributed to the independent variable) and girls (with 63.4% of variance), Bass test in girls (81% of variance is determined by the applied program) and boys (with 77.5% of the variance), Stork test in girls (68.7% of the variance is attributed to the program). The weakest influence is found for the Walk and turn field sobriety test in boys (15.6% of the variance is attributed to the effect of physical activity) and girls (with 14.6% of the variance), respectively Fukuda test in girls (only 5.8% of the variance of this sample is explained by the effect of the program).

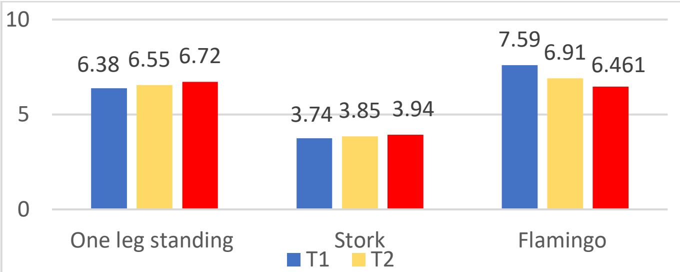

Fig. 1 Dynamics of average values of results in static balance tests (whole group)

Graphs 1 and 2 show the dynamics of the average values of the whole batch for the initial / T1, intermediate /T2 and final/T3 tests, for the evaluation of the static and dynamic balance, respectively. It is noted that for the whole set of tests there is progress from one stage to another, the differences between them and the related significance thresholds are summarized in Table 4. Between the initial test / T1 and the final / T3 significant progress is found for all 7 tests, which shows that the accumulations in the lessons allowed the improvement of the performances in the balance tests throughout the year ($p <0.05$). For all static balance tests and for the first 2 dynamic balance tests (Bass test and Functional reach test) significant differences are also reported between the initial / T1 test and the intermediate / T2 test, respectively between the intermediate / T2 and the final / T3 test. However, better progress is reported, resulting in larger differences between T1 and T2, compared to the differences between T2 and T3. This aspect supports higher accumulations for these tests during the first semester, followed by slightly lower progress in the second semester, possibly as a reaction of adaptation to the planned exercises.

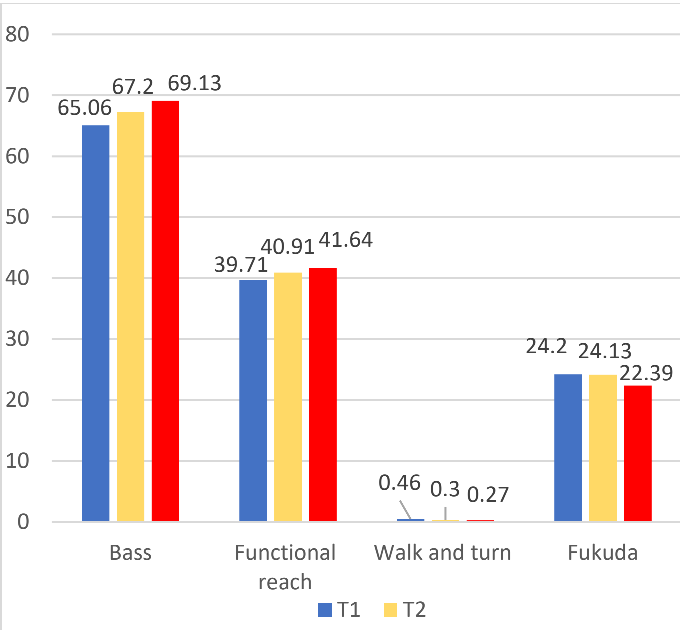

Fig.2 Dynamics of average values of results in dynamic balance tests (whole batch)

The results of the last 2 dynamic balance tests no longer fall into this pattern of evolution. For the Walk and turn field sobriety test there is significant progress only for the first semester (T1-T2), instead for the 2nd semester there is an insignificant progress ($p = 0.250$, value> 0.05) so at the level of the whole group there is the capping of accumulations for this test. For the Fukuda test the situation is reversed as accumulations per semester (for the first semester there is a weak and insignificant progress, with p = 1.00, value > 0.05, but the situation is remedied in semester 2, when the difference between T2 and T3 is statistically significant, with p = 0.010, value <0.05.

Graphs 3-4 show the evolution of the average performances of the two groups for the initial tests at the static and dynamic balance tests, graphs 5-6 the same dependent variables for the intermediate tests / T2, and graphs 7-8 the dynamics of the performances of the 2 groups for the final tests / T3.

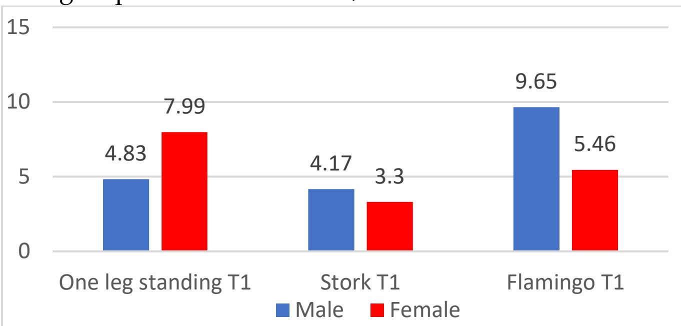

Fig. 3 Gender comparison of mean values in static balance tests (initial assessment / T1)

The initial tests to assess the static balance show the superiority of the girls for 2 tests: One leg standing, with almost double values of maintaining position and Flamingo, where they have a lower number of attempts (and implicitly falls, to total the 60 sec standing). However, the boys had slightly higher average results on the Stork test.

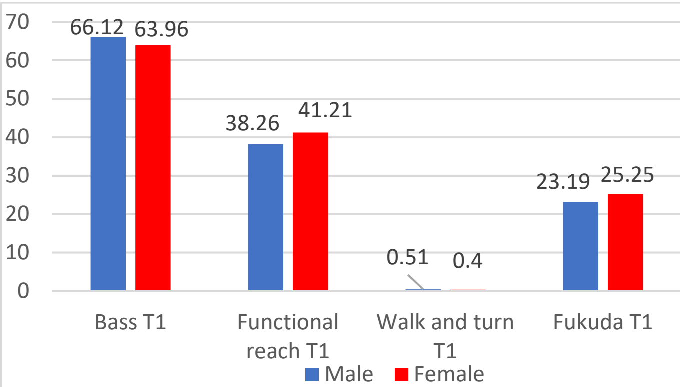

Fig. 4 Gender comparison of average values in dynamic balance tests (initial assessment / T1)

Initial tests to assess the dynamic balance show that boys perform slightly better on the Bass test and the Fukuda test (fewer degrees of rotation around the body axis), and that girls score better on the Functional reach test (possibly also due to their flexibility) and the Walk and turn field sobriety test (where they make fewer mistakes in covering the distance on the line drawn on the ground).

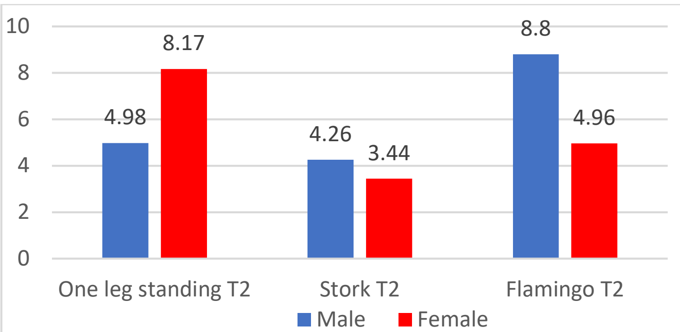

Fig. 5 Gender comparison of average values in static balance tests (mid-term evaluation / T2)

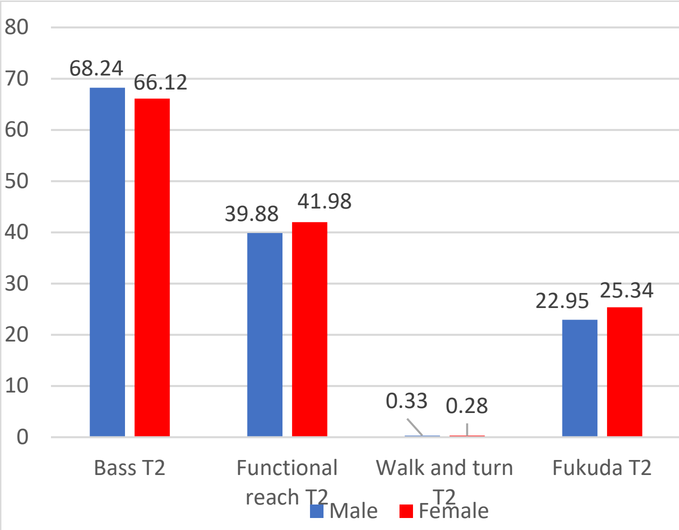

Fig. 6 Gender comparison of average values in dynamic balance tests (mid-term evaluation / T2)

Graphs 5 and 6 show the value of the average performances for the balance tests, gender based in the mid-term evaluation/T2 tests. It is observed that the values are improved compared to the first assessment for each gender, with statistically significant values ($p < 0.05$), the only test where the progress is not significant is Fukuda, in girls there is even a regression ($p = 1$, value> 0.05) and for boys the progress is weak ($p = 0.232$, value> 0.05), according to the data in tables 5-6.

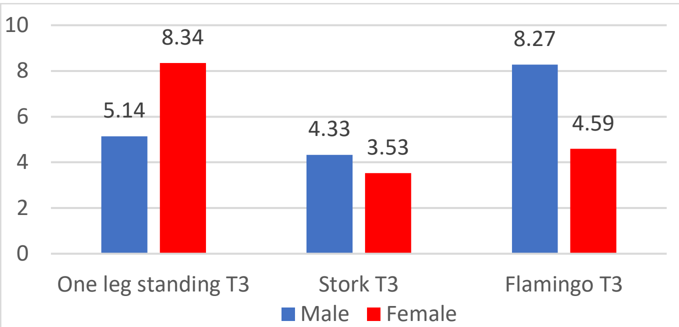

Fig. 7 Gender comparison of average values in static balance tests (final evaluation / T3)

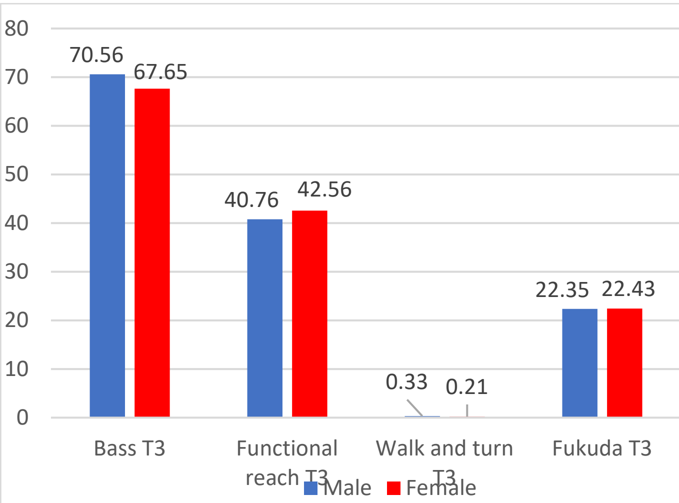

Fig. 8 Gender comparison of average values in dynamic balance tests (final assessment / T3)

Graphs 7 and 8 show the values of the average performance for the balance tests at the final/T3 tests. Although the progress between intermediate and final tests is more limited than between initial and intermediate tests, the thresholds for these differences are in most cases still significant (p <0.05). The only exception is the Walk and turn test, where there is a stagnation of performance, with the absence of the minimum progress rate (p = 1, value> 0.05). The differences between the initial / T1 and final / T3 test averages are entirely significant for both genders (p <0.05), which confirms the applicability and the practical utility of the proposed program.

Table 1 – Types of exercises included in the experimental program

Table 2 –

Table 2

Motor structures proposed for the development of static balance
• Standing, stand on tiptoes and hold the position, with the palms together at the level of the chest. • From sitting on one leg, swinging the other leg back and forth (sagittally). Same with frontal swing. Same with rotating the knee outward and moving the arms in various directions. Same with rotating the outstretched foot forward from the ankle joint. • From standing on one leg, with the other one raised and supported behind the knee of the supporting leg (popliteal space), maintaining the position with the arms outstretched sideways or vertically. • From standing on one leg with the arms sideways, successively lifting one knee and back, without touching the ground with the foot. Same with reversing the support leg. Same with raising the knee with the palms, up to the abdomen and holding position for 5-10 sec. • From standing on one leg, rotating with the tip of the other leg pointed to the ground, the knee is slightly flexed. • From standing facing the wall or fixed ladder / appliance, lifting one knee, unbalancing forward and balancing by placing your palms on the wall / ladder. Same with twisting the torso right / left and placing one hand on the wall. • Making the scale on one leg (low, medium or high). Same with twisting the torso right / left. • Maintaining balance by sitting on a medicine / basketball / football ball, with your palms on the wall, then raising your palms off the wall. • Forward and lateral bends, with easy lifting of the outstretched foot (back or side) from the ground and maintaining the position for 5-20 sec. • Tiptoes lifts on a support (bench-step) with maintaining the position for 5-10 seconds and return. The same goes for climbing on the bench and maintaining balance only on the tip of one leg.
Motor structures proposed for the development of dynamic balance
• Running in different directions with bypassing obstacles / poles, balancing a tennis ball on a racket. Same with keeping a cane upright balanced on the palm. • Lateral jumps over a line or cord placed on the ground, with detachment on one leg and landing on the other. The same with landing on the detachment leg and maintaining balance for 2-3 sec. • From standing on one leg facing 5-6 bottles arranged in an arc, raising the other leg and successively touching the top of the bottles, then in the opposite direction with the other leg. The same goes for placing a glass on each bottle after touching it with your foot. • Moving on a line with an object / book held on the head in balance. The same goes for walking on a winding line or bypassing obstacles. • Lateral jumps on one leg from step to step, while maintaining balance. Same with turning the body to 90^0 for each jump. • Jumping over obstacles with body rotation in the air and landing on one foot, in circles or on clearly marked areas. • Move in pairs (one after another), keeping in balance a stick placed on the shoulders of the partners on one side right / left. • Moving between poles, keeping 2 balls in balance on the lateral outstretched hands. • Exercises performed on a special balance ball (bosu balance trainer): squats, pushups, lunges, maintaining the position of plank, etc. • Jumping from the ground on the gym bench and landing in support on one leg, maintaining the balance for 5-20 seconds, then return and the action resumes for the other leg.

ANOVA results with repeated measurements whole group (N=195)

Test	Maucly's Test of Sphericity		Correction factor	df	Error df	F	Sig.	Partial eta squared (η^2_p)
	Sig.	ε						
One leg standing	.000	.682	Greenhouse-Geisser	1.363	264.491	163.095	.000	.457
Stork	.000	.700	Greenhouse-Geisser	1.400	271.527	284.856	.000	.595
Flamingo	.000	.738	Greenhouse-Geisser	1.475	286.156	200.799	.000	.509
Bass	.000	.738	Greenhouse-Geisser	1.475	286.156	200.799	.000	.509
Functional reach	.000	.763	Huynh-Feldt	1.527	296.219	474.557	.000	.710
Walk and turn	.000	.819	Huynh-Feldt	1.639	317.962	33.365	.000	.147
Fukuda	.000	.555	Greenhouse-Geisser	1.111	215.449	9.128	.002	.045

Table 3 – ANOVA results with repeated measurements by gender (male / N=99); (female / N=96)

Test	**Lot**	**Maucly's Test of Sphericity**		**Correction factor**	**df**	**Error df**	**F**	**Sig.**	**Partial eta squared (η^2_p)**
		Sig.	**ε**						
One leg standing	M	.000	.677	Greenhouse-Geisser	1.354	132.645	76.888	.000	.440
	F	.000	.676	Greenhouse-Geisser	1.351	128.367	85.899	.000	.475
Stork	M	.000	.612	Greenhouse-Geisser	1.223	119.887	100.432	.000	.506
	F	.000	.789	Huynh-Feldt	1.578	149.935	208.817	.000	.687
Flamingo	M	.000	.739	Greenhouse-Geisser	1.477	144.759	133.219	.000	.576
	F	.000	.783	Huynh-Feldt	1.565	148.702	78.111	.000	.451
Bass	M	.005	.922	Huynh-Feldt	1.843	180.641	338.172	.000	.775
	F	.000	.835	Huynh-Feldt	1.670	158.627	403.702	.000	.810
Functional reach	M	.000	.836	Huynh-Feldt	1.671	163.775	466.817	.000	.826
	F	.000	.851	Huynh-Feldt	1.702	161.728	164.825	.000	.634
Walk and turn	M	.000	.816	Huynh-Feldt	1.633	160.002	18.092	.000	.156
	F	.000	.807	Huynh-Feldt	1.613	153.239	16.220	.000	.146
Fukuda	M	.391	1	Sphericity Assumed	2	196	32.980	.000	.252
	F	.000	.537	Greenhouse-Geisser	1.075	102.079	5.889	.015	.058

Table 4 – The results of the differences in the mean values of the whole group (N=195)

Test	**Mean**	**Std. deviation**	**Std. error**	**T1-T2**	**Sig.[b]**	**T1-T3**	**Sig.[b]**	**T2-T3**	**Sig.[b]**
One leg standing T1	6.3859	6.07458	.435	-.170*	.000	-.338*	.000	-.168*	.000
One leg standing T2	6.5561	6.09961	.437						
One leg standing T3	6.7241	6.12893	.439						
Stork T1	3.7437	3.37345	.242	-.115*	.000	-.199*	.000	-.083*	.000
Stork T2	3.8590	3.37198	.241						
Stork T3	3.9425	3.37013	.241						
Flamingo T1	7.5949	4.46463	.320	.677*	.000	1.133*	.000	.456*	.000
Flamingo T2	6.9179	4.35694	.312						
Flamingo T3	6.4615	4.28282	.307						
Bass T1	65.0615	13.49938	.967	-2.138*	.000	-4.072*	.000	-1.933*	.000
Bass T2	67.2000	13.61571	.975						
Bass T3	69.1333	13.84720	.992						
Functional reach T1	39.7168	6.74373	.483	-1.201*	.000	-1.932*	.000	-.731*	.000
Functional reach T2	40.9179	6.53270	.468						
Functional reach T3	41.6487	6.31811	.452						
Walk and turn T1	.4615	.72674	.052	.154*	.000	.185*	.000	.031	.250
Walk and turn T2	.3077	.55398	.040						
Walk and turn T3	.2769	.57007	.041						
Fukuda T1	24.2051	26.92944	1.928	.072	1.000	1.810*	.000	1.738*	.010
Fukuda T2	24.1333	27.82053	1.992						
Fukuda T3	22.3949	26.15385	1.873						

*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Table 5 – Results of differences in mean values male (N=99)

Test	Mean	Std. deviation	Std. error	T1-T2	Sig.b	T1-T3	Sig.b	T2-T3	Sig.b
One leg standing T1	4.8305	3.37245	.339	-.157*	.000	-.318*	.000	-.161*	.000
One leg standing T2	4.9878	3.41993	.344						
One leg standing T3	5.1489	3.45799	.348						
Stork T1	4.1704	3.99939	.402	-.095*	.000	-.164*	.000	-.069*	.000
Stork T2	4.2651	4.00559	.403						
Stork T3	4.3340	4.00868	.403						
Flamingo T1	9.6566	4.37097	.439	.848*	.000	1.384*	.000	.535*	.000
Flamingo T2	8.8081	4.49189	.451						
Flamingo T3	8.2727	4.59773	.462						
Bass T1	66.1212	12.13972	1.220	-2.121*	.000	-4.445*	.000	-2.323*	.000
Bass T2	68.2424	12.31980	1.238						
Bass T3	70.5657	12.90085	1.297						
Functional reach T1	38.2677	7.58399	.762	-1.616*	.000	-2.495*	.000	-.879*	.000
Functional reach T2	39.8838	7.40099	.744						
Functional reach T3	40.7626	6.95772	.699						
Walk and turn T1	.5152	.70514	.071	.182*	.000	.182*	.000	.000	1.000
Walk and turn T2	.3333	.53452	.054						
Walk and turn T3	.3333	.58902	.059						
Fukuda T1	23.1919	25.69471	2.582	.232	.064	.838*	.000	.606*	.000
Fukuda T2	22.9596	25.86461	2.599						
Fukuda T3	22.3535	25.11293	2.524						

*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Table 6 – Results of differences in mean values female (N=96)

Test	Mean	Std. deviation	Std. error	T1-T2	Sig.b	T1-T3	Sig.b	T2-T3	Sig.b
One leg standing T1	7.9900	7.64858	.781	-.183*	.000	-.358*	.000	-.175*	.000
One leg standing T2	8.1734	7.66193	.782						
One leg standing T3	8.3484	7.68908	.785						
Stork T1	3.3038	2.52069	.257	-.137*	.000	-.235*	.000	-.098*	.000
Stork T2	3.4403	2.51374	.257						
Stork T3	3.5388	2.50844	.256						
Flamingo T1	5.4687	3.46396	.354	.500*	.000	.875*	.000	.375*	.000
Flamingo T2	4.9688	3.22312	.329						
Flamingo T3	4.5938	2.95075	.301						
Bass T1	63.9687	14.75588	1.506	-2.156*	.000	-3.688*	.000	-1.531*	.000
Bass T2	66.1250	14.82264	1.513						
Bass T3	67.6562	14.68105	1.498						
Functional reach T1	41.2113	5.39371	.550	-.773*	.000	-1.351*	.000	-.578*	.000
Functional reach T2	41.9844	5.32741	.544						
Functional reach T3	42.5625	5.46965	.558						
Walk and turn T1	.4063	.74802	.076	.125*	.001	.188*	.000	.063*	.041
Walk and turn T2	.2812	.57497	.059						
Walk and turn T3	.2188	.54682	.056						
Fukuda T1	25.2500	28.24330	2.883	-.094	1.000	2.813*	.000	2.906*	.044
Fukuda T2	25.3437	29.79150	3.041						
Fukuda T3	22.4375	27.31794	2.788						

*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

DISCUSSION

The literature presents numerous studies that highlight the role of physical activity in optimizing postural control for normal subjects and those with various disabilities.
A study in young adults (x = 21 years) indicates that subjects who have moderate to vigorous physical activity have better balance values (the balance area is smaller). Women have better scores than men, and the open-eyed version outperforms the closed-eyed one. Reducing sedentary behavior can improve the static balance (45). The assessment of balance according to gender and age ranges is performed by (46). The 20-49 age range has similar performances, but they decrease after 50 years. Men perform slightly better than women.
High-intensity exercise generates a decrease in one leg standing test immediately after exercise, and 15 minutes after exercise there is an improvement in balance, according to (47). For the elderly, engaging in a variety of physical activities (swimming, dancing, tennis, badminton, netball, cricket, along with ice skating) are options with positive effects on health, improving balance and preventing falls (48). An exercise program for the elderly (6 weeks x 2 workouts / week), focused on flexibility, balance and strength of the lower limbs is proposed and applied by (49). Positive effects are found: limitation of the postural balance in the antero-posterior / AP direction with significant progress, associated with the decrease of the fear of falling, due to the improvement of the general posture.
Balance development programs should be applied differently, depending on age. For 6-12 year olds, using programs for 8 weeks demonstrates that the DIM / direct instructional model (in which students work in isolation / individually) is more effective in the 7-8 year range, while the TGM / tactical games model is viable for students over the age of 8, according to (50). The comparison of fitness values obtained in public schools vs. the private ones for children aged (7-11 years old) is made by (51). No significant differences were obtained in the Flamingo test (11.88 for public school and 11.66 for private school).
An unexpected result related to the balance of young football players is obtained by (52). No significant differences were found between pre-workout and post-workout balance values, so accumulated fatigue does not adversely affect performance on balance tests.
Applying a balance development program (6 weeks x 2 sessions / week x 30 minutes) for children in Brazil aged (6-9 years) improves plantar support (the surface of the support for the CoP), especially for the dominant leg (53). The use of static Yoga asanas for college students (18-25 years), by applying a program of 6 weeks x 3 workouts / week x 30min / session is proposed by (54), being noted improvements in muscle strength and static balance assessed by the Stork balance test.
Skiing used for 5 days - for people who have not used it before - successfully contributes to improving the dynamic balance, but also to maintaining the static one on the AP / antero-posterior direction (55). The effectiveness of Ai Chi / Ai Chi aquatic therapy and its combination with dry land therapy to improve static and dynamic balance for people with stroke (more exposed to the risk of falling) are identified by (56).
Strong associations between the shooting abilities of Indian snipers and the performance of the Stork static balance test are reported by (57).
The effect of WBV (whole body vibration) on the static and dynamic balance of healthy students, assessed by the flamingo test and the Y balance test is studied by (58). Significant improvements in balance are observed in the final tests, with WBV being useful and recommended for optimizing balance in the elderly and athletes.
The implementation of a dynamic core exercise program (DCE / dynamic core exercise) in the warm-up part of the physical education lessons, for 6 weeks, for children aged 10-11 has beneficial and significant effects on physical parameters, flexibility and balance, according to (59). The application of a program that requires visual analyzer / image training, for healthy students (x = 20 years), applied for 2 weeks x 10 min./day did not generate significant improvements in the values of static and dynamic balance, according to (60).

Improving static and dynamic balance for people with flat foot, using a combination of SMT (sensorimotor training) and SFE (short foot exercises) is proposed by (61), which by applying this variant 6 weeks x 3 sessions / week finds the efficiency in optimizing the balance.

Higher values of balance for male college students in the US compared to women, both in the static assessment on a stable / firm surface and unstable / dynamic, with eyes open and closed, women having almost 48% more body balance (62). However, the small number of subjects (16) is a limiting factor in generalizing these results.

The limits of balance development exercises for children with severe deafness are highlighted by (63). An exercise program for static balance improved performance only for standing time on one leg, but the degree of body balance was not significantly affected.

A study made on college students showed that those with ADD / ADHD performed poorly on balance tests (by measuring the median-lateral balance of the torso), when the level of awareness is low, but the results are better if the level awareness is high, according to (64).

A way to improve balance for those who sit / siting postural balance about 10 hours a day is proposed by (65), which uses a Linear Actuator and MR Dampe. The device offers combined exercises, strengthening the back muscles too weak and relaxing the contracted one, regulating the muscular activity of the trunk between the dominant and the non-dominant part.

The analysis of values in Eurofit tests, including static balance (Flamingo test), in 7-12 year old students with visual impairment shows their scores are lower compared to subjects without this disability. However, those with SVI (severe visual impairment) have better balance scores than those with MVI (moderate visual impairment), one explanation being that peripheral vision is more important in maintaining balance than the quality of central vision, according to (66). Also in the Flamingo test, a similar study of young people in Kosovo and Montenegro (13-15) years showed similar values of the results between the sexes, according to (67).

The sports practiced influence the manifestation of balance. Comparison between the values of static and dynamic balance of football players vs. handball in Turkey (15-18 years old) does not identify significant differences, due to the similarity of agility movements / changes of direction in the 2 sports. However, for football, significant differences are reported between the dynamic right / left balance, due to the asymmetrical development of the muscular strength of the dominant leg, which in handball is not found, according to (68). A 6-week study of athletes in Iran (based on plyometric training, strength exercises, but especially mixed exercises) demonstrated the effectiveness of such a program in improving dynamic balance and reducing the chances of injury, according to (69). The investigation made by (70) on Turkish athletes (x = 13 years old) involved in various fields and events (karate, gymnastics, judo, table tennis, basketball, volleyball, handball, tennis) showed that the balance improves with age, and the increase in time spent for workouts optimize dynamic balance. Higher values of those who do individual sports are found for balance tests, but they are weaker in reaction times, where the better values belong to those who practice team sports.

Significant differences in the manifestation of static balance are reported between women dancers over 7 years seniority and non-dancers (18-23 years), both for the dominant leg and for the non-dominant leg. The non-dancer group loses their balance more easily, so dance therapy is effective in preventing falls and good postural control, according to (71). Dancer women have fewer anterior cruciate ligament injury rates compared to active but non-dancing ones. The dancers obtain superior performances in some balance tests, but for the Bass test the results of the 2 studied groups are similar (72).

However, balance tests are not useful for highlighting basketball playing ability. The comparison of the results between the categories of collegiate basketball players, novice basketball players and collegiate basketball players non starter does not indicate significant differences between the results of these groups for the Bass and Stork tests, according to (73). Other authors highlight the differences between manual and bimanual balance values by using Bosu balls, inflated to different pressure values, the reduced pressures negatively influencing the balance (74).

Healthy young people (x = 22.9 years) evaluated by FMS (Functional movement screen) and who have lower scores / profiles of movement, have a greater instability of balance on the antero-posterior direction, according to (75).

Impairing the dynamic balance for those with visual impairment generates an increased risk of falling. Stability training applied for 8 weeks to visually impaired children in Iran (8-14 years old) resulted in a significant improvement in the results of the Bass test, with high efficiency on walking safety, according to (76). The physical exercise with emphasis on static and dynamic balance is recommended for students with mental retardation in Iran (who have a lower level of fitness than the normal ones), in order to improve body posture. Progress is being made on static and dynamic balance on one leg, after applying a program for 8 weeks (77).

CONCLUSIONS

The results of the study at the level of the whole group and separated by gender demonstrate the applicability and efficiency of the proposed motor structures, to optimize the indices of static and dynamic balance, at the level of this age sample. Even if the differences between the initial and final tests are entirely significant (thus confirming the working hypothesis H1), these values must be viewed with caution, the low level of physical training and sedentary behavior of most students providing the premises for such progress, even with a weekly physical activity. It should be noted that the performance improvements are greater in the first part of the study (differences between initial and intermediate tests, with $p < 0.05$), compared to those in semester 2 (differences between intermediate and final tests), which can be explained by the adaptation to the planned and applied stimuli, so modifying or changing their dosage is necessary in order to have a better chance of improving the results. Working hypothesis 2 (H2) is confirmed for most tests of both genders ($p < 0.05$), with exceptions being the Walk and turn field sobriety test for boys (at the level of differences between intermediate and final testing) and the Fukuda test for both genders (for differences between initial and intermediate testing).

Regarding the comparison of the average values by gender, they demonstrate a relatively balanced distribution of performance, so we cannot say that girls have better results than boys or vice versa, in the whole set of tests. It is noticed that the girls have better scores in the tests: One leg standing, Flamingo, Functional reach and make fewer mistakes in the Walk and turn field sobriety test. The boys have a higher efficiency for the tests: Stork, Bass and Fukuda (where the values of the degrees regarding the body rotation are lower).

Limits of the study and future research directions

The investigation is not exhaustive; there are a number of statistically processed data, which could not be presented in this paper, due to the high volume of results obtained. It does not analyze the statistical differences between genders (independent samples), nor the influence of BMI levels (underweight, normal weight, overweight and obese) on the performance of balance tests, interesting aspects that deepen the investigation, but which will be presented in other publications. The study made by (78) emphasizes the importance of BMI values in sports (the distribution of basketball players in different positions / areas to optimize performance. One limitation of the study is the absence of laboratory tests, even if the entire set of field tests is internationally approved. Recent studies (79, 80) made on baropodometric platforms allow through the use of sensors, investigations of high accuracy of parameters that influence body balance, related to the projection of the center of pressure (CoP), weight distribution on each leg and plantar area, body oscillations in the frontal and sagittal planes, etc.

Declaration of conflict of interests-

There is no conflict of interest for the author regarding this paper.

Informed consent

The tested group received the information related to the study and its objectives, the research being carried out with the consent of all investigated subjects, respecting the rules of personal data protection.

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