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Study on the Optimisation of Coordination Abilities Among Junior Female Gymnasts Aged 10-12

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Abstract: Coordination abilities have a considerable influence on the acquisition and improvement of specific elements and their stability. They enable the execution of motor acts in various conditions with high efficiency and determine the performance of movements in optimal conditions. The primary goal of this study was to underline the most appropriate means of training that would lead to improved balance and general coordination among junior female gymnasts aged 10-12. The study was conducted on a sample of 13 female gymnasts between September 2020 and January 2021. The tests applied were the following: Flamingo test, Standing static balance test and Matorin test. The training programmes included means for improving balance and general coordination, namely: maintaining the body in static positions on a small support surface, maintaining body stability in balance positions, maintaining body balance while performing acrobatic elements, changing body positions depending on the working level. The results were interpreted using the ANOVA test and t-test. The Flamingo test indicated a significant change in results, with $t = 19.13$ ($p < 0.0001$); in the Standing static balance test, the value improved, with $t = 10.58$ ($p < 0.0001$); the results in the Matorin test recorded significant progress, with $F = 6.854$ ($p < 0.0001$). Given the results obtained, it can be stated that the training programmes applied to junior female gymnasts have proven to be effective tools for improving the coordination abilities analysed in this study.

Keywords: *gymnastics, balance, training programmes, monitoring, coordination.*

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Introduction

Sport managers and coaches do their best to find future successful athletes using psychological, physiological, technical and anthropometric data (May, T. et al., 2013.) Nonetheless, should the selection process begin too early, many mistakes may arise; thus, a promising champion may fail to enrol at a younger age (Di Cango et al., 2014).

Among the components that affect the athletic level of gymnasts, the ability to maintain body balance is discussed and assessed in numerous studies (Kochanowicz et al., 2009; Krištofič et al., 2018). This ability not only has an impact on the characteristics of featured gymnastic elements but is an essential factor concerning a better safety of athletes during the movement executed (Omorczyk et al., 2018).

In gymnastics, the level of technical training is directly related to sports skills and competitive success. As the volume of exercise increases, the coordination becomes more complex, the result improves, and the ranking will be better. Consequently, some authors state that the essential element in gymnastics is the ability to quickly "explore new and increasingly difficult exercises, as well as the ability to properly assess the range of motion and muscle effort" (Dimitrova, 2015, p. 242).

Gymnastics for all shows is a special sports activity used in performance, which comprises a series of interconnected acrobatic and gymnastic skills to combine the movement to the device. Due to its difficulty, this sport requires athletes to have special physical, psychological and mental skills but also to work hard in order to reach the desired international level, which involves the implementation of an integrated team plan (Issa, 2016).

As a significant sport, the branch of artistic gymnastics impairs the development of various motor skills such as power, coordination, flexibility and, not least, balance (Carrick et al., 2007); of them, coordination is the most complex gymnastic element. Regular tests and monitoring of skills shown by young athletes are essential in characterising a training routine adjusted to the needs and age of gymnasts. We can thus attain a well-balanced and healthy development of primary motor skills in agreement with the physical development of athletes (Ricotti, 2011).

Applied gymnastics can help develop coordination, strength, muscular endurance, flexibility and balance among children. Gymnastics requires maintaining balance while highlighting the aesthetic value of the routine. For such critical criteria to be met, balance training is a primary aspect of gymnastics training (Cohen et al., 2002).

One of the essential components of coordination abilities is balance. Concerning this issue, we state that it is influenced by several factors, such as sensory information (specific to various systems: somatosensory, visual and vestibular), range of motion and power (Grigg, 1994). This ability ensures the correct performance of complex athletic movements and the protection against injury (Ricotti, 2011).

As for balance control, it represents a comprehensive motor skill that includes the planning and executing the flexible shapes and integrating sensory inputs (Triolo et al., 1992).

Balance is a multidimensional process that comprises the following: peripheral nervous system, central nervous system, muscle strength, range of motion, flexibility and visual, vestibular and proprioceptive systems. Both muscle tone and muscle strength, as internal factors, can impair balance (Heyward & Gibson, 2018).

Balance is commonly defined as the ability to control a person's position in space; static balance involves a moving line/centre of gravity and a fixed base of support, while dynamic balance involves the movement of both (Dunsky et al., 2017; Granacher et al., 2012).

Intersegmental coordination, as part of the psychomotor field, has represented an interesting theme in recent years for numerous research studies. Coordination is the ability to perform fluid, correct and controlled movements. Coordinated movement includes various joints and muscles, all of them being activated at the right time and with the proper level of strength so as to produce fluid, effective and correct movements (Grigore et al., 2016).

Gymnastic skills are complex and require very good neuromuscular coordination as well as longer training time and a lot of experience to master them. It has been shown that gymnastics can become an instrument for enhancing the motor skills of children and adolescents, but this is a long-lasting endeavour, an aspect that needs to be taken into account (Ávalos-Ramos & Vega-Ramiréz, 2020).

The ability to perform complex movements, solve complex motor tasks, apply the acquired motor programmes and quickly adopt new motor programmes (Miletić, 2005, as cited in Purenović-Ivanović et al., 2016, p. 64), which is "known as motor coordination, is one of the substantial determinants of motor functioning and of the development of the body as a whole. Coordination as an aspect of physical fitness is a complex entity which allows a person to use the neuromuscular and kinesthetic senses of body part to perform exercises successfully and accurately" (Purenović-Ivanović et al., 2016, p. 64).

Sensorimotor coordination is a complex motor ability that forms the basis of dexterity and distinguishes between the skills of experienced athletes and novice athletes. In the initial training stages, the actions composing sensorimotor coordination can include a chain of distinct sensorimotor reactions with its own distinct beginning and end. During every training session, they make up a form of flexible systems of sensorimotor corrections of the performed movement, with it being the target of the entire routine. Another complication of sensorimotor coordination is recorded if the multiple connection system needs to be controlled (Tereschenko et al., 2013).

Coordination abilities are among the essential pillars of performance skills and encompass a common denominator with other elements designed to facilitate player access to higher levels, according to each one's physical potential. Beginners whose coordination abilities are better than those of their peers may have better physical capabilities (Hafez, 2016).

In our research, the goal was to administer the most suitable tests to determine the static balance and general coordination, their relevance, and to point out the best gymnastics-specific means for educating them. Another study has reached a similar outcome. Its purpose was to identify the importance of coordination and balance in Artistic Gymnastics. The study included 100 female junior gymnasts. The assessment of coordination involved Hirtz's test battery. The tests were correlated with the ranking of the results obtained by each gymnast; the findings were statistically significant. The authors conclude that the female gymnasts who obtained good scores at the tests applied also had good results in competitions; thus, they suggested that coordination and balance may play an essential role in Artistic Gymnastics (Di Cango, et al., 2014).

Our study confirms an instruction model based on developing training routines, and we believe that the approach to the topic by coaches from other countries may be useful in the education of female gymnasts because the performance of tests to assess the coordination skills is necessary within the sports branch.

Methodology

Given the growing popularity of gymnastics among children and the fact that most athletes start training at an early age, it is necessary to examine the impact of gymnastics-specific means on the education of balance and coordination in children aged from 10 to 12.

The primary purpose of the study was to show the most appropriate means of practice, which would improve the balance and general coordination of female junior gymnasts aged 10-12. The research study was carried out on a sample of 13 female gymnasts between September 2020 and January 2021. We have administered the following tests: to assess the static balance, we applied the Flamingo Test; to determine the static balance and general coordination, as well as the spatial orientation, we used the Matorin Test. For the statistical data processing, we used the SPSS 23 version. The descriptive statistics comprised the following indicators: arithmetic mean, standard deviation, confidence interval, and variation coefficient. Concerning the evaluation of the statistical significance of the mean differences between the means of two sets of scores, we used the "t" STUDENT Test.

The tests applied were the following:

• Flamingo test - used to assess static balance. Gymnasts were tested on a metal support 50 cm long, 4 cm wide and 3 cm high. The gymnast placed the preferred leg on this support, with the free leg flexed, and the foot held close to the buttocks. The examiner helped secure this stance, let the gymnast hold it, and then started the stopwatch. When an athlete lost balance by touching the ground with any part of the body or "exiting" the position, the examiner stopped the timer (Marcu, 2009).

• Standing static balance test - used to assess the athlete's capacity to preserve a state of balance in a static position. The gymnast must follow these instructions: "stand comfortably on both feet; hands on your hip; lift one leg and place the toes of that foot against the knee of the other leg; on command from the assistant, raise the heel and stand on your toes. Assistant starts the stopwatch. Balance for as long as possible without letting either the heel touch the ground or the other foot move away from the knee. Coach records the time you were able to maintain the balance" (Mackenzie, 2005, p. 91).

• Matorin test - used to assess balance and general coordination. The examiner draws on the floor a circle measuring 40 cm in diameter and a line marking the start. The gymnast stands with each foot on either side of the line while holding the arms down. The athlete performs a jump with a turn to the dominant side and a jump with a turn to the non-dominant side. After each jump with a turn, the gymnast remains in the landing position (which should coincide with the initial one) while the examiner measures the turning angle (Tudor, 2013).

The training programmes included means for improving balance and general coordination, namely: maintaining the body in static positions on a

small support surface, maintaining body stability in balance positions, maintaining body balance while performing acrobatic elements, changing body positions depending on the working level.

In order to point out the effects of an exercise routine on the balance and coordination at the level of the study group, we designed and implemented a training routine. The means used are described below.

• Means for improving balance

1. Standing on tiptoes, arms up, maintaining position for 30 seconds (6 x 30 seconds)

2. Standing on tiptoes, arms up, maintaining position for 45 seconds (4 x 45 seconds)

3. Standing on one leg, the free leg in split, maintaining position for 10 seconds (4 x 10 seconds)

4. Standing on the floor, maintaining the *passé* on tiptoe for 30 seconds (4 x 30 seconds)

5. On the floor: standing on tiptoes, eyes closed, maintaining position for 30 seconds (4 x 30 seconds)

6. On the balance board: standing legs apart, knees bent, maintaining position with eyes closed and eyes open for 30 seconds (4 x 30 seconds)

7. On the bosu ball: standing legs apart, knees bent, maintaining position with eyes open and eyes closed for 30 seconds (4 x 30 seconds)

8. On the bosu ball: standing on one leg, the free leg bent in different positions and directions, maintaining balance with eyes closed and eyes open for 10 seconds (4 x 10 seconds)

9. On the beam: standing on one leg, the free leg in *passé*, maintaining position for 30 seconds (4 x 30 seconds)

10. On the beam: standing on one leg, the free leg maintained forward and sideways at 90^0 for 30 seconds (4 x 30 seconds)

11. On the beam: back scale, maintaining position for 10 seconds (4 x 10 seconds)

12. On the bench/beam: Sissonne jump and jump step (4 x 10 reps)

• Means for improving coordination

1. Execution of *chaîné* turns: 1 diagonal; turns will be performed to the left and right sides (1 diagonal)

2. Tour en l'air: 1 execution on the right and 1 execution on the left (1 diagonal)

3. Standing and holding a ball in each hand: active rebounds simultaneously and alternately (3 x 30 seconds)

4. Standing, arm and leg movements in different planes (3 x 30 seconds)

5. Standing, rope jumping on both legs, on one leg and while traveling (3 x 30 seconds)

6. Performing movements with body segments in various positions, with eyes closed and eyes open - on the floor, the bench and the beam (2 x 30 seconds)

7. Performing movements with the indicated segments in rhythms/tempos imposed by the coach (2 x 45 seconds)

8. On the floor/beam: standing long jumps (forward or backward) on the dominant and non-dominant legs with eyes open and eyes closed (2 x 30 seconds)

9. Asymmetrical movements: standing, hoop in the right hand, horizontal rotations and ball-floor rebounds with the left hand; movements will be performed simultaneously (3 x 30 seconds)

10. On the beam: standing straight jumps moving back and forth; salto with ½ turn to the right and left sides (10 repetitions)

The planning of the training process is shown in Table 1.

Table 1. Planning of the training process for the period September 2020 - January 2021

Test	Number of training days	Number of training lessons	Number of days off	Day	Time
Means for improving balance (4 times/week)	144	144	72	Monday, Wednesday, Friday, Saturday	15’
Means for improving coordination (3 times/week)	108	108	72	Tuesday, Thursday, Saturday	15’

Source: Authors' own conception

Results

Table 2 and Figures 1, 2 and 3 illustrate comparatively the results obtained by the female gymnasts included in this study, highlighting the differences between their scores in the initial and final tests.

Table 2. Test results

	Mean	SD	95% CI of the mean Lower	95% CI of the mean Upper	Coefficient of variation	t-Test/ Tukey Test	p
Age (years)	11	0.7	10.57	11.43	6.43%		
Height (cm)	140.8	9.2	135.3	146.4	6.53%		
Body weight (kg)	32.97	5.72	29.51	36.43	17.36%		
Flamingo_I (s)	37.8	16.74	27.69	47.92	44.29%	t=19.13	p< 0.0001
Flamingo_F (s)	45.24	16.72	35.14	55.34	36.95%		
Matorin_dominant_I (degrees)	557.7	82.07	508.1	607.3	14.72%	q=14.78	p< 0.0001
Matorin_dominant_F (degrees)	621.9	76.25	575.8	668	12.26%		
Matorin_nondominat_I (degrees)	435.4	70.22	393	477.8	16.13%	q=11.41	p< 0.0001
Matorin_nondominat_F (degrees)	480	64.94	440.8	519.2	13.53%		
Static balance_I (s)	37.52	26.47	21.53	53.52	70.53%	t=10.58	p< 0.0001
Static balance_F (s)	45.36	25.49	29.95	60.77	56.20%		

Source: Authors' own conception

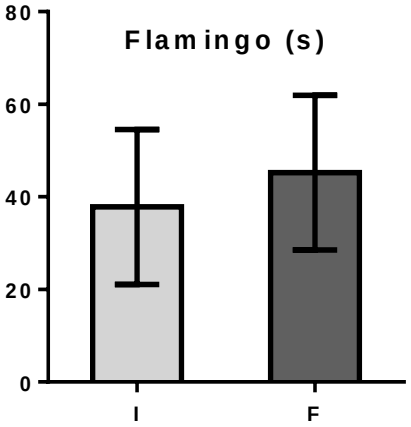


Figure 1. Flamingo test results
Source: Authors' own conception

After interpreting the Flamingo test results, it was noted that the mean in the final test increased by 7.44 ± 0.02 seconds, and the homogeneity of the group improved by 7.42%, $t = 19.13$, $p < 0.0001$.

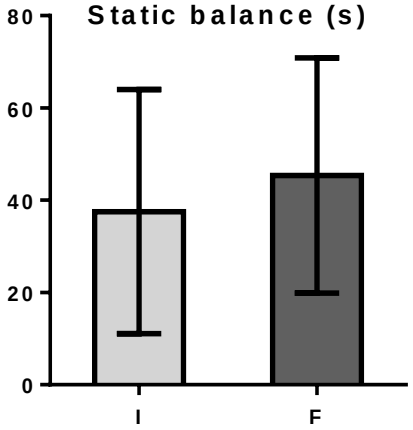


Figure 2. Static balance test results
Source: Authors' own conception

According to the results, the mean in the final test improved by 7.84 ± 0.98 seconds, and the homogeneity of the group decreased by 14.33%, $t = 10.58$, $p < 0.0001$.

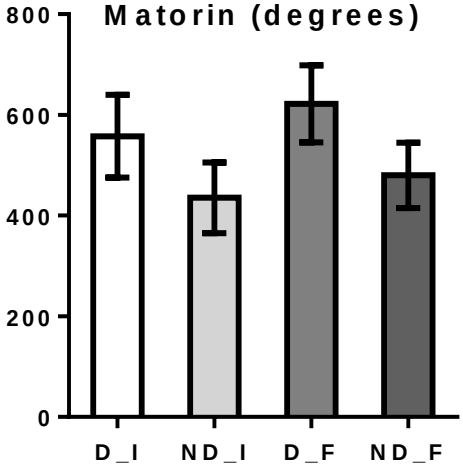


Figure 3. Matorin test results
Source: Authors' own conception

The findings point out that the average in the final test concerning the dominant side increased by 64.2 ± 5.82 degrees, and the homogeneity of the group improved by 2.46%, the Tukey test value being q = 14.78 with a significance threshold of $p < 0.0001$; for the non-dominant side, the mean increased by 44.6 ± 5.28, the dispersion decreased, and the homogeneity of the group improved by 2.6%, the Tukey test value being q = 11.41 with a significance threshold of $p < 0.0001$.

Discussion

Gymnastics landing, "which requires maintaining balance after performing very complex elements (floor, beam and lands on the other gymnastic apparatus) influence the development of superior balance compared to other sports" (Alexić-Veljković et al., 2014, p. 294). The authors above found relevant differences only in the one-leg position, and the static balance test, but such findings were predictable given that older gymnasts (aged 12 years) obtained higher scores than 9-year-old gymnasts in tests such as the one-leg position and the handstand on the balance beam. This finding supports the hypothesis that balance is age-dependent.

Genc and Kizar (2020) examined the effect of gymnastic exercises on static and dynamic balance in children aged 7-10 years and found a statistically significant increase in both right foot and left foot tests for the experimental groups in comparison with the control groups ($p < 0.05$).

Studies have shown that, the higher the number of training years, the better the ability to control balance; however, there are sports where the number of years of training does not increase or decrease this ability. Thus, Granacher et al. (2011) investigated "the impact of balance training followed by detraining on postural control, plantar flexor strength, and jumping height in prepubertal children" (p. 1759) but failed to find statistically significant improvements in these parameters following four weeks of balance training integrated into the physical education classes.

In a study on postural sway as a measure of static balance, Pasma et al. (2016) used a force plate and found that maximally reliable estimates were achieved only after multiple trials over multiple sessions. "The availability of specialised equipment and sufficient time, in this case, represent practical considerations of crucial logistical and environmental factors influential to test selection" (Muscat-Inglott, 2020, p. 3).

Another study (Grigore et al., 2015) assessed various correlations: intersegmental coordination and the values scored by athletes for landing, a technical component in artistic gymnastics. Study participants were 21 female artistic gymnasts aged 9-10 years. The RCMV test (part of the

Psiselteva battery developed by RQ Plus) was administered to evaluate intersegmental coordination shown by various psychomotor parameters. The result analysis indicated a significant positive correlation between diverse psychomotor parameters, such as perceptual-motor learning skills, performance coefficient, endurance to time pressure and the values scored by gymnasts for landing (in the vault event).

Akin (2013) investigated the effect of a 12-week gymnastics routine on dynamic balance abilities in preschool children. The study was carried out on a sample of 136 kindergarten pupils aged 4-6 who participated voluntarily in the survey. While the experimental group followed a gymnastics training programme two days a week for one hour per session during 12 weeks, the control group participated in the daily school programme. Physical and strength characteristics as well as dynamic balance skills were assessed to determine the effects of this programme on preschool children. Dynamic balance did not correlate with gender, gymnastics training, height, weight, Sargent jump and long jump. Gender had an important effect only on motor skills. The above author concluded that the effects of gymnastics training on preschool children aged 4-6 years were significant in terms of balance.

In what concerns the limits of the study, we underline that it was impossible to assess a greater number of Artistic Gymnastics practitioners due to the current pandemic context.

Conclusion

The results of our research highlight that:

1. The training programmes used have facilitated the improvement of the indicators of coordination abilities addressed in this study.

2. The means used for improving balance and coordination abilities were effective, which has led to an improvement in the performance of technical elements by the female gymnasts included in the research.

3. The development of intersegmental coordination can have a positive influence on the performance of technical elements by the female athletes practising artistic gymnastics. Both coaches and athletes need to consider this important issue.

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participants were previously informed about the procedures and we obtained their consent.

Authors' Contribution

All authors have equally contributed to this paper and should be considered as main authors.

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