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COMBINING WEIGHT TRAINING WITH PLYOMETRIC TRAINING IN WOMEN'S ARTISTIC GYMNASTICS

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Abstract. *Women's artistic gymnastics is supposed to be a sport of grace and beauty. The way gymnastics is practiced nowadays has made us change our perspective on how the training of female gymnasts should be regarded. Current exercises contain elements of great difficulty, which cannot be performed efficiently without appropriate physical training. This physical training has a dual role: on the one hand, it predisposes the body to high and very high efforts, and on the other hand, it prevents injuries that may occur during training or competitions. In the training methodology of gymnasts worldwide, weight training has been used for some time. Therefore, we decided to introduce high-load weight training combined with plyometric training in the workouts of Romanian female gymnasts. The research presents a 22-week program combining the two strength development methods, the results obtained before and after program implementation, how the loads were adapted during the experiment, and the way of applying the proposed program. The results of the experiment encourage us to continue applying this program as a training method for future competitions. It is worth mentioning that, when establishing training loads in this sport, the specifics of each apparatus should be taken into account, as their demands are different, and a proper understanding of the real training stimulus might require more than just the number of repetitions and training loads.*

Keywords: *combined training; plyometrics; jumps; women's artistic gymnastics.*

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Introduction

Jumps are extremely important skills in women's artistic gymnastics, which not only improve performance but also make an essential contribution to strengthening the lower limb muscles. Based on the objectives pursued, jumps can be divided into two categories, predominantly horizontal or predominantly vertical, depending on the trajectory of the center of gravity. In gymnastics, take-offs are performed to make an artistic or acrobatic jump that precedes or follows an acrobatic element, depending on the technical element concerned, the direction of movement, the apparatus on which the element is performed, the axes of rotation, etc. In order to optimize actions and thus make jumps more efficient, some aspects should be considered, for example, obtaining the optimal take-off point (for run approach jumps), achieving perfect spatial adjustment (for jumps with rotations in different axes), and reaching a take-off angle specific to the targeted element, which should be as close as possible to the biomechanically prescribed one. Studying the activity of eight muscle groups in three successive phases (countermovement, take-off, and flight) of four standing acrobatic jumps, Król et al. (2020) noticed that the highest muscle activation levels were found during the take-off phase and that the rectus femoris and rectus abdominis were the exceptions, having the highest values in the flight phase. Okubo et al. (2012) observed that the same phenomenon occurred in the aforementioned muscles when the head was tilted, with high values of muscular activity in the flight phase; similar differences were found during a tucked backward somersault than in a vertical jump, which can be explained by the rapid flexion of the hip joints during the flight phase of somersaults. Jacobs et al. (1996) highlighted that the rectus femoris transferred power from the hip to the knees; however, the kinematic analysis during vertical jumps showed that the hamstring muscles were involved in the power transfer from the knees to the hip. The above authors conclude that the result of the simultaneous contraction of these antagonist muscles is the net transfer of force from the hip to the knees. Medved et al. (1995) noticed that a significantly higher vertical impulse was created in the take-off phase. Considering this, the current findings are particularly interesting. In the take-off phase of acrobatic jumps with rotation, the average muscle activation levels of biceps femoris were higher than those of rectus femoris. In the countermovement jump, the rectus femoris acts as a prime mover, while the biceps femoris acts as a stabilizing muscle. Electromyography, as a dynamic type of assessment for neuromuscular control, quantifies preparatory and reflexive muscle amplitudes around a specific joint, and represents an important indicator in determining joint stability during functional tasks (Wikstrom et al., 2008; Ebig et al., 1997; McKinley & Pedotti, 1992).

The main objectives are the following: self-propulsion in space; using the ground reaction force in the athlete's actions with the lowest possible energy loss; maintaining both the correct position specific to the element performed in the flight phase and its trajectory; achieving a controlled displacement of body segments in accordance with the mechanical characteristics of the specific trajectory; optimizing and securing the landing as well as controlling it through segmental alignment, symmetry of arm and leg movements, tension of the back and upper- and lower-limb muscles, with head position being also important for a correct landing. The factors that can have a major influence on take-offs and landings are: elasticity of the working surfaces, degree of body tension, biomechanics of movement, level of motor skills, orientation in time and space, general coordination, and level of specific technical training. Of all these aspects, we will focus on the development level of specific motor skills that result in increased jumping height.

Landings are extremely important in women's artistic gymnastics to both improve athletic performance and reduce the number of injuries. For these reasons, this topic is frequently addressed by researchers and coaches who want to achieve performance improvement. The success of landings depends on the athlete's level of physical fitness and motor control, with the latter referring to the degree of control over the skill performed (Marinšek, 2010). Various studies on this topic show a low success rate in competitive landings (Gittoes & Irwin, 2012). During the 1996 Atlanta Olympics, McNitt-Gray et al. (1998) investigated 20 landings from the horizontal bar and parallel bars and found that only one was performed without any mistakes. Another study conducted at the 2004 European Championships showed that, of all the saltos performed on the floor, only 30% were done correctly, and 70% contained errors

(Marinšek, 2009). Depending on the knee angle, landings can be classified as soft or stiff. Soft landings are those where the knee angle is greater than 63 degrees, while in stiff landings, the knee angle is smaller than 63 degrees (Marinšek, 2010). Elite female gymnasts use different landing techniques compared to amateurs (McNitt-Gray et al., 1993). Thus, amateur gymnasts perform landings with a higher range of motion in the knee and hip joints compared to elite gymnasts, and one of the reasons for this difference in performance is increased muscle pre-activation (Devita & Skelly, 1992). The improvement of jumps and landings in women's artistic gymnastics can be achieved by developing strength as a motor ability and its form of manifestation, explosiveness. That is why we propose a protocol based on combined strength training for the development of explosive strength.

Combined strength training leads to physiological changes in the muscles, which results in significant performance improvement. (Uysal et al., 2023). To explain combined training, we will briefly review how weight training and plyometrics have been regarded over time as complementary to each other. Published studies describe weight training as a prerequisite for plyometric training. Recommendations include implementing plyometric training after a certain period of preparation, for example, after 4 to 6 weeks of weight training, after several weeks or months of sprint and resistance training, after developing core strength, or after gaining experience in basic jump training and weight training. Weight training is used to prepare plyometric training in order to reduce injury risk, develop core strength, and train the musculoskeletal system for high-impact forces. The literature provides numerous recommendations for weight training and plyometric training, especially regarding the implementation of plyometric training into a weight training program (Ebben & Watts, 1998). Nowadays, it would be difficult to offer a definitive explanation for the physiological changes induced by combined training. Theoretically, any factors could play a role: neuromuscular, hormonal, metabolic, myogenic, and psychomotor.

Combined training could serve as a strategy that allows for constant neural adaptations in trained athletes, besides morphological adaptations usually associated with advanced training. Apparently, the most powerful adaptive mechanism of combined training is neuromuscular. High-load weight training increases motor neuron excitability and reflex potentiation, which provides optimal training conditions for subsequent plyometric workouts. Moreover, the fatigue associated with this type of training may force the recruitment of more motor units during the plyometric phase, which will possibly enhance the training state (Chu, 1996). Plyometric training is widely used to improve physical performance in a lot of sportive disciplines activities that involve explosive force. It typically involves exercises based on the stretch-shortening cycle (SSC). The effective use of SSC is related to the contributions of various mechanisms such as elastic energy storage (Komi & Gollhofer, 1997), preload (Walshe et al., 1985), increased time to muscle activation, muscle history dependence (force enhancement) (Caron et al., 2020), stretch-reflexes (Trimble et al., 2000), and muscle-tendon interactions (Aeles et al., 2019), which facilitate greater power production in subsequent muscle actions (Radnor et al., 2017).

Changes in neural and muscular mechanical properties (for example, musculotendinous stiffness and architecture) are also reported as a result of plyometric training and may explain improvements in physical abilities. The number of research exploring the effects of plyometric training on physical abilities has increased significantly worldwide. Particularly in the last two decades, papers included a lot of sports activities, ages, and physical performance outcomes (Kons et al., 2023) Several studies have investigated the effects of plyometric training on drop jump (DJ), countermovement jump (CMJ) (with arm swing or hands on hips), Sargent jump, etc. In athletes from team sports such as handball, volleyball, football, or basketball (Ramirez-Campillo et al., 2020a, 2020b, 2020c, 2022), plyometric training mostly had moderate-to-large effects, which indicates that performance enhancement is more relevant for this category compared to other sports groups (Kons et al., 2023).

Shih et al. (2024) investigated the effect of a strength and plyometric training program on jumping and landing, and found that it effectively improved lower-limb muscle strength. At the end of a 12-week intervention, participants showed not only significant improvements in lower limb strength, but also an increase in the rate of force development during both jumping and landing, which contributed to better stability on landing. Plyometric training involves a quick transition from eccentric to concentric muscle contraction. In the aforementioned study, explosive jump-based means were used to exemplify the three phases of plyometric training: eccentric pre-stretch, rebound, and concentric shortening. The eccentric pre-stretch phase generates ground reaction forces and is the predominant source of explosive power (Davies et al., 2015). Plyometric training improves rapid muscle stretch (Seiberl et al., 2021) using the stretch-shortening cycle to optimize power output (Ramírez de la Cruz et al., 2022). Moreover, this type of training facilitates high-intensity eccentric contractions immediately after concentric contractions (Verma et al., 2015). According to Strate et al. (2022), this training technique improves rapid muscle contraction and stretching, particularly in vertical jumping exercises. Solid evidence supports the idea that plyometric training increases vertical jump height (Kons et al., 2023; Ramirez-Campillo et al., 2022).

Another study related to the effects of plyometric training on increasing lower limb strength and power was conducted by Raharjo et al. (2024). The findings of this study demonstrate that long-term high-intensity plyometric training improves lower-body muscle strength and power in young healthy males. Therefore, these results can serve as a basis for coaches and athletes to consider improving lower-body muscle strength and power in order to support the achievement of optimal performance. Consequently, this study aims to assess the effectiveness of long-term plyometric training in enhancing lower-body muscle strength and power in healthy young men. Moreover, the study in question hypothesizes that plyometric training will not only improve physical performance but will also contribute to muscle health, providing a potential strategy to mitigate the adverse effects of physical inactivity.

In sports, physical forces do not manifest themselves separately but constantly interact. The degree of this interaction varies according to the sports discipline and is influenced by the athletes' level of technical training and the development of other motor skills. The balance between the three types of strength (maximal strength, explosive strength, and resistance strength) plays a key role. Some sports require high combinations of maximal and explosive strength, others require explosive strength and resistance, while in certain disciplines, a balance between all three forms is essential. For example, in artistic gymnastics, a major emphasis is placed on the development of explosive strength, while maximal strength is trained just enough to support explosive performance. In this context, strength-resistance mainly has the auxiliary role of sustaining explosive movements over a prolonged period, such as in the case of repeated jumps.

Therefore, in the training process, it is important to take into account how the improvement of one type of strength can positively or negatively influence the other forms of strength manifestation. In the world of sports, there is a widespread perception that bulky muscles, which are capable to develop high levels of maximum force (Fmax), would not be able to generate a great speed of movement, and this would limit performance in exercises requiring high explosive strength. However, this idea is contradicted by specialized studies and the latest sports practices. Actually, there is a close relationship between maximal strength and explosive strength, which becomes evident especially when speed movements are performed with an external resistance exceeding 25-30% of Fmax. The higher the external resistance, the more the maximum force contributes to increasing explosive strength values. Maximum force plays an essential role in the development of muscle strength, whether working with light or high loads. Improving maximum force can help to increase explosive strength in low- and higher-resistance movements alike. Training focused on increasing maximal strength can lead to improvements in muscle power and the rate at which force is generated (Stone et al., 2003).

On the other hand, training that involves overcoming low external resistance at high speed does not require a high level of maximal strength. In this situation, there is a negative correlation between maximal strength and explosive strength. However, maximal strength remains a key factor influencing not only muscular power but also the execution of movements at different speeds (Peterson et al., 2006). A high level of maximum force achieved through increased cross-sectional muscle area and improved intramuscular coordination is the basis for the explosive strength development. At the same time, progress in explosive strength development requires advanced intramuscular coordination, which in turn contributes to increased levels of maximum force (Izquierdo et al., 1999).

Methodology

Purpose

This study aims to demonstrate that it is possible to work with high-load weights and to combine weight training with plyometric training in women's artistic gymnastics too.

Hypothesis

Combining weight training with plyometric training in women's artistic gymnastics leads to an improvement in the jumping height and power developed by athletes.

Participants

The research involved 7 junior gymnasts (women), members of the Romanian National Junior Team, who participated in a program aimed at developing explosive strength in the lower limbs.

Research methods

This is an applied research where we used general methods (literature review), investigative methods (observation and experiment) and interpretation methods (statistical-mathematical statistics). The dependent variable is the gymnasts' manifestation after a period of training, and the independent variable is represented by the means used.

Measure and Procedure

The program was applied to the experimental group over a period of 22 weeks; thus, in the first weeks, a program to eliminate muscle imbalances was used, and then, in the following 16 weeks, the explosive strength development program was implemented.

The initial testing was carried out on 10 January 2022. This was followed by a three-week period during which the data obtained from the initial testing were processed, and training programs were developed. Between 24 January and 12 February 2022, work was done for muscle balancing, and from 14 February 2022, explosive strength development programs were applied to the experimental group for 18 weeks. The final testing took place on 6 June 2022. The two testing sessions were performed on the OptoJump device. Subsequently, all the obtained data were processed and interpreted in order to draw research conclusions.

Muscle imbalance occurs when antagonist muscles do not perform harmonious movements, meaning that they do not produce equal amounts of force, which causes different tensions in the joint capsules they control. Muscle imbalances are the result of repetitive movements/postures in only one direction, which puts stress on certain agonist muscles without involving antagonist muscles. Muscle imbalances are conditions affecting the nerves that send electrical signals to the muscles in order to control movement. Most muscle imbalances start by affecting large skeletal muscles (such as those of the arms and legs) but can progress to affecting smaller neck and chest muscles, which is likely to cause problems. These imbalances can be exemplified by the triple extension movement of the lower limbs that occurs in gymnasts during the swing, take-off and jump phases. Following repeated stress, the quadriceps femoris tends to shorten, which is why an imbalance may occur between this muscle and the hamstrings. The first step is to detect these imbalances, which requires working with a physiotherapist. In the previous example, the reverse process is used: the agonist muscle (quadriceps femoris) is relaxed, and the antagonist muscle (hamstring) is tensed. The working principle is illustrated in Table 1.

Table 1. *Working principle to eliminate muscle imbalances*

REVERSE PROCESS		
Agonist muscle relaxation		Antagonist muscle activation
Relaxation through acupressure	Stretching	Single-joint (monoarticular) exercises

This process lasted for 3 weeks (from 24 January to 12 February 2022) and was individualized for each athlete.

a. *Program for lower-limb maximal strength development*

As a training strategy for strength development, we chose the following methodological approach: a combined maximal strength development workout, followed by two explosive strength development workouts based on the plyometric method. The program used to develop maximal strength is shown in Table 2.

Table 2. *Program for maximal strength development*

Day	Monday
Intensity and number of repetitions	8x60%; 6x70%; 4x80%; 2x90%; 1x100%
Series	2
Execution speed	Constant and uniform during both contraction and relaxation
Break between series	4 minutes

The movements chosen for this program are: calf extension, calf flexion, plantar flexion and extension, and press. Since adaptation to a given weight occurs after approximately four weeks of training, maximal strength or force (Fmax) was tested at the end of the fourth week using the following assessment method:

- the muscle development machine was loaded with a random weight;
- the athlete performed repetitions up to the limit with a constant speed during both contraction and relaxation;
- the repetitions were counted;
- the number of repetitions and the number of kilograms worked with were entered into the formula below (Hantău, 2011):

$$F\max = \frac{no.\ of\ kilograms}{1.0278 - (no.\ of\ repetitions\ x\ 0.0278)}$$

The plyometric training program included jumping on one or two legs.

b. *Program for explosive strength development through plyometric exercises* (Table 3)

Table 3. *Plyometric exercise program*

Day	Exercise	No. of repetitions	Series
Wednesday	Connected jumps over 40-cm hurdles	8	3
	Connected jumps over 50-cm hurdles	8	3
	Jumps on the right leg over 25-cm hurdles	8	3
	Jumps on the left leg over 25-cm hurdles	8	3
	Zigzag jumps on the right leg over the gym bench	8	3
	Zigzag jumps on the left leg over the gym bench	8	3
	Zigzag jumps on both legs over the gym bench	8	3
	Frog jumps up to 90 degrees	10	3
Saturday	From standing with legs apart on two 30-cm blocks placed 40 cm away from each other, drop jump to legs together and return on blocks	8	3

	From standing with legs apart on two 60-cm blocks placed 40 cm away from each other, drop jump to legs together and return on blocks	5	3
	From standing with legs apart on two 90-cm blocks placed 40 cm away from each other, drop jump to legs together and return on blocks	3	3

Note. This program should be applied for 16 weeks.

Workout planning

Muscle balancing was conducted between 24 January and 12 February 2022 under the supervision of a physiotherapist, and took place four times a week (on Mondays, Tuesdays, Thursdays, and Fridays) after the afternoon training (Table 4).

Table 4. *Muscle balancing planning*

Period	24 January to 12 February 2022						
Day	24	25	26	27	28	29	
	31	1	2	3	4	5	
	7	8	9	10	11	12	13
Muscle balancing	X	X		X	X		
F_{max} assessment							X

The first testing session for maximal strength assessment was carried out on 13 February 2022. The tests were performed on Sundays, so that the athletes would not have other activities on the testing day. From 14 February 2022, the explosive strength development program was applied for a period of four weeks. The second testing session for maximal strength assessment took place on 13 March 2022 (Table 5).

Table 5. *First training period*

Period	14 February to 13 March 2022						
Day	14	15	16	17	18	19	
	21	22	23	24	25	26	
	28	1	2	3	4	5	
	7	8	9	10	11	12	13
F_{max} development	X						
Plyometrics I			X				
Plyometrics II						X	
F_{max} assessment							X

In the second training period, namely between 14 March and 9 April 2022, explosive strength development continued. The third maximal strength assessment was conducted on 10 March 2022 (Table 6).

Table 6. *Second training period*

Period	14 March to 10 April 2022						
Day	14	15	16	17	18	19	
	21	22	23	24	25	26	
	28	29	30	31	1	2	
	4	5	6	7	8	9	10
F_{max} development	X						
Plyometrics I			X				
Plyometrics II						X	
F_{max} assessment							X

In the third training period, more specifically between 11 April and 7 May 2022, explosive strength development continued. The last maximal strength assessment was carried out on 8 May 2022 (Table 7).

Table 7. *Third training period*

Period	11 April to 8 May 2022						
Day	11	12	13	14	15	16	
	18	19	20	21	22	23	
	25	26	27	28	29	30	
	2	3	4	5	6	7	8
F_{max} development	X						
Plyometrics I			X				
Plyometrics II						X	
F_{max} assessment							X

In the fourth training period, namely between 9 May and 4 June 2022, maximal strength and explosive strength development continued. The final testing was conducted on 6 June 2022 (Table 8).

Table 8. *Fourth training period*

Period	9 May to 5 June 2022						
Day	9	10	11	12	13	14	
	16	17	18	19	20	21	
	23	24	25	26	27	28	
	30	31	1	2	3	4	5
F_{max} development	X						
Plyometrics I			X				
Plyometrics II						X	
F_{max} assessment							X

The initial and final tests were performed on the OptoJump device for countermouvement jump (CMJ), drop jump from 30 cm (DJ30), drop jump from 60 cm (DJ60), and drop jump from 90 cm (DJ90). The power developed by female athletes in the four tests was monitored.

Results

Table 9. *Jump height*

Experimental group	Experimental group							
	CMJ (cm)		DJ30 (cm)		DJ60 (cm)		DJ90 (cm)	
	Initial testing	Final testing	Initial testing	Final testing	Initial testing	Final testing	Initial testing	Final testing
1	24.2	30.4	23.6	28.4	26.4	33.7	21.9	28.8
2	25.3	32.2	21.2	27.2	25.4	36.2	19.5	26.3
3	22.9	29.3	22.6	28.7	22.6	29.1	21.9	28.2
4	24.2	31.8	23.3	27.9	19.8	28.9	16.8	23.4
5	15.6	23.6	22.9	29.2	23.4	29.9	22.1	29.2
6	29.1	36.1	23.6	30.3	21.1	29.2	25.6	31.6
7	34.2	41.2	30.4	35.6	31.3	39.2	30.5	38.7
Mean	25.07	32.08	23.94	29.61	24.28	32.31	22.61	29.45
S	5.70	5.50	2.96	2.81	3.84	4.12	4.39	4.80
CV	0.277	0.171	0.123	0.095	0.158	0.127	0.194	0.163

According to Table 9, the arithmetic mean of the results for this parameter increased from the initial to the final assessment in all four tests. The coefficient of variation decreased in all four tests, indicating an increase in homogeneity for the experimental group.

Table 10. *Wilcoxon test results – Jump height*

Statistical indicators	Wilcoxon test			
	Assessment tests			
	CMJ	DJ30	DJ60	DJ90
W	0	0	0	0
p	<0.01	<0.01	<0.01	<0.01
z	-2.366	-2.366	-2.366	-2.366
r	0.89	0.89	0.89	0.89

Applying the Wilcoxon non-parametric statistical test to identify the existence of statistically significant differences between the initial and final test results for the experimental group in terms of jump height, the following data have been obtained (Table 10):

- for CMJ, the statistical test result is $W = 0$ ($Z = -2.366$, $p < 0.01$), indicating a significant difference between the two testing sessions; the effect size is $r = 0.89$, which shows that there is a very strong effect on the results obtained by the research participants;
- for DJ30, DJ60, and DJ90, the Wilcoxon test results are identical (because all athletes have improved their results): $W = 0$ ($Z = -2.366$, $p < 0.01$); the effect size is $r = 0.89$, which also highlights a very strong effect of the intervention on the participants' results.

Table 11. *Power developed at the jump moment*

Experimental group	Experimental group							
	CMJ (w)		DJ30 (w)		DJ60 (w)		DJ90 (w)	
	Initial testing	Final testing	Initial testing	Final testing	Initial testing	Final testing	Initial testing	Final testing
1	16.23	21.1	40.37	44.26	46.6	51.7	37.01	41.6
2	17.07	22.6	28.35	31.86	27.7	39.2	27.79	33.9
3	16.53	21.3	43.42	45.79	43.4	48.3	36.74	42.1
4	15.89	20.7	39.21	42.51	31.9	38.6	24.60	31.2
5	8.72	16.9	35.05	39.26	32.4	39.2	24.82	28.6
6	16.46	23.2	41.06	43.93	35.5	41.3	30.40	33.2
7	20.21	25.4	43.10	45.87	41.2	46.9	32.19	36.8
Mean	15.87	21.6	38.65	41.92	36.95	43.6	30.50	35.34
S	3.47	2.62	5.33	4.97	6.91	5.28	5.14	5.10
CV	0.218	0.121	0.137	0.118	0.187	0.121	0.168	0.144

The data obtained by calculating the mathematical and statistical indicators specific to descriptive statistics (Table 11), the arithmetic mean of the results increases from the initial to the final testing in all four tests. As regards the standard deviation, it decreases from the initial to the final testing, which shows that the final values of all four tests tend to group around the mean, automatically leading to an increase in homogeneity for the experimental group. The fact that the coefficient of variation decreases from the initial to the final testing in all four tests also confirms the above statement.

Table 12. *Wilcoxon test results – Power developed at the jump moment*

Statistical indicators	Wilcoxon test			
	Assessment tests			
	CMJ	DJ30	DJ60	DJ90
W	0	0	0	0
p	<0.01	<0.01	<0.01	<0.01
z	-2.366	-2.366	-2.366	-2.366
r	0.89	0.89	0.89	0.89

Applying the Wilcoxon non-parametric statistical test to identify the existence of statistically significant differences between the initial and final test results for the experimental group in terms of power developed at the jump moment, the following data have been obtained (Table 12): for CMJ, DJ30, DJ60 and DJ90, the Wilcoxon test results are identical, $W = 0$ (all athletes improving their results), $Z = -2.366$, while $p < 0.01$, indicating a significant difference between the two testing sessions.

The effect size is $r = 0.89$, which shows that there is a very strong effect of the intervention on the results obtained by the research participants.

Discussions and Conclusion

The literature review has revealed that the use of weights in combination with plyometric training is not a widely addressed topic. Changes in the Code of Points have encouraged the execution of difficult elements, which cannot be performed without appropriate physical support (He et al., 2022).

A study conducted by Trucharte Martínez and Grande (2021) showed that statistically significant differences were obtained from the recorded mean values of RPE (rate of perceived exertion) and sRPE (session-rate of perceived exertion) when comparing training content. Also, the variables associated with injury risk control provided relevant information to establish that top-level gymnasts were at higher risk of injury than medium-level gymnasts. Therefore, sRPE was a useful tool for assessing internal training load in women's artistic gymnastics. Such information may help quantify future training loads. That is why we used clear loads when working with weights, and the reference systems for the loads concerned were updated every four weeks.

Training load management is a broad term encompassing several variables, procedures, stages, and systems (Gabbett, 2020) used to understand the dose-response relationship in the training process, contribute to athletic performance improvement, and minimize the risk of injury (Impellizzeri et al., 2023). From this perspective, constantly monitoring external and internal training loads (i.e., what the athlete has done vs. how the athlete's body responds to the stimulus) is a key part of training (Jeffries et al., 2022). Despite extensive scientific and technological advances in recent decades, this topic is still a challenge in complex aesthetic sports such as gymnastics (Gamarano de Freitas et al., 2025).

The current study highlights that the use of weight training combined with plyometric training in women's artistic gymnastics gives satisfactory results. However, when establishing training loads in this sport, the specifics of each apparatus should be taken into account, as their demands are different, and a proper understanding of the real training stimulus might require more than just the number of repetitions and training loads.

Considering the limits of the research, one can observe the very small sample size (however, athletes are members of the Romanian National Team, a *hard-to-reach* population). Also, other results could be obtained in male gymnasts, a gender-related approach being necessary.

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Institutional Review Board Statement: The research was conducted according to the principles stated in the Declaration of Helsinki and approved by the Research Ethics Committee of UNEFS Bucharest (number assigned 118/0125).

Informed Consent Statement: Written informed consent was obtained for all participants involved in this study.

Data Availability Statement: Data can be made available upon request to the contact author.

Conflicts of Interest: The authors declare no conflict of interest.

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