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Optimization of body balance indices according to Body Mass Index categories during physical education lessons for university students

George D. Mocanu[1ABCDE], Gabriel Murariu[1ACE], Vladimir Potop[2,3ADE]

[1] *Faculty of Physical Education and Sport, "Dunarea de Jos" University of Galati, Romania*
[2] *University of Pitesti, Romania*
[3] *State University of Physical Education and Sport,* Moldova

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Abstract

Background and Study Aim Body stability is an important factor in the manifestation of human motor skills. The purpose of the research is to evaluate the efficiency of balance exercises, applied for 28 weeks, with a frequency of one activity / week, on a group of undergraduate students of the "Dunărea de Jos" University of Galați.

Material and Methods 195 subjects participated (99 males and 96 females), divided for analysis into 3 groups (underweight, N = 21, age = 20.16 ± .38, BMI = 17.46 ± .20); (normal weight, N = 111, age = 20.30 ± .21, BMI = 21.70 ± .17); (overweight / obese, N = 63, age = 19.90 ± .18, BMI = 30.69 ± .61). The tests were applied at 3 distinct times: initial T1 at the beginning of the academic year, intermediate T2 towards the end of semester 1 and final T3 at the end of semester 2. 3 static balance assessment tests were used (One leg standing test with closed eyes, Stork test and Flamingo test), respectively 4 tests to evaluate the dynamic balance (Bass test, Functional reach test, Walk and turn field sobriety test and Fukuda test).

Results ANOVA with repeated measurements and the differences between the test moments highlight in most cases values of F associated with significant thresholds ($p < 0.05$), so there is an improvement in results for all 3 groups. The differences between T1 and T2 tests are larger than those between T2 and T3, so for almost all tests the progress is higher in the first semester, and in semester 2 there is a slight reduction, as a result of adapting to the proposed exercises. Even if they progress significantly, the group of overweight people has obviously weaker average results than normal weight and underweight people, signaling numerous individual cases that have problems in maintaining static balance and commit errors in dynamic balance tests. The better performances of the underweight in 3 cases (One leg standing test, Flamingo test Fukuda test and Walk and turn field sobriety test) cannot be generalized due to their small number compared to the other 2 groups, and this aspect can be considered as a new direction of investigation.

Conclusions There are premises for a favorable evolution of the balance indices for the group tested in this age group, but it must be taken into account that the low initial fitness level (generated by the lack of concerns for a lifestyle based on physical activities) is a factor that facilitated these less spectacular advances, but still statistically significant.

Keywords: students, static and dynamic balance, assessment, BMI stages, physical activity

Introduction

The balance of the body is important in maintaining different positions and the correct execution of movements, and along with increasing postural muscle strength has a decisive role in the stability of the body of obese people, who have high risks of falling [1, 2, 3]. The sense of balance is fundamental in ensuring the technical correctness of the procedures in sports activities and reducing the risks of injury [4, 5, 6]. The importance of dynamic balance training for young athletes in Malaysia as a factor in injury prevention is highlighted by Lee et al. [7]. The use of balance assessment tests (as elements of the functional fitness battery) may signal possible postural control deficits, induced by the occurrence of muscle fatigue and affecting the efficiency of motor activities [8]. Poor balance values are often correlated with problems and risks of ligament and muscle injuries, requiring actions to improve coordination, which also has beneficial effects on the results of balance tests [9].

The optimal interaction between the vestibular, proprioceptive and visual systems conditions the performance associated with balance, which may be affected by aging [5, 10, 11, 12]. The values of the balance evaluated with the eyes open are higher than the ones evaluated with the eyes closed, aspect confirmed by the testing of the Polish ballerinas, at which better performances are signalled with increasing age, those aged 18 years old having higher results than puberty 14 years old [13]. Postural stability also depends on the information provided

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by the cervical proprioceptors, whose feedback improves the balance on the non-dominant leg of Taekwondo fighters, compared to untrained people [14]. Ways to optimize body stability for different age groups are frequently sought.

The introduction of additional actions with the additional demand for attention can affect the balance. Frequent use of mobile phones for Taiwanese students (texting while walking) affects dynamic balance performance and reduces postural stability, but it has been found that younger subjects can easily prevent falls and adapt more quickly to such tasks, according by Nurwulan et al. [15].

For children and adolescents (9-18 years) there is an improvement in postural balance with increasing age, for groups of athletes aged 9-12 years are found better values for girls, but this difference between genders is no longer reported for the group 13-18 years [16]. The use of hover-boards has beneficial effects on the static balance (One leg standing test and Stork test), respectively dynamic (Balance beam walking test) at the level of young Italian football players, being indicated the use of these devices also in other sports [17]. Playing handball as a recreational sport for postmenopausal women (49-79 years old) facilitates the improvement of postural balance and bone health, reducing the risk of falls and injuries for this category of population [18].

The comparison of performances between athletes (football players) and groups of sedentary students of the same age confirms the significantly better values of athletes, so the involvement in physical activities improves balance [19]. The associations between balance issues and the low level of fitness of African children is highlighted by Verbecque et al. [20]. The authors indicate that there is a high chance of impaired balance with increasing BMI values, so the preventive role of physical activity in maintaining and reducing body weight is vital. The decrease in leg muscle strength and antero-posterior balance performance for pubertal children (overweight and obese classes) is highlighted by Alhusaini et al. [21]. The application of the Bruininks-Oseretsky test battery on young people (10-21 years old) highlighted the difficulties related to balance for the overweight, compared to the normal-weight one [22]. For adults, there are difficulties in maintaining balance for the inactive and obese, so physical activity has the role of improving these problems [2, 3, 23]. For the obese, a greater balance is identified compared to the normal weight, and the reduction of body weight in these cases (through physical exercise) is a solution that ensures an improvement of the postural control [24]. The idea is supported by another study, where increasing muscle strength for obese people does not necessarily bring an improvement in balance, the weight loss being more important [25].

A comparison between obese young Japanese girls (9 years old) and adult men showed poor results of girls in static and dynamic balance tests, with high chances of injury and reduced control of movements during motor activities [26]. In obese and overweight young adults, poor results are confirmed in dynamic balance tests, with obvious mid-lateral displacement of the center of gravity, major risks of falling and higher time required for performing various motor tasks, aspects to which are added postural problems at the level of the spine [27].

Purpose of the Study. The study purpose was to evaluate the efficiency of balance exercises, applied for 28 weeks, with a frequency of one activity / week, on a group of undergraduate students of the "Dunărea de Jos" University of Galați, divided into 3 BMI categories (underweight, normal weight and overweight).

Materials and Methods

Participants.

The studied group consists of 195 students from "Dunărea de Jos" University of Galați (99 males and 96 females included in the undergraduate study programs of years 1 and 2 of the Faculty of Automation, Computers, Electrical and Electronic Engineering, respectively Medicine and Pharmacy), made up by random selection to ensure numerical balance by gender and divided for data analysis into 3 categories: underweight (N = 21, age = 20.16 ± .38, BMI = 17.46 ± .20), normal weight (N = 111, age = 20.30 ± .21, BMI = 21.70 ± .17), overweight / obese (N = 63, age = 19.90 ± .18, BMI = 30.69 ± .61). Participants do not have constant concerns about performance physical activities, so the influence of this factor on results cannot be taken into account. The study group was informed about the duration, purpose and balance tests applied, ensuring the confidentiality and protection of personal data, in accordance with the Helsinki Declaration [28, 29].

Research Design.

The research took place at the level of the Research Center for Human Performance within the Faculty of Physical Education and Sports in Galați (Romania), respecting the design of longitudinal investigations. The applied tests evaluate the dynamics of static balance indicators (One leg standing test with eyes closed / s, Stork test / s, Flamingo test / number of falls), respectively the evolution of performance at dynamic balance (Bass test / points, Functional reach test / cm, Walk and turn field sobriety test / errors and Fukuda test / degrees of rotation), the application and quantification of the results being exemplified by Walden, Zhang et al. [30, 31, 32, 33]. The batch testing was performed during the academic year 2018-2019, in 3 distinct stages (T1-initial testing, at the beginning of the academic year; T2-intermediate testing, in the 12th week

/ December, before the winter holidays; T3-final testing, at the end of the academic year). Students who were absent from physical education lessons were not included in the statistical calculation, in order to highlight the efficiency of the motor structures proposed for the development of balance. Participants were advised not to engage in stress-based efforts prior to testing, so that muscle and nerve fatigue does not affect the value of the results.

Training program. The exercise program was implemented over a period of 28 weeks, with a frequency of one activity per week, the structures oriented towards the development of balance being explained and practiced for 15-25 minutes in each lesson, with variable and individualized dosage, according to the effort potential of each participant. Table 1 selectively presents proposed exercises to optimize the level of static and dynamic balance, with the mention that they have been alternated and changed during the activities, in order to avoid capping the results, by adapting the participants to the proposed stimuli.

Statistical Analysis.

The statistical calculation was based on the use of Anova parametric techniques with repeated measurements, separately for each subgroup analyzed (underweight, normal weight and overweight / obese). We preferred to include the overweight and obese in a single category, in order to simplify the statistical analysis and reduce the resulting data volume. Data on: Maucly's Test of Sphericity were synthesized, with the application of the Greenhouse-Geisser correction factors (for $\varepsilon < 0.75$) and Huynh-Feldt (for $\varepsilon > 0.75$) when the sphericity could not be assumed, the values of F and associated significance thresholds (sig.), size effect expressed by Partial eta squared ($\eta^2 p$), the differences between the average values between the test moments and their significance, using the Bonferroni correction factor [34, 35]. The confidence interval was set at 5% ($p < 0.05$), according by Murariu, Opariuc [36, 37, 38].

Table 1. Selection from the variants proposed and applied for the development of balance

Motor structures proposed for the development of static balance
• From standing, lunging by making a step back with your palms on your hips and holding the position with your arms up. • From sitting with the palms on the hips, raising the right knee and thigh parallel to the ground, maintaining the position for 5-30 seconds, then the action is repeated for the left leg. Same with lifting a leg outstretched forward / sagittal plane, with the heel at a distance of 10-30 cm above the ground. • From standing on one leg, throwing a tennis ball vertically and holding the arm on the side of the support leg. The same goes for holding the raised leg with the arm. Same with throwing the ball from one hand to the other. • Maintaining balance by flexing and extending the knees from sitting on the platform or balance ball / bosu balance trainer. • From standing on one leg, bending the torso forward and touching the tip of the supporting leg with the opposite arm, the free leg is bent / flexed from the knee and oriented / lifted back. • From standing on one leg, slight half-flexion with return and arms outstretched sideways, vertically or in other planes. • From standing facing the wall, lifting on tiptoes with a slight bend of the torso forward to the limit of imbalance, then balancing by pushing with the palms towards the wall.
Motor structures proposed for the development of dynamic balance
• Moving on various hardness surfaces (soft, semi-hard or hard mattresses), jumping from one foot to the other while maintaining balance. • Successive jumps on one leg, over a drawn line or a cord stretched on the ground, maintaining the position 2-3 sec before the next jump. On return, the detachment leg changes. The same with alternate jumps, from one foot to the other. • From standing sideways to a column of 5-6 bottles, spaced 50 cm apart, jump on one leg next to each bottle, maintaining balance and placing a glass on it. The same with zigzag / snake jumps between bottles. The same jumping back to each bottle. • Running bypassing milestones at 360^0 alternating the direction of rotation: left / right. • Walking on the narrow side of the gym bench with variable speed, with jumps over various objects and turning at 90, 180. 360^0. The same by moving backwards on the gym bench. • Jumps on one leg or from one leg on the other, on different signs / markings drawn on the ground, maintaining the unipodal balance for 1-5 sec. The same with jumps on one leg, in circles arranged under different variants / arrangements on the ground.

Results

The values of the Anova parametric test with repeated measurements (table 2) indicate significant progress at the level of the 3 groups for most tests (F values correspond to thresholds p <.05), except for the group of underweight in Walk and turn field sobriety test, where p = .329, statistically insignificant value. Partial eta squared scores indicate a strong influence of the applied balance exercise program on the results, with the highest values for all 3 groups in the Bass test and Functional reach test (for underweight, in the Bass test, 81.5% of the variance is explained by the intervention of the proposed program, and for overweight, at the Functional reach test, 81% of the variance is attributed as an effect of the applied program). It should be noted that for the rest of the tests, at the level of the group of normal weight, stronger influences of the program are registered (through the values of ($\eta^2 p$) than at the level of the groups of underweight and overweight. The weakest effects of balance exercises are found in the Walk and turn field sobriety test and Fukuda test for underweight and normal weight, but with strong effects on overweight.

Comparison and analysis of average differences in pairs at the level of the underweight (Table 3) indicates in most cases significant progress (p <.05), except for the Walk and turn field sobriety test (where errors are missing in the intermediate and final tests), respectively in the Fukuda test (where no significant progress is found between intermediate and final testing). With the exception of One leg standing test, where slightly higher progresses are found between intermediate and final tests, for the other data pairs there are larger differences between initial and intermediate tests compared to those between intermediate and final tests, which confirms the higher progress in the first stage of preparation / semester 1, the adaptation to the stimuli / exercises in the program generating a lower improvement of the results in semester 2.

The situation is similar for the group of normal weight (table 4) with larger differences for the first semester of preparation and smaller for the second, but significant for most data pairs. In the case of the Walk and turn field sobriety test, only for the initial test-final test pair there is significant progress (so at

Table 2. ANOVA results with repeated measurements on BMI steps (1 = underweight, 2 = normal weight, 3 = overweight)

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	1	0.000	0.595	Greenhouse-Geisser	1.191	23.811	22.371	0.000	0.528
	2	0.000	0.656	Greenhouse-Geisser	1.312	144.367	173.947	0.000	0.613
	3	0.000	0.658	Greenhouse-Geisser	1.317	81.630	35.441	0.000	0.364
Stork	1	0.000	0.532	Greenhouse-Geisser	1.063	21.266	19.095	0.000	0.488
	2	0.000	0.734	Greenhouse-Geisser	1.469	161.587	229.964	0.000	0.676
	3	0.000	0.688	Greenhouse-Geisser	1.376	85.289	86.992	0.000	0.584
Flamingo	1	0.000	0.633	Greenhouse-Geisser	1.267	17.683	13.178	0.001	0.397
	2	0.000	0.742	Greenhouse-Geisser	1.485	163.345	137.359	0.000	0.555
	3	0.000	0.769	Huynh-Feldt	1.538	95.363	57.571	0.000	0.481
Bass	1	0.005	0.702	Greenhouse-Geisser	1.403	28.063	88.068	0.000	0.815
	2	0.002	0.919	Huynh-Feldt	1.809	198.952	410.853	0.000	0.789
	3	0.000	0.779	Huynh-Feldt	1.558	96.586	193.259	0.000	0.757
Functional reach	1	0.001	0.669	Greenhouse-Geisser	1.337	26.740	45.000	0.000	0.692
	2	0.000	0.719	Greenhouse-Geisser	1.438	158.150	213.035	0.000	0.659
	3	0.051	0.941	Sphericity Assumed	2	124	264.773	0.000	0.810
Walk and turn	1	-	0.500	Greenhouse-Geisser	1.000	20.000	1.000	0.329	0.048
	2	0.000	0.797	Huynh-Feldt	1.576	173.349	6.424	0.004	0.055
	3	0.035	0.932	Huynh-Feldt	1.863	115.529	33.036	0.000	0.348
Fukuda	1	0.768	1.000	Sphericity Assumed	2	40	8.138	0.001	0.289
	2	0.000	0.536	Greenhouse-Geisser	1.072	117.948	5.201	0.022	0.045
	3	0.000	0.836	Huynh-Feldt	1.671	103.633	29.853	0.000	0.325

Table 3. The results for differences of underweight average values (N=21)

Test	Mean	Std. deviation	Std. error	T1-T2	Sig.b	T1-T3	Sig.b	T2-T3	Sig.b
One leg standing T1	11.013	9.912	2.163						
One leg standing T2	11.275	9.954	2.172	-0.262*	0.001	-0.544*	0.000	-0.282*	0.001
One leg standing T3	11.556	9.936	2.168						
Stork T1	3.957	4.335	0.946						
Stork T2	4.140	4.345	0.948	-0.183*	0.004	-0.257*	0.000	-0.073*	0.000
Stork T3	4.213	4.347	0.949						
Flamingo T1	5.095	4.288	0.936						
Flamingo T2	4.476	3.855	0.841	0.619*	0.006	1.048*	0.003	0.429*	0.026
Flamingo T3	4.047	3.556	0.776						
Bass T1	61.952	13.573	2.962						
Bass T2	64.095	14.390	3.140	-2.143*	0.000	-4.048*	0.000	-1.905*	0.000
Bass T3	66.000	14.679	3.203						
Functional reach T1	40.142	4.980	1.087						
Functional reach T2	41.214	4.779	1.043	-1.071*	0.000	-1.714*	0.000	-0.643*	0.000
Functional reach T3	41.857	4.855	1.060						
Walk and turn T1	0.004	0.218	0.048						
Walk and turn T2	0.000	0.000	0.000	0.048	0.988	0.048	0.988	0.000	-
Walk and turn T3	0.000	0.000	0.000						
Fukuda T1	18.476	21.864	4.771						
Fukuda T2	17.571	22.048	4.811	0.905*	0.018	1.286*	0.001	0.381	0.225
Fukuda T3	17.190	21.671	4.729						

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

the level of the entire study stage / academic year), but without significant accumulations per semester (p> 0.05). A particular situation is encountered at the Fukuda test level, where there is a slight decrease in performance for intermediate testing (several degrees of rotation), but without the difference between the initial and intermediate testing being significant. The situation is remedied by the better performance from the final testing, which generates significant progress between the level of semester 2 and the entire stage of implementation of the proposed program (p <0.05).

The overweight group made significant progress on almost all data pairs associated with the tests (Table 5), with the exception of the Walk and turn field sobriety test, between intermediate and final testing. For One leg standing test and Stork test, however, greater progress is found for semester 2, so adapting overweight and improving performance in these 2 tests are slower, but this is not confirmed for other situations, where the biggest differences are still between initial and intermediate tests. For the Fukuda test, the average performance is poor (around 30 degrees), which is the threshold for the manifestation of vestibular disorders on the side of body rotation.

Graph 1 shows the average performance values of the 3 batches at the final tests. Overweight people have the weakest results in tests to assess static and dynamic balance, but their progress (statistically confirmed) does not allow the approach to the values of normal weight and underweight. They have the shortest holding times at static balance, the lowest score on the Bass test, they make the most errors on the Flamingo test and the Walk and turn field sobriety test, and they have the highest rotation scores around the body axis on the Fukuda test. It is interesting that the underweight group has results close in value to that of the normal weight in most tests and even slightly better than them in One leg standing test, Flamingo Fukuda test and Walk and turn field sobriety test, which requires checks by studies on larger groups in this category, in order to generalize these results.

Discussion

Our study identifies the effectiveness of the diversified exercises proposed to optimize the level of balance, an aspect confirmed by other similar research.

Applying core training on unstable surfaces for 18–25-year-olds in Turkey generates gender

Table 4. The results for differences of normal weight average values (N=111)

Test	Mean	Std. deviation	Std. error	T1-T2	Sig.b	T1-T3	Sig.b	T2-T3	Sig.b
One leg standing T1	6.320	6.098	0.579						
One leg standing T2	6.480	6.106	0.580	-0.160*	0.000	-0.291*	0.000	-0.131*	0.000
One leg standing T3	6.610	6.135	0.582						
Stork T1	4.298	3.855	0.366						
Stork T2	4.419	3.837	0.364	-0.121*	0.000	-0.200*	0.000	-0.079*	0.000
Stork T3	4.498	3.838	0.364						
Flamingo T1	6.378	3.482	0.331						
Flamingo T2	5.603	3.151	0.299	0.775*	0.000	1.279*	0.000	0.505*	0.000
Flamingo T3	5.099	2.954	0.280						
Bass T1	69.360	12.137	1.152						
Bass T2	71.549	12.380	1.175	-2.189*	0.000	-4.279*	0.000	-2.090*	0.000
Bass T3	73.639	12.584	1.194						
Functional reach T1	40.076	6.035	0.573						
Functional reach T2	41.247	5.785	0.549	-1.171*	0.000	-1.874*	0.000	-0.703*	0.000
Functional reach T3	41.9505	5.630	0.534						
Walk and turn T1	0.234	0.485	0.046						
Walk and turn T2	0.189	0.457	0.043	0.045	0.074	0.072*	0.013	0.027	.250
Walk and turn T3	0.162	0.437	0.042						
Fukuda T1	20.891	24.770	2.351						
Fukuda T2	21.477	26.628	2.527	-0.586	1.000	1.964*	0.000	2.550*	0.040
Fukuda T3	18.927	23.760	2.255						

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

differences for dynamic balance (Y test), but not for the rest of the fitness components [39]. In order to reduce the risk of injury, for American football players are recommended exercises for vestibular, proprioceptive, neuromuscular, with eyes closed and open, respectively on various surfaces - stable and unstable [40]. The use of unstable surfaces improves the values of dynamic balance and reduces the static postural balance for 7-year-old gymnasts [41]. Exercises performed on stable ground are less effective than the variant of unstable surfaces, for women of the 3rd age (60-80 years), by applying a program of this type (12 weeks, with 2 workouts of 45 min./week and 25 minutes oriented to equilibrium structures) progress is achieved, according by Matla et al. [42]. Our program also included this kind of exercises, and the significant progress at the level of the 3 categories confirms their viability.

The variants proposed by specialized studies for balance optimization are extremely varied. An improvement of the results by applying a Tabata training program (for young football players / ages = 23 years) is obtained for the Flamingo test, but without statistical significance, according by Ceylan et al. [43]. Other research highlights the role of various physical activity programs (combat sports, pilates) on increasing balance values and reducing the risk of falls in different categories of the population [2, 3, 6, 44, 45]. The type of sport practiced influences the values of balance. Higher values in the balance tests of young Turkish athletes who are involved in individual sports (karate, gymnastics, judo, table tennis) compared to those involved in team games (basketball, volleyball, handball), as well as the increase the performance of the dynamic balance as age increases are identified by Turkeri et al. [46]. A program of balance exercises applied to children (10-12 years), for 8 weeks x 3 sessions per week generated superior performance in the Flamingo test, but also the speed and agility tests [47]. For teenagers in Kosovo, in the Flamingo test, girls perform better only for the 14-15 years old age group, then boys get superior performance [48]. Balanced values between Montenegrin and Kosovo teenagers in the Flamingo test are obtained by Morina et al. [49]. Long-term application of fitness programs (3 years x 3 sessions / week x 90 min) and their combination with diet positively influences the performance of fitness tests, including the Flamingo test, for boys aged 8-11 years [50]. We obtained in this test the best results for underweight, followed by normal weight, overweight having the lowest performances.

Table 5. The results for differences of overweight average values (N=63)

Test	Mean	Std. deviation	Std. error	T1-T2	Sig.b	T1-T3	Sig.b	T2-T3	Sig.b
One leg standing T1	4.959	2.907	0.366						
One leg standing T2	5.116	2.935	0.370	-0.157*	0.000	-0.353*	0.000	-0.196*	0.000
One leg standing T3	5.312	2.990	0.377						
Stork T1	2.695	1.220	0.154						
Stork T2	2.777	1.256	0.158	-0.082*	0.000	-0.177*	0.000	-0.094*	0.000
Stork T3	2.871	1.245	0.157						
Flamingo T1	10.571	4.599	0.579						
Flamingo T2	10.047	4.681	0.590	0.524*	0.000	0.905*	0.000	0.381*	0.000
Flamingo T3	9.666	4.700	0.592						
Bass T1	58.523	13.023	1.641						
Bass T2	60.571	12.630	1.591	-2.048*	0.000	-3.714*	0.000	-1.667*	0.000
Bass T3	62.238	12.708	1.601						
Functional reach T1	38.941	8.292	1.045						
Functional reach T2	40.238	8.129	1.024	-1.297*	0.000	-2.107*	0.000	-0.810*	0.000
Functional reach T3	41.047	7.778	0.980						
Walk and turn T1	1.000	0.879	0.111						
Walk and turn T2	0.619	0.658	0.083	0.381*	0.000	0.429*	0.000	0.048	0.964
Walk and turn T3	0.571	0.734	0.093						
Fukuda T1	31.952	30.571	3.852						
Fukuda T2	31.000	30.526	3.846	0.952*	0.000	1.714*	0.000	0.762*	0.000
Fukuda T3	30.238	29.899	3.767						

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

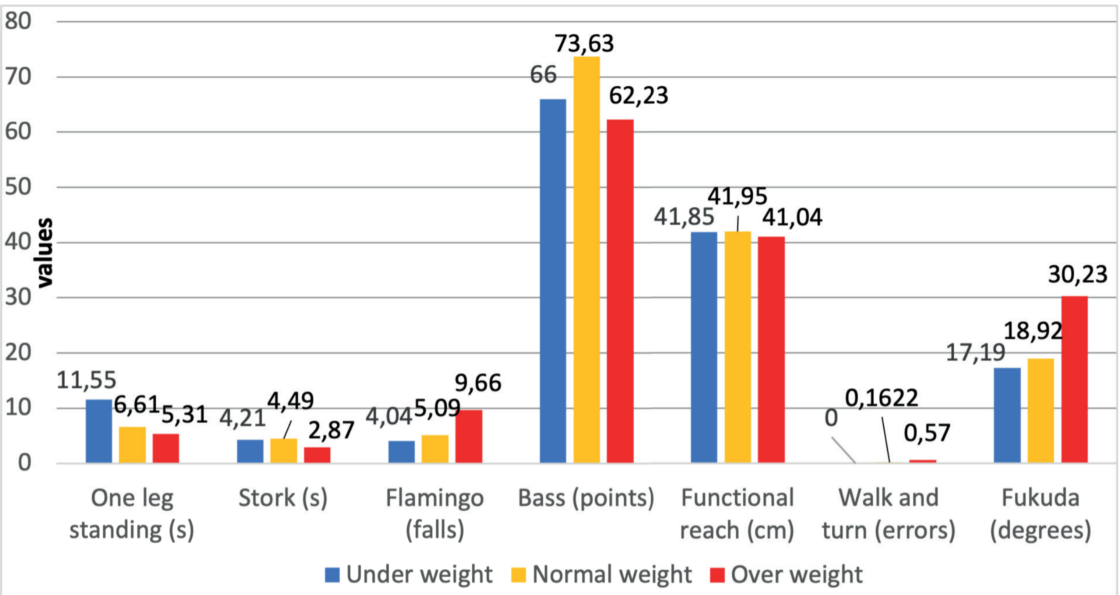

Figure 1. Presentation of the average values of the performances of the 3 lots at the final tests

A decrease in performance in balance tests is reported after the age of 50, and for the interval 20-49 years similar results are recorded, overweight women obtaining lower scores than normal weight [51]. The differences between obese and normal weight for One leg standing test and dynamic balance assessment tests are also reported among Chinese children aged 8-10 years [52]. Young obese people (21.7 years) have the poorest results in bipodal and unipodal balance tests, compared to normal weight and underweight, according by Ku et al. [53], aspect similar to our research. Young people (ages = 21 years) with concerns related to physical activities (moderate to vigorous intensity) have a lower balance area and implicitly a better balance, with higher values for testing with eyes open [54].

Comparisons between static balance values between female dancers with at least 7 years of activity and sedentary ones (18-23 years) indicate higher balance values for dancers and superior postural control [55]. An exercise program applied 5 weeks, to influence the dynamic balance in elderly and overweight women is proposed by Bellafiore et al. [56]. In this case, performance improvements are obtained for most of the people involved, as a result of the efficiency of the muscular structures and the visual system, which ensures the postural balance. The use of DCE / dynamic core exercise in the warm-up part of physical education lessons for children at the beginning of puberty (10-11 years), for 6 weeks has favorable effects on balance and flexibility [57]. Other authors propose exercises with elastic cord at the level of elite gymnasts' girls (14 years), through an applied program 12 weeks x 18 hours per week + 2 hours dedicated to exercises with elastic cord, which generate favorable effects on body balance [58]. There are also researches that demonstrate the effectiveness of applying oriental techniques (Yoga asanas) for obese young people (21-25 years), for a period of 4 weeks x 3 sessions per week x 45 min / session. Significant improvements are found in the Functional reach test and One leg standing balance test [59]. Our study confirms the effectiveness of programs based on balance exercises for the age category investigated, even if it was applied with a frequency of one session / week, being in accordance with the other research previously analyzed, through the beneficial effects found.

Conclusions

The application of balance exercises generates performance optimization in the tests applied to all groups investigated, so they are prerequisites for increasing body stability in static and dynamic actions for university students. The progress made is not spectacular, but the fact that they are statistically significant is still a positive aspect. It should be noted that for most tests there is more progress between the initial and intermediate tests, and slightly less between the intermediate and final tests, as a result of a possible adaptation to the exercises proposed in the second part of the program implementation. Even if the group of overweight progresses significantly, its results are weaker than those of normal weight and underweight; this category having the biggest problems in maintaining the body in different positions, but commits most errors and has poor scores in dynamic balance tests. The fact that underweight people get results close to those of normal weight and for 3 even better tests (One leg standing test, Flamingo test Fukuda test and Walk and turn field sobriety test) must be interpreted with some reservations, their weight / representation in the study group requiring the repetition of the research on a much larger sample at the level of underweight. Favorable results can also be explained by the low initial fitness level of the group (without concerns about sports activities), which facilitated the progress made.

The limits of the study and new research directions. The high volume of data did not allow the presentation of differences in gender and between gender tests, or the analysis of the significance of differences between BMI classes / (independent samples), which are the subject of another scientific paper. It would be interesting to analyze the results of the battery of tests for students of the Faculty of Physical Education and Sports and whether reading the practical contents of the curricula generates significant improvements in performance related to balance (these data are already collected and will be statistically processed). The use of modern equipment and technologies (which investigate static and dynamic balance using sensors and baropodometric platforms) would facilitate a more nuanced investigation of the mechanisms that condition body stability and identify factors that reduce the value of performance in balance tests.

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Conflict of interest

No potential conflict of interest that is of any relevance to this study was reported by the authors.

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Information about the authors:

George D. Mocanu; https://orcid.org/0000-0002-3534-5055; george.mocanu@ugal.ro; Faculty of Physical Education and Sport, "Dunarea de Jos" University of Galati; Galati, Romania.

Gabriel Murariu; https://orcid.org/0000-0002-7107-2007; gabriel.murariu@ugal.ro; Faculty of Sciences and Environment, "Dunarea de Jos" University of Galati; Galati, Romania.

Vladimir Potop; (Corresponding Author); https://orcid.org/0000-0001-8571-2469; vladimir_potop@yahoo.com; University of Pitesti, Pitesti, Romania; State University of Physical Education and Sport, Chisinau, Moldova.

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