

Balance coordination: An important ability for young gymnasts

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Abstract:

Background: Training in artistic gymnastics is a conscious and systematic process involving training loads, designed to develop various components such as movement skills, technical and tactical abilities, health and psychological, aspects. During the stages of sports training, the primary focus is on enhancing execution ability. Execution refers to the unity between the movement and its outcome, encompassing one or more motor actions performed within a specific timeframe, measurable through defined evaluation procedures. Balance defined as the ability to maintain postural control or equilibrium by managing the body's center of gravity within its base of support during any that involves shifting the center of gravity through muscular activity. **Methods:** In this study, were analyzed to balance test, eight young male gymnasts of Albanian national team, who are participants in gymnastics competitions at national level and 5 of them at international level. Measurements were made with same methodology in both periods. The tests were carried out in laboratory of Sports Scientific Research Center at Tirana Sports University. All the data obtained from performed tests were subjected to statistical processing, presenting average, standard deviation, variance, probability. Average (X) and coefficient of variance (CV) are calculated by ANOVA method according to general formula: = AVERAGE (Date). Standard deviation (SD) and probability (P) are calculated with EXEL 2019 method, with the general formula of EXEL = STDEV (Data). Significance was set to $p < 0.001$ level. **Results:** In balance test B.T. for 10 seconds with eyes closed, four important parameters were measured in two test periods. Std. Ellipse Area cm² surface that describes P.C. during test, rel. Pathlength.mm/s, displacement speed P.C., abs. Pathlength.mm, length of path that describes P.C., EQ (AP) % balance result (equilibrium). **Conclusions:** Measuring balance gives us valuable information in programming muscle work. In artistic gymnastics, many element require this skill. For this reason, coach prioritizes this component during training. To our subjects conclude average level of balance.

Key Words: artistic gymnastic, performance, motor skill, education component, male, training

Introduction

Gymnastics is a popular sport that requires strength, flexibility and personal growth benefits for athletes. Both static and dynamic balance are developed from a young age and are essential for top-level gymnastics (Isla, S., et al., 2022) (Atikovic & Čuk, 2017).

Training in artistic gymnastics is a multi-year systematic activity that grows progressively and individually. Physiological and psychological functions are modeled in such a way that they complete the tasks imposed by competitions. The commitment to achieve higher results requires advanced physical condition, in a word, a harmonious combination of physical, technical, tactical preparation with humanistic spiritual education, fair play. Taking training as a product of relationship between physical exercises and adaptation, it is clearly defined as: "the total sum of all adaptive physiological, anatomical and psychological reactions of organism to loads of training program" (Arkaev & Suchilin, 2009) (Meta, A., 2019).

Training in artistic gymnastics is a conscious and systematic process that is carried out through training loads, which affect, according to the purpose, moving components, technical, tactical, health, psychological, etc. During stages of sports training, this effect focuses on improvement of execution ability. Execution means unity between it and result, of one or more moving actions, work performed in a certain time that is expressed with a controllable result, through defined evaluation procedures (Barreto, P., et al., 2016) (Vieru, 1997).

Basic problems of training gymnast in education of movement habits are basis of high result in artistic gymnastics. High results of sports training in artistic gymnastics are achieved if there is a realistic plan that can be implemented by gymnast and is persistently requested by trainer (Böning, D., et al., 2017) (Jemni, 2018).

Equilibrium is a characteristic of quality of a system, as a special coordination ability. While it may be claimed that there is no absolute balance, any position or movement is a constant process of creating balance through corrective movements. That is why we do not consider these movements disturbing. However, tendency is to minimize these corrective movements. Through these movements we are able to eliminate range and transfer of disturbing movements to different parts of body, especially center of gravity. Therefore, a quick reaction to stimulus that informs brain about disturbance of balance is necessary (Potop, 2014).

Balance is described as ability to maintain postural control or equilibrium by controlling body's center of gravity within its base of support during any skill in which movement of one's center of gravity occurs due to muscular activity (Di Stefano, et al., 2009) (Sands, 2017). From physiological point of view, balancing consists of a number of phases: The first phase is a detection of a specific situation via sensory systems. When maintaining an upright position, a man uses a combination of information from vestibular apparatus, visual and proprioceptive information. The function of vestibular apparatus may be limited by an uncommon head position. Simultaneously, there is a direct relation between the functional status of vestibular apparatus and a quality of formation of some movement routines (Mkaouer, B., et al., 2018). The development of coordination abilities in young gymnasts has its own characteristics (MonfortTorres et al., 2024). At this age, children are predominantly playful, so learning occurs through games, game exercises and relay races. Children of this age quickly get tired of monotonous exercises, so it is necessary to alternate different types of activities: physical exercises, outdoor games, dances. In general, the development of coordination abilities in gymnasts of years should be gradual and systematic, which will allow achieving good results in the future (Dveyrina et al., 2024).

In young athletes, motor acrobatic skills should be developed alongside coordination and functional abilities (Rudd et al., 2017). This combination ensures the achievement of high sports results in gymnastics. At the initial stage of gymnastics training, it is crucial to focus on teaching athletes the technique of the entire exercise rather than just individual components (Biino et al., 2023). Various authors have different opinions on how much the different components vestibular, visual and proprioceptive contribute to balancing.

Dabbs N. et al., (2017) and Potop V. et al., (2013), based on an experiment, came to a conclusion that proprioceptive organs play most important role in maintaining a stable position.

Kabak, B., et al., (2019) and others think that most important component is vestibular system. Sometimes, a certain sense conflict may appear when an important part is ability to choose which information acquired by visual, somatosensory and vestibular systems are reliable and which are not (Wrisley & Whitney, 2004).

Postural control is thus a very complicated process with several phases. Postural control, whether in dynamic or static conditions, is dependent on body being able to react to sensory, inner and outer perturbations. During a balancing process it is important to observe the time characteristics of individual phases. When passing through individual phases there always is a certain time delay depending on structural and functional status of the system. The quality of visual system, mainly visual acuity and stereoscopic vision, in other words the depth of vision may influence the quality of performance of a balancing element (Kothari, A., et al., 2015).

In their works several authors have already dealt with question of the third phase of balancing process. They were investigating a relationship between balancing ability and amount of muscle strength of a corresponding muscle group into which an impulse from CNS is delivered in order to maintain the balance position of body. Most previous studies focused on analysis of influence of muscle strength on static and dynamic balance in people with a significant increase in muscle flaccidity (Heitkamp, C., et al., 2001) (Ricotti, L., 2011).

When analyzing balance positions it is necessary to take into consideration that human body is not a compact matter but a set of connected items from which every deviation results in change of position of center of gravity. In many works, mainly those focusing on mechanics authors state that static balance is equal to a stable position. But as Dabbs, N., et al., (2017) note, there is no absolute balance in human activity because human body constantly passes through certain changes in position. Every position or movement is a continuous process of recreating a balanced position using correcting movements.

Purpose of study

Efficacy, implementation, and evaluation of a training protocol in improving balance in young male gymnasts using a standardized laboratory test.

Material & methods

In this study, were analyzed to balance test, eight young male gymnasts of Albanian national team, who are participants in gymnastics competitions at national level and five of them at international level. Tests with male gymnasts were carried out in period beginning December 2024 (first measurement) - March 2025 (second measurement). Measurements were made with same methodology in both periods. Tests were carried out in laboratory of Sports Scientific Research Center at Tirana Sports University.

Used equipment

- Leonardo Mechanography (GRFP)

To measure important indicators that are presented in its manual, certified Leonardo Mechanography (GRFP) apparatus was used, which is a platform connected to computer that also measures balance of legs in various tests. Specific data for performed test were obtained from this apparatus (Fig. 1).

- Computer



Figure 1. Leonardo Mechanography (GRFP)

Balance Test / Stability

Subjects try to stay as still as possible for a defined time interval (10 seconds). Standing on one leg, eyes closed (1L_EC). Position of one foot resting on ground, other raised back up, and eyes closed are chosen to increase difficulty.

Type Balance Test & Coordination (Platform manual).

In figure 2, balance test is presented:

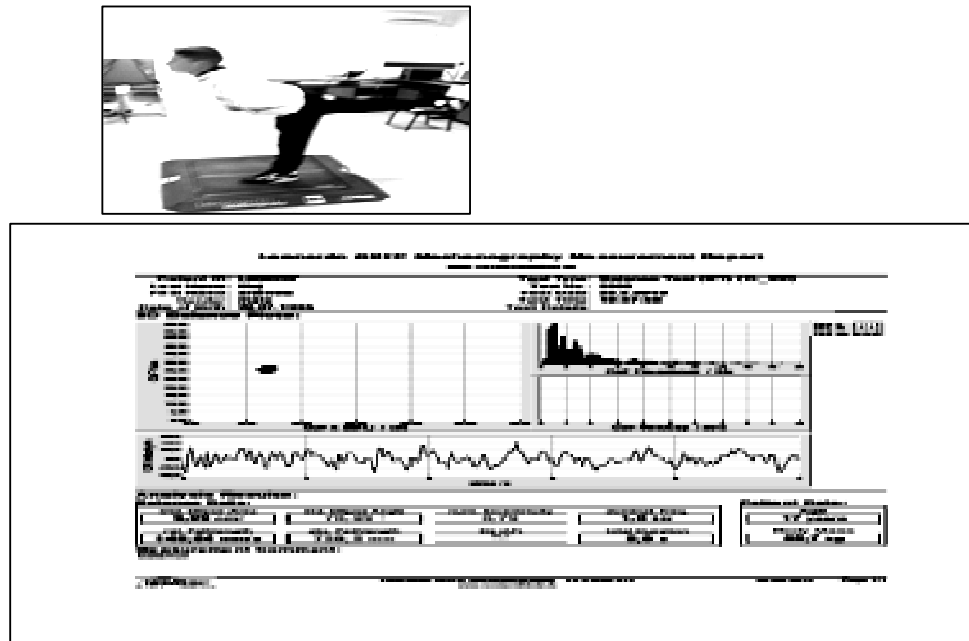


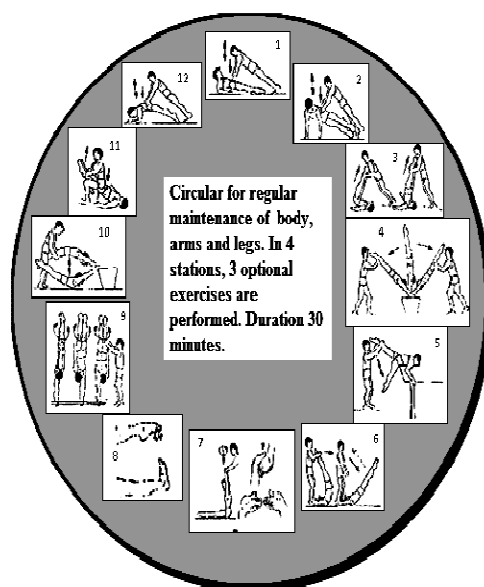
Figure 2. Balance test

In balance test measured:

- Std. Ellipse Area* cm^2 - surface described by the center of pressure during the test,
- rel. Pathlength* mm/s - speed of displacement of the center of pressure,
- abs. Pathlength* mm - length of path described by center of pressure during test,
- EQ (AP)* % - balance result

Exercises physical preparation

Studies presents that gymnasts who regularly train in strength exercises show significant improvement balance compared to those who engage less (Cretu & Mihăilă, 2012). During training six times a week, physical preparation program was carried out in preparatory part or at end of basic part of training for twelve weeks. Development methodology of physical qualities to gymnasts according week days: Monday - Thursday circle 1, Tuesday - Friday circuit 2, Wednesday - Saturday circuit 3. In figures 3, general and specific exercise models are given in circular form for strength ability, in specific muscles of body (A, G, F., a. g., 2020).

**Circle 1.**

Regardless of order in figure, our practice with gymnasts taken in study, we grouped exercises into 4 stations, as follows:

At station 1:- Exercises 1, 2 and 12

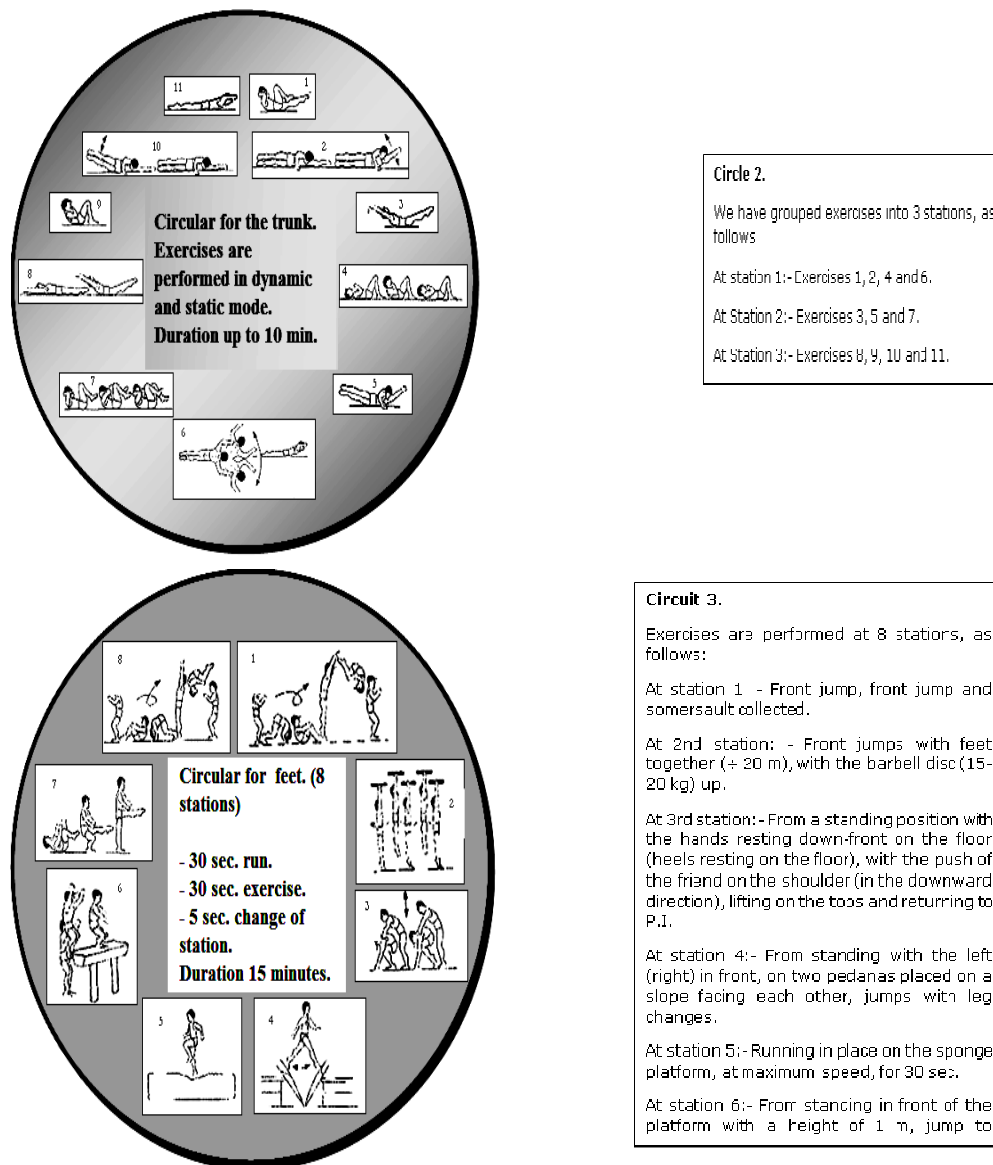


Figure 3. Exercise patterns in circular form

Statistical method

Through method of statistical processing, we systematized and reflected progressive results of study, as concrete and argumentative material. All the data obtained from performed tests were subjected to statistical processing, presenting average, standard deviation, variance, probability. Average (X) and coefficient of variance (CV) are calculated by ANOVA method according to general formula: = AVERAGE (Data). Standard deviation (SD) and probability (P) are calculated with EXEL 2019 method, with the general formula of EXEL = STDEV (Data). In Excel 2019, "Data Analysis" package was used to perform statistical analysis. The "Data Analysis" package is an additional Microsoft package, which was activated by t user when we needed statistical analysis.

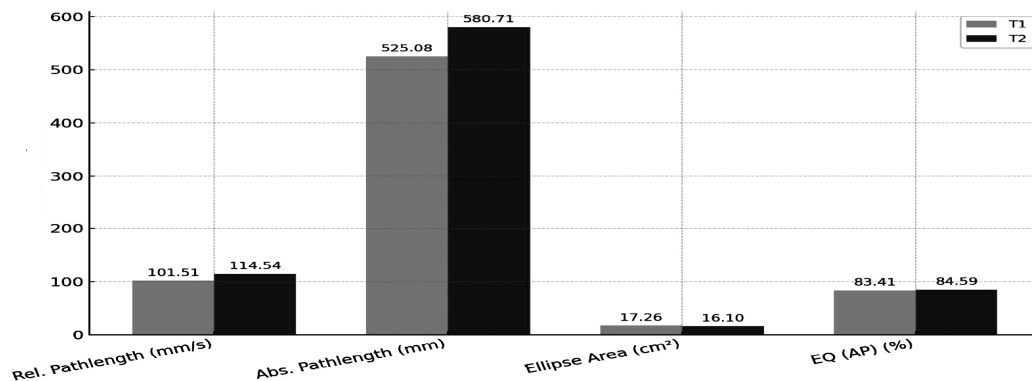
Results and discussions

The content results of indicators of test balance fully explains all practical experimental activity with gymnasts, giving corresponding results. Experimentation, data comparison in balance test, took a major place in study. Leonardo Mechanography Platform (GRFP) gave us important results during two periods of experimentation which are reflected in tables 1 and figure 4.

Analysis of data of balance test (B.T.) with eyes closed for 10 seconds in two testing periods (T1 and T2) shows significant changes in four main parameters related to postural balance and performance of Pressure Center (P.C.). These data are useful to assess improvement or regression of balance skills in individuals who have undergone a training program or intervention. During balance test were measured in two different testing periods (T1 and T2), which provide valuable information about state of postural balance and development of body endurance skills.

Table 1. Data obtained in balance test

B T	Speed mm/s	Speed mm/s	Road Q.P. mm	Road Q.P. mm	SurfaceQ. P.cm ²	Surface Q.P.cm ²	E.Q. (AP)	E.Q. (AP)
	T1	T2	T1	T2	T1	T2	T1	T2
A. N.	218,01	203,04	1090,0	1042,0	96,41	38,72	31,7	44,1
A. L.	145,64	173,34	728,2	824,5	9,29	17,56	86,2	87,4
A. B.	70,99	70,99	354,9	524,6	4,08	14,39	92,0	92,8
B. R.	146,17	153,48	730,8	747,9	10,41	21,92	77,6	85,6
E. K.	99,34	105,38	496,7	526,9	3,86	10,16	89,3	90,5
F. T.	131,16	131,16	655,8	715,4	11,57	19,83	80,8	82,1
D.M.	67,23	67,23	336,2	336,2	5,41	5,41	86,9	87,3
P.C.	105,32	119,65	526,6	583,9	9,10	16, 87	84,6	84,6
Mean	101.512	114.54	525.083	580.71	17.256	16.102	83.41	84.59
Standart Dev.	±41.11	±37.54	±182.0	±185.82	±25.08	±12.18	±11.76	±15.62
Variance	1690.18	1409.79	33136.8	34532.3	629.46	148.52	138.37	244.18
Propability		p < 0.01		p < 0.01		p < 0.001		p < 0.001

**Figure 4. Graphic representation results of balance test**

1. *Relative velocity of P.C. – rel. Pathlength (mm/s)*: This indicator measures how quickly P.C. moves during test. Average value increased from 101.512 mm/s (T1) to 114.540 mm/s (T2). The high standard deviation in both periods indicates considerable individual variability. However, difference is statistically significant ($p < 0.01$). Increased speed of displacement may signal a decrease in postural stability. Higher speed implies greater efforts to maintain balance with eyes closed.
2. *Path of P.C. – abs. Pathlength (mm)*: Represents total length that P.C., traverses during test. It increases from 525.083 mm (T1) to 580.710 mm (T2). The change is also statistically significant ($p < 0.01$). A longer path of P.C., indicates more body movement and less postural control. This indicates a deterioration of balance.
3. *P.C. Area – Std. Ellipse Area (cm²)*: Indicates total area described by P.C., in frontal plane. The values fall from 17.256 cm² (T1) to 16.102 cm² (T2). The change is significant ($p < 0.001$), but high mean value of standard deviation at T1 indicates a large dispersion of results in this period. The decrease in area described by P.C., may suggest an improvement in stability. However, this should be analyzed in context of other parameters.
4. *Overall Balance – EQ (AP) %*: This indicator represents overall level of balance in antero posterior plane. Values are relatively similar: 83.41% (T1) and 84.59% (T2). Difference is statistically significant ($p < 0.001$), which indicates that even small changes are stable at group level. The increase is small, but signals a stability or slight improvement in balance control.

The data show a contrast between increased P.C., movement (more effort to maintain balance) and improved antero posterior balance and decreased P.C., movement area.

- Relative velocity and path of P.C., increased at T2 compared to T1. This indicates an increase in postural activity to maintain balance, which can be interpreted as a tendency for lower stability or a greater effort to compensate for lack of visual information.
- Relative velocity of displacement of Center of Pressure (P.C.). *More movement, less stability (increase).*
- Absolute length of path traveled by C.P. *Increased P.C., mobility, poorer control.*
- Surface described by C.P. decreased at T2, suggesting an improvement in postural stability and a reduction in unnecessary body deflections in frontal axis. *The decrease may signal improvement in stability.*
- Antero posterior balance index (EQ-AP) increased slightly, reflecting an overall improvement in postural control. *Indicates slight improvement in antero posterior balance.*

This analysis is essential for evaluating effectiveness of training or rehabilitation interventions in young gymnasts. The data suggest that, although there is an increase in mobility of P.C. (speed and longer path), individuals have managed to improve postural control in frontal and antero posterior plane, as evidenced by decrease in area described by P.C., and increase in EQ (AP). This may be result of a specific balance training or of a natural development of neuromotor skills, especially in adolescence.

Conclusions

Based on content of our study, we arrived at some basic conclusions, which we are listing as follows:

- Strength training improve balance and reversely, balance training improves strength.
- Results of our study showed that in artistic gymnastics, among gymnasts, balance, without underestimating other movement skills, is one of important coordination skills.
- Measuring balance gives us valuable information in programming muscle work. In artistic gymnastics, many elements require this skill. For this reason, coach prioritizes this component during training. To our subjects conclude average level of balance.
- Sportsmen who during training process put accent on precise movement control show balance of a higher level on both upper and lower extremities.
- When visual control is limited, correcting movements are of greater extent.
- Static balance is equal to a stable position.
- Function of vestibular apparatus may be improved by physical exercise.
- Visual system provides very important information about where body is located with respect to environment in which it moves, eventually it provides information about speed of movement.
- In movement preparation of gymnasts, it is important to know correlations of movement skills, content of specific preparation as well as necessity of improving balance, for an execution with a high technical level.

Conflicts of interest

The authors state that they have no conflict of interest.

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