

Training process for developing movement skills in male gymnasts

EDISON IKONOMI¹, ELTON BANO², ARBEN BOZAXHIU³
^{1,2,3}Sports Department, Tirana University Sports. ALBANIA

Published online: March 31, 2024

(Accepted for publication March 15, 2024)

DOI:10.7752/jpes.2024.03079

Abstract:

Introduction: In artistic gymnastics, training is organized by coaches and implemented by gymnasts, where they work together to get a high sports result. The most effective forms and methods used in this process give highest sporting result. **Ultimate goal of study:** achieving peak athletic performance. The efficacy of various training modalities directly correlates with level of sporting success attained. **Objective:** This study aims to identify optimal methodologies enhancing the physical skills of gymnasts, serving as a foundation for elevating overall athletic performance. **Material and Methods:** In this study, twenty-four male gymnasts from six sports clubs in different cities of Albania, who are participants in gymnastics competitions at the national level and four of them at the international level, were analyzed. The strength tests in the lower limbs were: squat jump, counter movement jump, drop jump. In Excel 2015, the "Data Analysis" package was used to perform statistical analysis. This package includes, standard deviation and probability, while mean and variance are calculated in ANOVA. Significance was set to $p < 0.05$ and $p < 0.01$ levels. **Results:** Observing results in S.J. we noticed a small decrease in the average value of speed $V_{\max} = VT_2 - VT_1 = 2.2540 - 2.2624 = -0.0124$ m/s. This average speed value is compensated by value maximal of the high jump. This impact with a different sense in this case comes as a result of not being well coordinated in pushing, increasing total maximal force per mass unit by 0.42KN from the first to the second test and the average increase in total max power with 0.1KW. **Conclusions:** The results of our study showed that in artistic gymnastics among gymnasts, strength (especially the relative one) with forms of its manifestation, without underestimating other movement and coordination skills, is one of most important physical skills.

Key Words: exercise, physical preparation, artistic gymnastics, force, training methodology

Introduction

The high level of artistic gymnastics in the world is based on movement and technical skills. The breakdown of this binomial in practical field and the evaluation of preparation in quality gymnast, make it possible to perfect movement skills in unity with the technical preparation (Jemni, M., 2018).

The wide culture of movements, synthesized in the quality of execution, demonstrated by gymnasts with high sports level, are not only product of quality of training process organized by trainers, but also the product of a fair and accurate coordination of content in training process with all its components (Asadi, A., et al., 2017).

In artistic gymnastics, training is organized by coaches and implemented by gymnasts, where they work together to get a high sports result. The most effective forms and methods used in this process give highest sporting result (Arkaev, L., & Suchilin, N. G. 2009).

Modern training theories of gymnasts are guided by new concepts of the training process, which include a broader understanding of the content of training methods, adaptation of movement skills, which guarantee success, avoid any mistakes in training process, and significantly shorten the time of achieving sports result (Vieru N., 1997)(Meta, A. 2019).

Training in artistic gymnastics is an educational, scientific learning process, carried out in the progressive repetition of loads that cause the development of the gymnast's movement, psychological, technical and tactical skills in increasing sports performance. It is a multi-year systematic activity that grows progressively and individually (Pion, L. 2015) (Potop, V., et al., 2015).

Training in artistic gymnastics is carried out through training loads, which affect, according to the purpose, moving, technical, tactical, health and psychological components. During stages of sports training, this effect focuses on improvement of execution ability. Execution means the unity between it and the result, of one or more moving actions, the work done in a certain time that is expressed with a controllable result, through defined evaluation procedures (Grigore, V., 2001) (Atikovic, A., et al., 2017).

In artistic gymnastics, sports performance expresses a harmonious union of the capacity movement skills with movement preparation, where a dominant place is occupied by strength and its skills. The sport of artistic gymnastics contains many technical elements, performance of which requires strength (Potop, V., 2014).

Strength training program begins after gymnast has consolidated the basics of sports technique. The increase in strength indicators affects not only maximum use of the skills that athlete has, but also enables the execution of technical elements (Girard, J., et al., 2018) (Jorgoni, A. 2007) (Böning, D., et al., 2017).

Gymnasts in order to increase the high level of sportsmanship, must mainly develop dynamic, static, stable strength, as well as other movement skills. Strength is one of the most important movement skills for gymnast. It is characterized by peculiarity of the muscles to develop stresses of different sizes during the performance of gymnastic exercises. Without using active strength of the muscles, no exercise, no matter how easy it is, can be performed (Potop, V., et al., 2013).

It is important that gymnast knows how to use ability of strength in relation to the concrete movement task, or in relation to structure of element to be performed. So, appearance of muscular strain is closely related to the ability of gymnast to deliver force at necessary speed, at the right time (Mkaouer, B., et al., 2018) (Isla, S., et al., 2022) (Barreto, P. M., et al., 2016).

Different authors distinguish fast force as fast explosive force or as fast impulsive force. By explosive strength, we mean ability of nerve-muscular actions, in shortest possible time (Feeney, D., et al., 2016).

Load and large number of exercises in artistic gymnastics are carried out with the arms and legs, where the explosive force in these extremities is a nerve-muscular capacity of special importance (Cretu, M., & Mihăilă, I. 2012)) (Bogdanis, C., et al., 2019).

Development of explosive strength is achieved through improvement of different movement habits, bearing in mind that each movement is characterized by a specific contraction regime. Over the years of training, increase in sports quality forces us to choose training tools more and more related to the performance model of gymnasts (Marina, M., & Jemni, M. 2014) (Kaufmann, S., et al., 2022).

Explosive force means maximum neuromuscular engagement, through which maximum acceleration of body mass or its separate parts is achieved, in shortest possible time. The understanding of power, with its components speed and strength, allows us to distinguish the type of strength fast, where speed dominates and type of explosive force, where strength dominates (Kosova, S., et al., 2022) (Ramirez-Campillo, R., et al., 2013).

In sports literature, explosive strength is usually treated as power. Power ability and its types (speed-strength and power endurance) are dominant for the physical condition of the gymnast. Based on this dependence, it is a requirement that every strength program be assigned loads that stimulate these abilities. Their development is preceded by the transition to a higher level of lactic and no lactic energy capacities. According to this physiological and biomechanical mechanism, trainer must design different strength programs (Romero, C., et al., 2021).

Purpose of study

To determine most successful methodologies for further improvement physical skills of gymnasts, as a starting point for raising the sports level.

Material & methods

In this study, twenty-four male gymnasts from six sports clubs in different cities of Albania, who are participants in gymnastics competitions at the national level and four of them at the international level, were analyzed. Testing with male gymnasts was carried out in period beginning September 2023 (first measurement), end of November 2023 (second measurement). Measurements were made with the same methodology in both periods. The tests were carried out in the laboratory of the Sports Scientific Research Center at the Tirana University of Sports. Environment temperature was 23°C.

Used equipment

🌀 Leonardo Mechanography (GRFP)

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



Figure 1. Leonardo Mechanography (GRFP)

🌀 Computer.

Strength tests in lower limbs

1-Jump up from position with half-bent legs, hands in middle of the body, (Squat Jump, (Petrigna, L., et al., 2019). In figure 2, the standard way of jumping from half-bent knee position is shown.

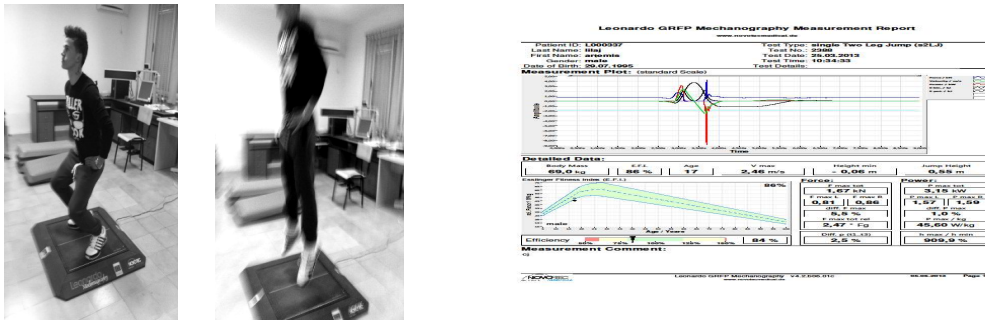


Figure 2. Jump model S.J.

2- From a standing position with hands in middle of the body, jump with a counter movement up (Counter Movement Jump), (Petrigna, L., et al., 2019).

♦ Type: Performance (Power Test).

♦ Movement: Common Jump (CMJ) for maximum height (manual platform).

In figure 3, the standard way counter movement up jump for maximum height is shown.

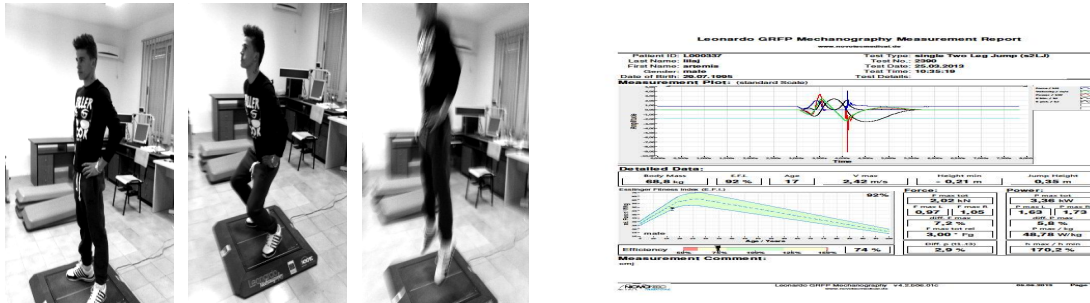


Figure 3. Jump model counter movement jump (C.M.J)

In SJ and CMJ tests measured:

- V max m/s - displacement speed of the center of mass
- Jump Height m. - jump height.
- F max tot k N - maximum total force
- P max tot kW - maximum total power
- F max tot rel.* F g - maximum total relative force
- P max / kg W/kg - relative maximum total power
- Efficiency % - how much the technique is used
- E.F.I. % - state of physical preparation

3- Drop jump. (D.J.) From standing on a spot (chair) 50 cm high, fall on the platform with straight legs and immediately jump up with the tips of the feet.

♦ Type: Ground contact time / speed test.

♦ Movement: Descending on platform from a certain height (chair, spot) and trying to jump as fast as possible and as high as possible. This test performed in sports has a very specific parameter the important thing is the combination of contact time and time of flight in the air (less contact time, the better).

♦ Field of application: Test D.J. is mainly used in sports (platform manual).

In Figure 4, standard drop jump mode is shown.

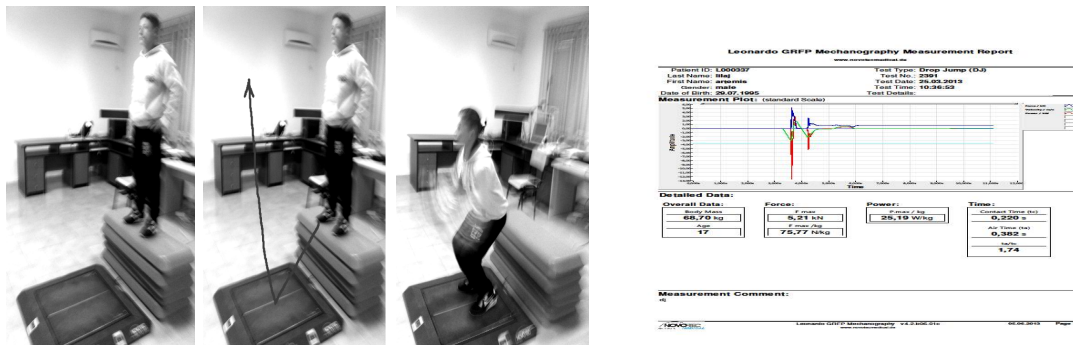


Figure 4. Drop jump mode

The test measured:

- F max k N	- maximum total force
- P .max / kg W/kg	- maximum total power
- F max /kg N/kg	- maximum force per body weight
- t a / t c	- ratio of flight time to contact time
- Air Time (ta) s	- flight time
- Contact Time (t c) s	- contact time

Methodology development of physical skills of gymnasts

Gymnasts competing at the highest levels, should be "light" weight. For this reason, coaches are very careful in strength training because it is an important skill motors in artistic gymnastics.

In Table 1, shown methodology exercises preparation physical was realized for three months to gymnasts take of the study (A., G., F., a. g., 2020).

Table 1. Methodology preparation physical to gymnasts

Training to develop	hypertrophy maximum and minimum	
	Maximum hypertrophy	Minimum hypertrophy
Intensity (%)	60 - 80%	85 - 100%
Number of repetitions	6 - 20x	1 - 5x
Series	3 - 6	5 - 12
Resting between series (min.)	2 - 4	4 - 5
Speed concentric (series)	1 - 10	1 - 4
Speed eccentric (series)	4 - 10	3 - 5
The duration of the series (sec.)	40 - 70	< 20

The data in Table 1, we see that two types of strength training, performed the gymnasts are specific exercises for artistic gymnastics. This means that gymnasts perform strength exercises, which hypertrophy muscles, but not increase maximum strength rather than sustainability in force.

To a part of gymnasts, were conducted strength exercises with weights two to three times a week. These gymnasts are not increased in weight compared with the other gymnasts, on the contrary, their weight was slightly less than those who do not perform these exercises strength.

Exercises preparation physical and special place three times a week alternating, a physical preparation day, another special day. They were carried at the end of the preparatory part training.

During training, the plyometric leg training program was developed three times a week for ten weeks, (Slimani, M., et al., 2016), which are shown in table 2 as follows:

Table 2. Plyometric training program

Week	Plyometric training program Number of sets × number of rebounds
1-3	Standing vertical hops 2 × 10
	Single foot hops 4 × 8
	Counter movement jumps 3 × 5
	Multiple two-foot hurdle jumps (hurdle height 0.55 m) 6 × 6
	Depth jumps (drop box height 0.20 m) 3 × 6
4-6	Lateral two-foot jumps 2 × 10
	Two-foot jumps 4 × 8
	Counter movement jumps 3 × 5
	Multiple two-foot hurdle jumps (hurdle height 0.65 m) 6 × 6
7-10	Depth jumps (drop box height 0.30 m) 3 × 6
	Two-foot jumps forward and backward: 2 × 10
	Single foot jumps 2 × 8 on each foot
	Counter movement jumps 3 × 5
	Multiple two-foot hurdle jumps (hurdle height 0.76 m) 6 × 6
	Depth jumps (drop box height 0.40 m) 3 × 6

Exercises special preparation

Special preparation is exceptional value in the acquisition of gymnastic techniques, as exercises selected for this purpose, not only are similar from the standpoint of nerve-muscular strain, but above all, with technique self of performing elements in kind different many gymnastic competitions (A., G., F. a. g., 2020).

Exercises special preparation were for ten weeks. Dosage load calculated by the amount of tools in part basic to training.

Table 3. Methodology of special exercises

Floor exercises:	Pommel horse:	Ring:
• Run combined with jumps in diagonal. • Round of -flic row. • Back somersault, flic, back somersault. • Flic, back somersault, flic. • Tempo row. • Front somersault row.	• Scissors. (amount in time) • Amounts double leg circle in various parts of the horse. • Transportation, front and back, the horse lengthwise without pommels. • Combination with the more simple elements.	• Combination with 6-8 strength elements.
Vault:	Parallel bar:	High bar:
• Run 20-30m sprint. • Push the feet and hands from different positions.	• All press to handstand. (straddle, folded, swing) • Handstand up and down. • Up rise with swinging front (back) row from support on the arms. • Swinging hands over row times.	• Combination with the amount of elements of group A and B.

Exercises special preparation were included at half preparatory training by developing motor qualities to gymnasts at high level until the execution of gymnastic exercises as well.

Statistical method

Through method of statistical processing, we systematized and reflected the progressive results of the 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) was calculated by ANOVA method according to general formula: = AVERAGE (Date).
- Standard deviation (SD) was calculated with EXEL 2015 method, with the general formula of EXEL = STDEV (Data).
- Coefficient of variance (CV) was calculated using ANOVA method, theoretically it is calculated using the formula: $CV (\%) = (SD / X) * 100$. The change that occurs within a period (condition), depending on time, height, distance, etc.
- Probability (P) is calculated using EXEL 2015 method, which is a real number between 0 and 1.

In Excel 2015, "Data Analysis" package was used to perform statistical analysis. The "Data Analysis" package is an additional Microsoft package, which was activated by the user when we needed statistical analysis. In study, this package includes standard deviation and probability, while average and variance are calculated in ANOVA.

Results

The content results of indicators movement preparation fully explains all practical experimental activity with gymnasts, giving corresponding results.

Leg push tests

Experimentation, data comparison in three standard jumps (SJ, CMJ, DJ), took a major place in the study. Leonardo Mechanography Platform (GRFP) gave us important results during two periods of experimentation which are reflected in tables 4-9 as below follows:

Table 4. Jump results from half bent leg position (S.J.)

SJ	Vmax m/s	Vmax m/s	Jump Height m	Jump Height m	Fmax tot kN	Fmax tot kN	Pmax tot kW	Pmax tot kW
	T1	T2	T1	T2	T1	T2	T1	T2
A. N.	2,22	2,18	0,53	0,59	1,64	1,35	2,95	2,40
A. L.	2,46	2,54	0,55	0,64	1,67	1,22	3,15	2,72
A. B.	2,11	2,04	0,56	0,59	1,23	1,01	2,21	1,59
B. R.	2,10	2,41	0,51	0,37	1,09	1,55	1,80	2,88

E. K.	2,58	2,58	0,53	0,53	1,57	1,57	3,30	3,30
F. T.	2,54	2,46	0,64	0,55	1,22	1,67	2,72	3,15
23	2,41	2,10	0,37	0,51	1,55	1,09	2,88	1,80
24	2,55	2,63	0,59	0,69	1,37	1,39	2,94	2,99
Average	2.2664	2.254	0.53	0.565	1.45	1.87	2.69	2.79
Dev. Stand.	±0.209	±0.2083	±0.091	±0.096	±0.20	±1.98	±0.47	±0.47
Variance	0.043	0.043394	0.008	0.009	0.04	3.92	0.22	0.23
Probability		p < 0.001		p < 0.05		p < 0.01		p < 0.01

Table 5. Jump results from half bent leg position (S.J.)

SJ	F max tot rel.* F g	F max tot rel.* F g	P max / kg W/kg	P max / kg W/kg	Efficiency %	Efficiency %	E.F.T. %	E.F.T. %
	T1	T2	T1	T2	T1	T2	T1	T2
A. N.	2,10	2,10	42,67	42,67	81	81	71	71
A. L.	3,00	2,38	48,78	50,52	74	87	92	92
A. B.	2,33	2,05	43,55	36,48	85	79	83	83
B. R.	2,06	2,06	36,53	36,53	85	85	73	73
E. K.	2,16	2,56	45,92	48,92	84	94	76	86
F. T.	1,98	2,26	43,79	48,44	87	85	72	72
23	2,52	2,52	44,82	44,82	79	79	83	83
24	2,19	2,98	43,34	43,76	79	86	72	81
Average	2.3304	2.41148	43.33	44.963	78.44	82.74	75.8	79.2592
Dev. Stand.	±0.2619	±0.28368	±5.471	±5.3247	±9.535	±7.3463	±9.264	±9.167
Variance	0.0686	0.08047	29.93	28.352	90.92	53.968	85.833	84.0455
Probability		p < 0.001		p < 0.001		p < 0.01		p < 0.01

Table 6. Results of counter movement jump (C.M.J.)

CMJ	V max m/s	V max m/s	Jump Height m	Jump Height m	F max tot k N	F max tot k N	P max tot kW	P max tot kW
	T1	T2	T1	T2	T1	T2	T1	T2
A. N.	2,42	2,42	0,35	0,35	1,52	1,52	3,15	3,15
A. L.	2,42	2,82	0,35	0,48	2,02	1,64	3,36	3,54
A. B.	2,39	2,24	0,39	0,30	1,34	1,33	2,54	2,42
B. R.	2,19	2,19	0,36	0,36	1,00	1,00	1,82	1,82
E. K.	2,62	2,62	0,40	0,60	1,40	1,57	3,04	3,64
F. T.	2,54	2,72	0,41	0,47	1,23	1,51	2,77	3,29
23	2,52	2,52	0,40	0,40	1,53	1,53	2,77	2,77
24	2,62	2,34	0,45	0,64	1,45	1,62	2,92	2,92
Average	2.456	2.456296	0.39	0.4474	1.51	1.607	2.87	3.014
Dev. Stand.	±0.2259	±0.1830	±0.071	±0.106	±0.28	±0.328	±0.54	±0.545
Variance	0.05107	0.033524	0.005	0.0113	0.07	0.107	0.29	0.297
Probability		p < 0.001		p < 0.05		p < 0.01		p < 0.01

Table 7. Results of ounter movement jump (C.M.J.)

CMJ	F max tot rel.* F g	F max tot rel.* F g	P max / kg W/kg	P max / kg W/kg	Efficiency %	Efficiency %	E.F.T. %	E.F.T. %
	T1	T2	T1	T2	T1	T2	T1	T2
A. N.	2,10	2,10	42,67	42,67	81	81	71	71
A. L.	3,00	2,38	48,78	50,52	74	87	92	92

A. B.	2,33	2,05	43,55	36,48	85	79	83	83
B. R.	2,06	2,06	36,53	36,53	85	85	73	73
E. K.	2,16	2,56	45,92	48,92	84	94	76	86
F. T.	1,98	2,26	43,79	48,44	87	85	72	72
23	2,52	2,52	44,82	44,82	79	79	83	83
24	2,19	2,98	43,34	43,76	79	86	72	81
Average	2.3304	2.41148	43.33	44.963	78.44	82.74	75.8	79.2592
Dev. Stand.	± 0.2619	± 0.28368	± 5.471	± 5.3247	± 9.535	± 7.3463	± 9.264	± 9.167
Variance	0.0686	0.08047	29.93	28.352	90.92	53.968	85.833	84.0455
Probability		$p < 0.001$		$p < 0.001$		$p < 0.01$		$p < 0.01$

Table 8. Results in drop jump (D.J.)

DJ	F. max. k N	F.mak. k N	P. W/kg	P. W/kg	F. max /kg N/kg	F. max /kg N/kg
	T1	T2	T1	T2	T1	T2
A. N.	2,80	3,60	25,85	27,45	38,01	46,38
A. L.	5,21	5,42	25,19	35,79	75,77	75,77
A. B.	2,85	2,89	27,34	27,34	48,88	48,88
B. R.	1,98	2,74	19,70	34,46	40,38	40,38
E. K.	2,76	2,76	38,06	38,06	41,79	41,79
F. T.	2,92	4,46	36,16	39,52	46,28	53,47
23	3,22	3,22	41,02	42,05	52,14	52,14
24	2,64	3,85	32,05	40,97	39,27	60,03
Average	3.2245833	3.79963	28.9842	35.49	49.37416	55.1148
Dev. Stand.	± 0.8646737	± 0.836648	± 7.5841	± 11.61823	± 11.61383	10.7411
Variance	0.7476607	0.699981	57.5186	134.9832	134.8811	115.371
Probability		$p < 0.001$		$p < 0.001$		$p < 0.001$

Table 9. Results in drop jump (D.J.)

DJ	ta / t c	ta/ t c	Air time (ta) s	Air time (ta) s	Contact time (t c) s	Contact time (t c) s
	T1	T2	T1	T2	T1	T2
A. N.	1,45	1,34	0,439	0,453	0,303	0,249
A. L.	1,74	1,74	0,382	0,391	0,220	0,220
A. B.	1,66	1,66	0,428	0,448	0,257	0,247
B. R.	1,13	1,33	0,38	0,426	0,341	0,241
E. K.	1,92	1,92	0,541	0,541	0,281	0,281
F. T.	2,02	2,83	0,499	0,531	0,248	0,226
23	2,34	2,34	0,511	0,511	0,219	0,219
24	1,56	2,61	0,520	0,567	0,333	0,181
Average	1.64	1.74	0.4487	0.4811	0.2816	0.2465
Dev. Stand.	± 0.40	± 0.50	± 0.0699	± 0.0768	± 0.0509	± 0.0495
Variance	0.16	0.25	0.0048	0.0059	0.0026	0.0024
Probability		$p < 0.001$		$p < 0.01$		$p < 0.05$

Discussion

Observing results in S.J. we noticed a small decrease in the average value of the speed $V_{\max} = VT_2 - VT_1 = 2.2540 - 2.2624 = -0.0124$ m/s. This average value in speed is compensated by maximum value of the height jump where, $H_{\text{av.}} = HT_2 - HT_1 = 0.565 - 0.53 = 0.035$ m. This impact with a different sense in this case comes as a result of not being well coordinated in pushing, increasing force maximum total per unit mass 0.42KN from the first test to the second and the average power lift total max. 0.1KW. The preparation exercises used for this skill have influenced the increase in muscle hypertrophy in the leg muscles, despite the weight loss in the gymnasts in the second test. The total maximum relative power has a significant average change in value of 0.051 per kg/weight. Change in negative values has relative maximum power with -0.061w/kg, which comes as a result of the decrease in speed. Efficiency has an average increase: $E = ET_2 - ET_1 = 79.37 - 76.28 = 3.09\%$. This difference in

group is relatively low, but observing the general results, we notice that 7 gymnasts have an efficiency of 88% - 92%, the others have low efficiency. This difference is also shown by the variance, which changes in both tests: $T2-T1=85.93 - 62.12=23.81$. The technique in this case was not well used by 16 gymnasts, as the efficiency indicator in % shows how many gymnasts use the technique in the test. E.F.I. degree of physical preparation in this test varies: $E.F.I. \text{ av.} = E.F.I.T2-E.F.I.T1 = 74.037 - 71.36 = 2.697\%$, which is low. So, the general and special physical preparation for this skill must be developed with higher requirements, to achieve good results. Probability $p<0.001$ is found in V max., F. and P. max relative total, which show that the possibility of change in these indicators is very small. To F. and P. max total, Efficiency, E.F.I. the probability is $p<0.01$ and jump height (H) $p<0.05$, which show the possibility of change and good values, especially in the second case, in the jump height. In figure 5, data in S J are reflected, jumping up from position with legs half bent, hands in middle body.

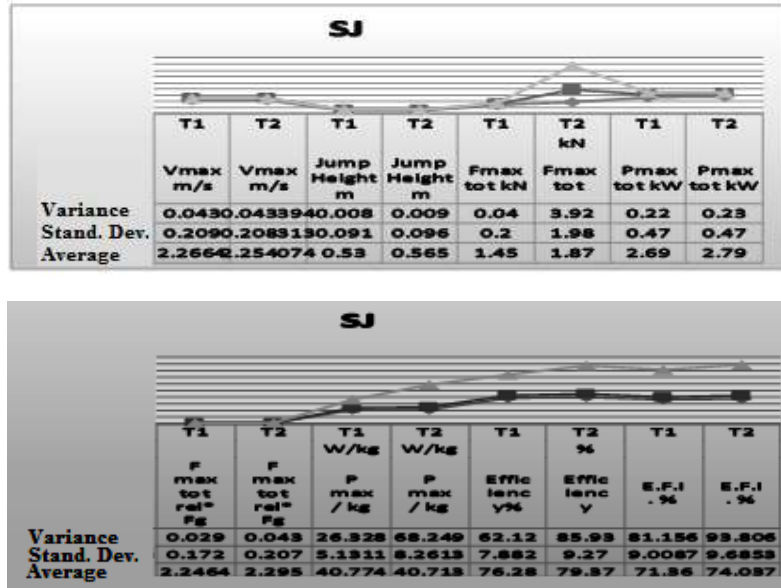


Figure 5. Data in Squat jump

In counter movement jump test performed on Leonardo Mechanography Platform (GRFP) are given see a small increase in average speed of breakaway jump is observed: $V_{max}=V_{T2}-V_{T1}=2.4563-2.4560=0.0003$ m/s. This average increase is offset by significant increases in jump height: $H_{mes.}=H_{T2}-H_{T1}=0.4474 - 0.39=0.0574$ m. The increase in speed and height has come as a result of the increase in F_{max} .total and P_{max} .total with probability $p < 0.01$ in both cases and with increasing changes. $F_{max}=F_{T2}-F_{T1}=1.607-1.51=0.097$ KN and $P_{max}=P_{T2}-P_{T1}=3.014 - 2.87=0.144$ KW.

Relative total F_{max} (Fg) and relative total P_{max} (W/kg) have a good positive difference per mass unit. $F_{max} \text{ t. relative}=F_{T2}-F_{T1}=2.411-2.33=0.081$ Pg. Probability $p < 0.001$. Change in elevation. $P_{max} \text{ t. relative} = P_{T2}-P_{T1}=44.963 - 43.33=1.63.3$ W/kg Probability $p < 0.001$. Change in landing. Efficiency and E.F.I. have a positive change, but low in %. $E. \text{ av.} = E_{T2}-E_{T1}=82.74-78.44=4.3$ %. E.F.I. between = $E.F.I.T2-E.F.I.T1 = 79.26 - 75.8 = 3.46$ %.

In figure 6, data for D.J. test are given. In this test we note the important relationships between: F_{max} kN (maximum total force), P_{max} / kg W/kg (maximum total power, F_{max} /kg N/kg (maximum force per body weight), ta/tc flight time ratio (Air Time) (ta) s with contact time (Contact Time) (tc) s. Maximum strength has increased maximum action. $F_{max}=F_{maxT2} - F_{maxT1}= 3.799 - 3.224= 0.575$ kN.

Standard deviation and variance have a decrease and probability with possibility of a small change $p<0.001$. The total maximum power, $P. \text{ max} = P_{T2}-P_{T1}=35.49 - 28.984= 6.506$ W/kg, has a significant increase per unit mass, despite the $p<0.001$ probability being small for the possibility of change.

Results of max. total strength have gone in parallel with the results of maximum strength per body weight. $F_{max}/kg= F_{T2} - F_{T1}=55.115-49.374= 5.741$ N/kg. Reduction of the contact time has influenced the increase of flight time. This is also observed in the probability where T.c. it is $p<0.005$ and in T.a. is $p<0.01$. The results are opposite, T.c. has a decrease, $T.c.=T.c.T2- T.c.T1=0.2465-0.2816 = - 0.0351$ sec. and Ta. flight time has an increase, as well as the height of the jump $T.a.=T.a.T2- T.a.T1=0.4811- 0.449=0.362$ sec.. The ratio Ta/Tc undergoes an average increase of 0.1 from the first measurement to the second. This difference, as we pointed out above comes as a result of a decrease in contact time and an increase in flight time, despite the fact that changes come in rise (0.09). The probability is small $p<0.001$.

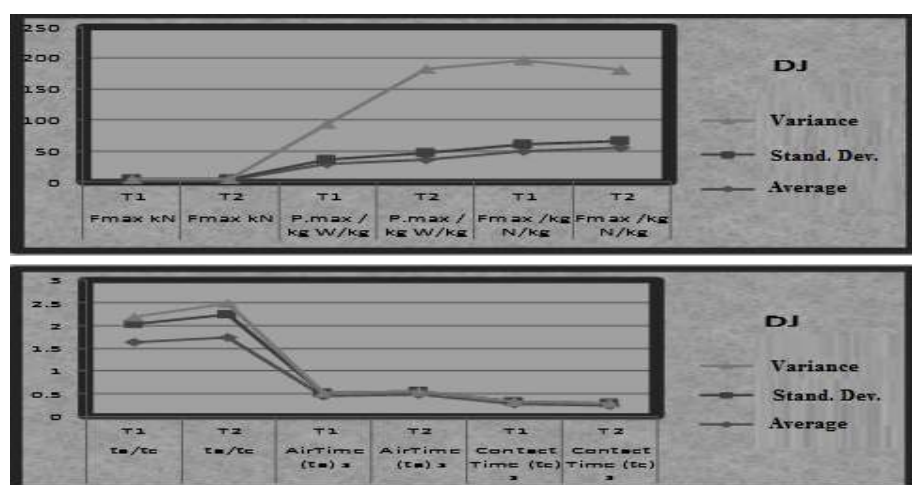


Figure 6. Data in drop jump

Conclusions

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

- Physical preparation is a necessary component for preparation of quality sportsman in artistic gymnastics. (Sands, W. 2017).
- The effects of physical preparation derive from the time and preoccupation devoted to it. Skills of gymnasts obtained in our study were found in this order: 4 were at a good level, other 14 were at an average level and 6 were poor.
- The measurement of SJ, CMJ and DJ gives us valuable information on strength and speed in programming of muscle work. In artistic gymnastics, many elements require this skill. For this reason, coach gives priority to one or other training component, favoring their situation. For our subjects it is concluded below sub average level of strength in lower limbs.
- The results of our study showed that in artistic gymnastics among gymnasts, strength (especially relative) with forms of its manifestation, without underestimating other movement and coordination skills, is one of most important physical skills.
- Physical preparation is the basis for high results. Its preparation and progressive development are evaluated as a special component in the annual training macro cycle, and it is accompanied by complex tests, through which level of training is determined, for achieving satisfactory results in various activities (Bacciotti, S., et al., 2017).

Conflicts of interest

The authors state that they have no conflict of interest.

Acknowledgments

Authors would like to acknowledge contribution of all study participants, male gymnasts from six sports clubs in different cities of Albania, coaches and clubs administrators, without their support completion of this study wouldn't have been possible.

References:

- Arkaev, L., & Suchilin, N. G. (2009). "Gymnastics". *How to create champions*. Meyer & Meyer Verlag, pp. 19.
- Atikovic, A., Kalinski, S. D. & Ćuk, I. (2017). "Age trends in artistic gymnastics across world championships and the Olympic Games from 2003 to 2016". *Science of Gymnastics Journal*, 9(3), pp. 251-263.
- Asadi, A., Arazi, H., Ramirez-Campillo, R., Moran, J., & Izquierdo, M. (2017). "Influence of maturation stage on agility performance gains after plyometric training: a systematic review and meta-analysis". *J Strength Cond Res*, 31(9), pp. 2609–2617. <https://doi.org/10.1519/JSC.0000000000001994>.
- Author group. A.G.F. (2020) Annual training program of gymnasts. *Buletin 1*, pp. 25-31.
- Bacciotti, S., Baxter-Jones, A., Gaya, A., & Maia, J. (2017). "The physique of elite female artistic gymnasts: A systematic review". *Journal of Human Kinetics*, 58, pp. 247-259. <https://doi.org/10.1515/hukin-2017-0075>.
- Barreto, P. M., De Moraes, M. G., Zanini, G. S., Neiva, C. M., Terra, G., Filho, D., Maffei, W. S., & Verardi, C. (2016). "Associated factors between the state of anxiety and a specific gymnastics skill with environmental variations". *Journal of Physical Education and Sport*, 16(1), pp. 187 – 191. <https://doi.org/10.7752/jpes.2016.01029>.

- Bogdanis, G.C., Donti, O., Papia, A., Donti, A., Apostolidis, N., & Sands, W. A. (2019) "Effect of plyometric training on jumping, sprinting and change of direction speed in child female athletes". *Sports*, 7, p. 116. <https://doi.org/10.3390/sports7050116>.
- Böning, D., Maassen, N., & Steinach, M. (2017). "The efficiency of muscular exercise". *German Journal of Sports Medicine*, 68 (9), pp. 203-214. <https://doi.org/10.5960/dzsm.2017.295>.
- Cretu, M., & Mihăilă, I. (2012). "Acrobatic Training of Junior Athletes in Gymnastics". *Procedia - Social and Behavioral Sciences*, 46, pp. 4165-4168. <https://doi.org/10.1016/j.sbspro.2012.06.219>.
- Feeney, D., Stanhope, S. J., Kaminski, T. W., Machi, A., & Jaric, S. (2016). "Loaded vertical jumping: Force-velocity relationship, work, and power". *J. Appl. Biomech.*, 32 (2), pp. 120-127. <https://doi.org/10.1123/jab.2015-0136>.
- Girard, J., Feng, B., & Chapman, C. (2018). "The effects of high-intensity interval training on athletic performance measures: a systematic review". *Physical Therapy Reviews*, 23 (2), pp. 151-160. <https://doi.org/10.1080/10833196.2018.1462588>.
- Grigore, V. (2001). "Gimnastica artistica". *Bucuresti: Editura Semne*.
- Isla, S., Athanasios, S., & Andronikos, G. (2022). "Investigating the reasons for dropping out by competitive artistic gymnastics". *Journal of Physical Education and Sport*, 22 (7), pp. 55 – 66. <https://doi.org/10.7752/jpes.2022.01007>.
- Jemni, M. (2018). "The Science of Gymnastics". *Advanced Concepts 2nd Edition. Routledge, Francis and Taylor Grp*, pp. 51-53.
- Jorgoni, A. (2007). "Methodology of strength training". *SHBLU. Tirane*, vol. 1 pp. 35, 38-43.
- Kaufmann, S., Ziegler, M., Werner, J., Noe, C., Latzel, R., Witzany, S., Beneke, R., & Hoss, O. (2022). "Energetics of Floor Gymnastics: Aerobic and Anaerobic Share in Male and Female Sub-elite Gymnasts". *Sports Medicine – Open*, 8 (1), pp. 1-10. <https://doi.org/10.1186/s40798-021-00396-6>.
- Kosova, S., Beyhan, R., & Kosova M.K. (2022). "The effect of 8-week plyometric training on jump height, agility, speed and asymmetry". *Pedagogy of Physical Culture and Sports*, 26 (1), pp. 13-18. <https://doi.org/10.15561/26649837.2022.0102>.
- Marina, M., & Jemni, M. (2014). "Plyometric training performance in elite orientated pre-pubertal female gymnasts". *J Strength Cond Res*, 28, pp. 1015-1025. <https://doi.org/10.1519/JSC.00000000000000247>.
- Meta, A. (2019). "The method of preparation of young gymnasts". *SHBLU. Tirane, Monography*, pp. 39, 64-65, 73-77.
- Mkaouer, B., Hammoudi-Nassib, S., Amara, S., & Chaabène, H. (2018). "Evaluating the physical and basic gymnastics skills assessment for talent identification in men's artistic gymnastics proposed by the international gymnastics federation". *Biology of Sport*, 35(4), pp. 383-392. <https://doi.org/10.5114/biolSport.2018.78059>.
- Petrigna, L., Karsten, B., Marcolin, G., Paoli, A., D'Antona, G., Palma, A., & Bianco, A. (2019). "A Review of Countermovement and Squat Jump Testing Methods in the Context of Public Health Examination in Adolescence: Reliability and Feasibility of Current Testing Procedures". *Front Physiol*, 10, pp. 1384. <https://doi.org/10.3389/fphys.2019.01384>.
- Pion, L. (2015). "Talent in female gymnastics: A survival analysis based upon performance characteristics". *International Journal of Sports Medicine*, 36(11), pp. 935-940. <https://doi.org/10.1055/s0035-1548887>.
- Potop, V., Grad, R., & Boloban, V. (2013). "Biomechanical indicators of key elements sport equipment gymnastics exercises". *Pedagogies, psychology, medical-biological problems of physical training and sport*, 9, pp. 59-72. <https://doi.org/10.6084/m9.figshare.751559>.
- Potop, V., (2014). "Theory and practice in artistic gymnastics. Bucharest". "Discobolul" Publishing House, 20, pp. 68 -71, 204-213.
- Potop, V., Manole, C., Nistor, D., & Andreyeva, N.O. (2015). "Didactic technologies of learning the double back somersault on floor based on the biomechanical analysis of sports technique in women's artistic gymnastics". *Journal of Physical Education and Sport*, 15(1), pp. 120 – 127. <https://doi.org/10.7752/jpes.2015.01020>.
- Ramirez-Campillo, R., Andrade, D., & Izquierdo, M. (2013). "Effects of plyometric training volume and training surface on explosive strength". *J Strength Cond Res*, 27, pp. 2714-2722. <https://doi.org/10.1519/JSC.0b013e3 18280c9e9>.
- Romero, C., Ramirez-Campillo, R., Alvarez, C., Moran, J., Slimani, M., Gonzalez, J., & Banzer, W.E. (2021). "Effects of maturation on physical fitness adaptations to plyometric jump training in youth females". *J. Strength Cond. Res*, 35, pp. 2870-2877. <https://doi.org/10.1519/JSC.0000000000003247>.
- Sands, W. (2017). "Fitness level of high-level gymnasts". In M. Jemni (Hrsg.), *The science of gymnastics*, Oxon: Routledge. pp. 22- 25.
- Slimani, M., Chamari, K., Miarka, B., Vecchio, F., & Chéour, F. (2016). "Effects of Plyometric Training on Physical Fitness in Team Sport Athletes". A Systematic Review. *Journal of Human Kinetics*, 53(1), pp. 231 – 247. <https://doi.org/10.1515/hukin-2016-0026>.
- Vieru, N. (1997). "Manual of Sports Gymnastics". *Bucharest, Driada Publishing House*, 14, pp. 182-197.