THE EFFECTS OF GYMNASTICS TRAINING ON FLEXIBILITY AND STRENGTH IN CHILDREN

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Abstract
The aim of this study was to examine the effects of gymnastics training on flexibility and strength parameters of gymnasts. A total of 48 boys aged 5-7 years participated in this study voluntarily. Participants were randomly assigned to two groups (Experimental group n=24; age, height, weight and BMI 6.21±1.10 years, 114.18±19.98 cm, 22.38±4.09 kg, 15.85±1.59 kg/m², respectively; Control group n=24; age, height, weight and BMI (6.87±0.74 years, 114.18±19.98 cm, 22.38±4.09 kg, 15.90±2.72 kg/m², respectively). Standing Long Jump test (SLJ), Bent Arm Hang (BAH), Sit Ups in 30seconds Cruch (SUC), Sit and Reach Flexibility Test (SRF) and Static Flexibility (SF) tests were applied to the experimental and control groups. The training was applied to the experimental group three days a week for 12 weeks, each time for the duration of 90 minutes. A two-way Repeated Measure ANOVA (2×2) was used to test for interactions and main effects for time (pre-test vs. post-test) and group (experimental vs. control) on the dependent physical performance variables. Results showed that there was a statistically significant difference in the TSC and SR values of the experimental group from pre to post-tests (p<0.01, d=0.95, p<0.01, d=0.75, respectively). There were no significant differences in other parameters. According to post-test group difference results, experimental group participants performed better than those in the control group in terms of BAH, SUC, SLJ and SRF values (p<0.02, d=0.780; p<0.04, d=0.614; p<0.00, d=2.11 respectively). As a conclusion, gymnastic training program significantly improved strength and flexibility of gymnasts aged 5-7 years.

Keywords: *gymnastics, training, strength, flexibility, performance tests.*

INTRODUCTION

Artistic Gymnastics (AG) is a highly demanding sport that requires several motoric competencies at high levels within the framework of certain rules on its unique competition apparatus (Zhao et al. 2021). AG predominantly uses specific movements such as jumps, leg-arm swings and static-dynamic stances (Özer and Soslu, 2019a).

To perform certain techniques in AG properly, various combinations and repetitions of these movement groups are required (Dallas and Kirialanis, 2013). Moreover, AG athletes are expected to have sufficient flexibility in their muscles, tendons, ligaments, and joint capsules in order to perform these movements better (Özer and Soslu, 2019b; Moeskops et al. 2019). Flexibility, one of the most important motoric abilities that distinguishes AG from other sports (Sands et al. 2016), ensures the speed, quality and aesthetics of technical movements (Ivanov and Bardina 2021; Dolbysheva et al. 2022). Muscle flexibility relates to the maximum extent of motion in a joint or several joints, as well as the length of muscles that span these joints and facilitate bending movements. Individuals exhibit varying degrees of flexibility, especially in relation to variations in the length of their multi-joint muscles. Explosive power, in the same a direction, pertains to the capacity to rapidly generate intense muscle contractions in a sudden burst of activity. Studies have demonstrated that the most significant factors for a gymnast's performance are flexibility, defined as a painless range of motion (ROM), and explosive power. Douda et al. found specific morphological and physiologic features exhibited by top gymnasts, such as exceptional flexibility and explosive force. Consequently, these levels were notably elevated in elite gymnasts compared to non-elite gymnasts (Douda et al., 2002). Studies clearly indicate that flexibility of AG athletes is a significant feature that should be developed at the beginning of gymnastics training (Ivanov and Bardina, 2021).

The preschool years are a crucial period for the development of motor abilities. Thus, it is appropriate that early childhood education standards emphasize that the development and enhancement of motor skills should be a fundamental component of educational programs. While children may naturally develop basic motor skills as they grow, their full mastery of these skills can only be achieved in an environment that is suitable for their development (Gagen and Getchell, 2006). This environment should offer encouragement, opportunities for focused practice, and stimulating physical conditions that allow for the use of skills in various contexts. When it comes to enhancing children's motor skills, educators should consider the individual qualities of each child within a physical and social setting while engaging them in tasks that have specific objectives and require appropriate equipment. In this sense, two important points stand out. First, the preschool period is described as the best time to start flexibility and strength training. Learning various skills (Jemni et al., 2011), perfecting them (Sawczyn et al., 2016), and suddenly transitioning from a dynamic movement to a static one (Prassas et al., 2006; Price, 2014) are only possible in the presence of sufficient strength (Moeskops et al., 2019). Considering AG training, athletes perform more than 20 complex jumping skills during the floor series, pull-ups, rings, parallel bars, and uneven bars series (Marinšek and Pavletič, 2020). During these series of movements, athletes' legs need sufficient strength to tolerate forces that exceed their body weights, compounded by gravity and their own body mass (Gittoes and Irwin, 2012). Studies in the literature have demonstrated that developmentally appropriate strength training at an early age provides adequate and necessary strength (Gallahue and Ozmun, 2005). According to studies, children show significantly better improvements in explosive leg strength, upper body strength, abdominal muscle strength, endurance, and flexibility after participating in developmentally appropriate training (Madić et al., 2018). Especially regarding fundamental movement skills (e.g., running, jumping, and throwing), which children are expected to perform better before school age, the movement patterns applied in training become more prominent (Takamoto et al., 2003; Nakamura et al., 2011).

Thus, for athletes to perform different movement patterns that require various qualities, they need to make effective and efficient physical preparations (Kochanowitz et al., 2010; Lamošová et al., 2021). Other factors include the age at which athletes begin AG and compete (Sawczyn et al., 2016). Moreover, it is imperative for gymnasts to undergo regular training sessions on advanced technical movements to enhance their performance and participate in competitions (Kochanowicz et al., 2009; Clowes and Knowlesvol, 2013). The aim of this study was to investigate the impact of gymnastics training on the flexibility and strength parameters of gymnasts.

METHODS

The participants of the study were 48 children who voluntarily agreed to participate. Participants in the Experimental Group (EG) (n=24) had the following characteristics: age, height, weight, and body mass index (BMI) were 6.21 ± 1.10 years, 114.18 ± 9.98 cm, 22.38 ± 4.09 kg, and 15.85 ± 1.59 kg/m², respectively. In contrast, the participants in the Control Group (CG) (n=24) had the following characteristics: age, height, weight, and BMI were 6.87 ± 0.74 years, 114.18 ± 9.98 cm, 22.38 ± 4.09 kg, and 15.90 ± 2.72 kg/m², respectively. They had no chronic diseases, lower or upper extremity injuries, or medical or orthopedic problems in the hamstring, meniscus, ankle, shoulder, elbow, or wrist.

Before the data were collected, participants and their parents were informed about the benefits and possible risks of the study. An informed consent form (in line with the Declaration of Helsinki) was given to the parents of the participants to obtain their written consent for participation. The study protocol was approved by the Research Ethics Committee of Karamanoğlu Mehmetbey University (Approval No: 01-2022/12).

For anthropometric measurements children's body weights were recorded using a Gold Master GM-7175R Slim Fit brand weighing machine with a sensitivity of ±100 g, and their height was recorded using a Mesilife Mc-210 brand height meter with an error margin of ±0.5 cm.

Test of Bend-Arm Hang: In this test, participants stood under a round bar with a 2.5 cm diameter, hands shoulder-width apart, thumbs at the bottom, elbows above, with a front grip. They were assisted from their armpits until their chin rose above the bar line. The time elapsed until the jaw dropped belowthe bar was recorded. Two attempts were made, and the highest duration was recorded in seconds and split-seconds (Lamošová et al. 2021).

Test of Sit-Ups in 30 seconds Crunch: Lying on their backs, participants placed their hands together on the back of their necks, with their knees slightly pulled toward their stomachs (knees at 90 degrees flexion) and their feet completely on the mat. As they sat up, they were instructed to bring their elbows forward to touch their knees at the end of the movement. Throughout the entire movement, they were required to keep their hands joined behind their necks and ensure their shoulders touched the mat when returning to the starting position. On the "Start" command, they repeated this movement for 30 seconds, performing as many sit-ups as possible until the "Stop" command. At the end of the test, the total number of sit-ups was recorded (Katsanis et al., 2021).

Standing long jump test: The knees were bent, with the toes just behind the line, and the feet placed shoulder-width apart. The torso was leaned forward, and both legs simultaneously leaped as far as possible, while the arms were flung forward from backward. The test was performed twice, and the best result was written in centimeters (Kiuchukov et al. 2019).

Sit and Reach Flexibility test: A test bench with a length of 35 cm and a width of 45 cm was used, the upper surface extending 15 cm outside the surface where the feet rested. Participant leaned on the soles of their feet against the upright surface of the box, with their arms extended forward without bending their knees. The flexibility test measurements of the participants were carried out without shoes, and they remained stationary for 1-2 seconds at the furthest point where they could flex with both hands. The test was repeated twice. The best result was recorded in centimeters (González et al. 2020).

Static Flexibility test: The participants lay their faces down on the flat ground with their foreheads touching the ground. They held a2.5 cm diameter round bar with their hands and extend it up over their head without bending their arms, keeping their foreheads on the ground. The highest point they could hold the bar was recorded. At the end of 3 trials, the best result was recorded in centimeters (Aslam, 2018).

The training was administered to the experimental group three days a week (Wednesday, Saturday, and Sunday) for 12 weeks, with each session lasting 90 minutes. Stretching was performed for 10 minutes after a 10-minute low-intensity warm-up run before every training session. Following the general and specific warm-up, walking and jumping movements (such as tiptoe and heel walking, closed leg, bear, and rabbit jumps) were executed. To ensure proper execution of movements, the first week focused on adaptation, with gradual introduction to the forward roll technique. Over the subsequent two weeks, backward roll, handstand roll, cartwheel, round-off, and front handspring techniques were progressively and fully integrated into the training regimen. Strength and flexibility training programs were conducted after the technical training (refer to Table 1). Children's performance tests were conducted before and after the training program, and their results were recorded. Prior to the test, the protocol was explained by an expert to the children, with a demonstration provided. Potential errors were highlighted, and methods to prevent them were explained. After anthropometric measurements, a standard warm-up was performed, including a 5-minute run, a 5-minute passive stretching, and three maximum vertical jumps. A 5-minute rest followed the warm-up session. Tests, including Standing Long Jump (SLJ), Bend-Arm Hang (BAH), Sit-Ups in 30 seconds (SUC), Sit and Reach Flexibility (SRF), and Static Flexibility (SF), were administered to both experimental and control groups. Each child underwent the test twice, with the second trial conducted after a 5-minute passive recovery from the first. The best value from the tests was recorded. All tests were conducted at the same time of day (14:00-16:00) under standard environmental conditions (26±2°C and 75±4% relative humidity) and in the same order.

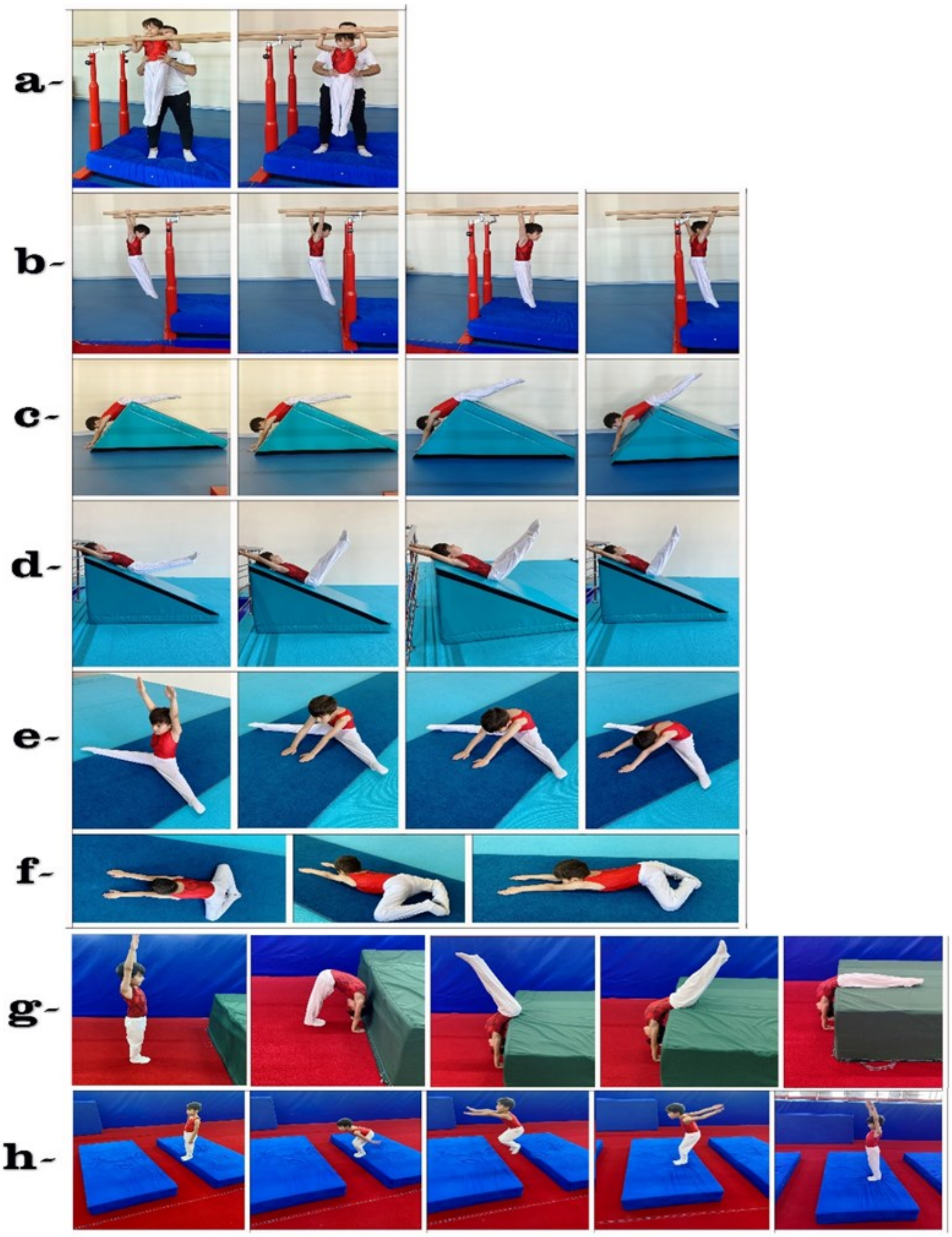

Figure 1. **a-**Assisted arm pull up bar **b-**Parallel bar hoist walking **c**–Reverse leg raise on cheese mat **d-**Leg raise on cheese mat **e**–Eagle leg stretch forward **f-**Squashed frog **g-**Bridge back from high mat **h-**Double leg jump between mats

Table 1
Training program

Week	**Main Training**	**Actions**	**Set/ Repeat**
1-2	Forward roll: Preparatory exercises to forward roll, assisted cradle rocking, cradle roll-off exercises, Incline assisted/unassisted forward roll, Forward roll assisted from elevation, Forward roll from elevation assisted/unassisted, forward roll exercises on flat ground, unassisted forward rolls, Backward roll entry exercise, assisted cradle, cradle roll-off exercises	Parallel bar hoist walking/ Leg raise on cheese mat /Reverse leg raise on cheese mat/Assisted arm pull up bar/ Squashed frog/Bridge back from high mat/Eagle leg stretch forward/Double leg jump between mats	2x3
3-4	Backward roll: Inclined assisted/unassisted backward roll, Assisted/unassisted backward rolls from elevation, Assisted/unassisted backward rolls on flat ground, Handstand work, robot exercises, Assisted/unassisted handstand exercises on the wall, Assisted/unassisted forward lunge exercises	Parallel bar hoist walking/Leg raise on cheese mat/Reverse leg raise on cheese mat/Assisted arm pull up bar/Squashed frog/Bridge back from high mat/Eagle leg stretch forward/Double leg jump between mats	2x4
5-6	Handstand: Assisted/unassisted handstand exercises on the wall, Assisted/unassisted handstand rolls by stepping on the wall, Assisted/unassisted handstand rolls from elevation, Inclined Assisted/unassisted handstand rolls, Assisted/unassisted handstand rolls on flat ground, Repetition of previous technical skills (Forward and backwards rolls)	Parallel bar hoist walking/Leg raise on cheese mat/Reverse leg raise on cheese mat/Assisted arm pull up bar/Squashed frog/Bridge back from high mat/Eagle leg stretch forward/Double leg jump between mats	3x4
7-8	Round-off: Assisted/unassisted hoop work round off exercises on the gymnastic beam, Inclined Assisted/unassisted hoop work round off exercises, Vertical assisted/unassisted hoop work from the pyramid frame, Round-off: Assisted/unassisted hoop work on the curved line, Assisted/unassisted hoop work on flat floor Cartwheel: assisted/unassisted single leg crossing card exercises on the gymnastic beam	Parallel bar hoist walking/Leg raise on cheese mat/Reverse leg raise on cheese mat/Assisted arm pull up bar/Squashed frog/Bridge back from high mat/Eagle leg stretch forward/Double leg jump between mats	4x4
9-10	Cartwheel: Inclined Assisted/unassisted cartwheel exercises, Vertical assisted/unassisted cartwheel exercises from the pyramid frame, Assisted/unassisted cartwheel exercises on the curved line, Assisted/unaided cartwheel exercises on flat ground, Repetition of previous technical skills (handstand and rolls),	Parallel bar hoist walking/Leg raise on cheese mat/Reverse leg raise on cheese mat/Assisted arm pull up bar/Squashed frog/Bridge back from high mat/Eagle leg stretch forward/Double leg jump between mats	4x5
11-12	Front handspring: Assisted/unassisted shoulder thrust exercises with high-frame hands on the ground, Assisted/unassisted shoulder thrust exercises from the trolley grip, Assisted/unassisted Front handspring exercises on flat ground, Repetition of previous technical skills, Repetition of previous technical skills, Repetition of previous technical skills.	Parallel bar hoist walking/Leg raise on cheese mat/Reverse leg raise on cheese mat/Assisted arm pull up bar/Squashed frog/Bridge back from high mat/Eagle leg stretch forward/Double leg jump between mats	5x5

Descriptive data were calculated for all variables, and the Shapiro-Wilk test was used to assess the normality of distributions. A two-way Repeated Measure ANOVA (2×2) was employed to test for interactions and main effects for time (initial vs. final) and group (training vs. control) on the dependent physical performance variables (BAH, SUC, SLJ, SRF and SF). ES was classified as follows: <0.2was defined as trivial; 0.2–0.6 was defined as small; 0.6–1.2 was defined as moderate; 1.2–2.0 was defined as large; >2.0 was defined as very large; and >4.0 was defined as extremely large (Soslu et al. 2022). Statistical analyses were performed in SPSS (SPSS, Version 25.0) and significance was determined at p<0.05.

RESULTS

The mean and standard deviation values of the motoric (SLJ, BAH, SUC, SRF, and SF) parameters of the training program, the effect level, and the significance levels of the training are presented in the tables below.

No statistically significant difference was found in the pre-test and post-test values of the control group (Table 2).

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The Experimental Group showed a statistically significant difference in the Sit-Ups in 30 seconds (SUC) and Sit and Reach Flexibility (SRF) values (p<0.01, d=0.95, p<0.01, d=0.75, respectively, Table 3). The effect size of the training on SUC and SRF values is moderate. The positive impact it has on flexibility is particularly beneficial for enhancing children's muscle flexibility improvements. While there were variations in some characteristics, these variations did not reach statistical significance.

When examining Table 4, it is apparent that there is a significant difference in Bend Arm Hang (BAH), Sit-Ups in 30 seconds (SUC), Standing Long Jump (SLJ), and Sit and Reach Flexibility (SRF) values, favoring the Experimental Group (EG) (p<0.02, d=0.780; p<0.04, d=0.614; p<0.00, d=2.11; p<0.00, d=2.11 respectively). The training program has a substantial impact (d = 2.11), especially on the SRF value of the EG. The disparity between the Control Group (CG) and the development of a significant motor skill, such as muscle flexibility, is evident and highly relevant when considering the impact of the training. Although the average disparities in other parameters favored the EG, these differences did not reach statistical significance

Table 2

Control group pre-post test height, weight, strength and flexibility averages

Variables	Group	N	Mean/SD	*MD*	*F*	p	*es*
Height (cm)	**CG Pre Test**	24	121.10±4.48	1.35	-0.88	0.38	0.280
	CG Post Test		122.45±5.15				
Weight (kg)	**CG Pre Test**		22.81±2.82	1.04	-1.04	0.30	0.338
	CG Post Test		23.83±3.31				
BMI (kg/m²)	**CG Pre Test**		15.90±2.06	0,22	-0.36	0.76	0.103
	CG Post Test		16.12±2.19				
BAH (sec)	**CG Pre Test**		0.18±0.01	0.57	-1.41	0.17	0.308
	CG Post Test		0.57±1.79				
SUC (number)	**CG Pre Test**		8.70±5.35	1.35	-0.72	0.47	0.230
	CG Post Test		10.05±6.32				
SLJ (cm)	**CG Pre Test**		96.30±7.98	0.00	1.18	0.24	0.374
	CG Post Test		91.05±8.39				
SRF (cm)	**CG Pre Test**		22.50±3.76	0.80	-0.61	0.54	0.194
	CG Post Test		23.30±4.46				
SF (cm)	**CG Pre Test**		20.50±4.27	0.35	-0.23	0.82	0.073
	CG Post Test		20.85±5.31				

*:p<0,05, BMI: Body Mass Index, BAH: Bent Arm Hang, SUC: Sit Ups in 30seconds Cruch, SLJ: Standing Long Jump Test, SRF: Sit and Reach Flexibility Test, Sf: Static Flexibility. MD: Mean differences, *es:* 0.2–0.6 small; 0.6–1.2 moderate; 1.2–2.0 large; >2.0 very large; >4.0 extremely large.

Table 3
Experiment group pre-post test height, weight, strength and flexibility averages

Variables	Group	N	Mean/SD	*MD*	*F*	p	*es*
Height (cm)	**EG Pre Test**	24	114.18±9.98	6.15	-1.40	0.17	0.402
	EG Post Test		120.33±8.16				
Weight (kg)	**EG Pre Test**		22.38±4.09	0.80	-0.70	0.51	0.191
	EG Post Test		23.18±4.26				
BMI (kg/m²)	**EG Pre Test**		15.85±1.59	0,05	-0.96	0,92	0.030
	EG Post Test		15.90±1.69				
BAH (sec)	**EG Pre Test**		2.74±4.63	1.55	-0.95	0.37	0.468
	EG Post Test		4.29±6.50				
SUC (number)	**EG Pre Test**		9.67±4.83	4.29	-2.62	**0.01**	0.945
	EG Post Test		13.96±6.40*				
SLJ (cm)	**EG Pre Test**		106.65±20.60	7.56	-1.19	0.23	0.344
	EG Post Test		114.21±23.25				
SRF (cm)	**EG Pre Test**		29.33±4.51	3.35	-2.59	**0,01**	0.747
	EG Post Test		32.68±4.45*				
SF (cm)	**EG Pre Test**		20.70±9.92	5.34	-1.77	0.82	0.522
	EG Post Test		26.04±10.51				

*:p<0,05, BMI: Body Mass Index, BAH: Bent Arm Hang, SUC: Sit Ups in 30seconds Crunch, SLJ: Standing Long Jump Test, SRF: Sit and Reach Flexibility Test, Sf: Static Flexibility. MD: Mean differences, *es*: 0.2–0.6 small; 0.6–1.2 moderate; 1.2–2.0 large; >2.0 very large; >4.0 extremely large.

Table 4
Experiment and control group post test height, weight, strength and flexibility averages

Variables	Group	N	Mean/SD	*MD*	*F*	p	*es*
Height (cm)	**EG Post Test**	24	120.33±8.16	2.12	-1.00	0.32	0.310
	CG Post Test		122.45±5.16				
weight (kg)	**EG Post Test**		23.17±4.26	0.66	-0.56	0.57	0.173
	CG Post Test		23.83±3.31				
BMI (kg/m²)	**EG Post Test**		15.90±1.69	0,22	-0,40	0,68	0.112
	CG Post Test		16.12±2.19				
BAH (sec)	**EG Post Test**		4.29±6.50	3.72	2.48	**0.02**	0.780
	CG Post Test		0.57±1.79				
SUC (number)	**EG Post Test**		13.96±6.41*	3.91	2.03	**0.04**	0.614
	CG Post Test		10.05±6.32				
SLJ (cm)	**EG Post Test**		114.21±23.25*	23.16	4.22	**0.00**	1.325
	CG Post Test		91.05±8.39				
SRF (cm)	**EG Post Test**		32.69±4.45*	9.39	6.96	**0.00**	2.110
	CG Post Test		23.30±4.46				
SF (cm)	**EG Post Test**		26.04±10.51	5.19	2.00	0.52	0.623
	CG Post Test		20.85±5.31				

*:p<0,05, BMI: Body Mass Index, BAH: Bent Arm Hang, SUC: Sit Ups in 30seconds Cruch, SLJ: Standing Long Jump Test, SRF: Sit and Reach Flexibility Test, Sf: Static Flexibility. MD: Mean differences, *es*: 0.2–0.6 small; 0.6–1.2 moderate; 1.2–2.0 large; >2.0 very large; >4.0 extremely large.

DISCUSSION

The study aimed to assess the extent to which a 12-week training program, implemented among athletes new to gymnastics, influences their motor characteristics, specifically strength and flexibility. It's acknowledged that children undergoing growth and development experience improvements in anthropometric and motor characteristics even without engaging in sports (Alves and Alves, 2019). Hence, analyzing the performance of children not participating in sports within the same age range is crucial in our study to emphasize the impact level of the training program applied to children experiencing similar growth effects.

Several studies indicate that training enhances technical capacities and contributes to improved scores (Arkayev et al., 2004; Kochanowicz et al., 2009; Clowes and Knowlesvol, 2013; Čeklić et al., 2022). Upon analyzing the Bend Arm Hang (BAH), Sit-Ups in 30 seconds (SUC), Standing Long Jump (SLJ), Sit and Reach Flexibility (SRF), and static flexibility (SF) values measured in the study, the post-test values of the experimental group demonstrated a statistically significant difference compared to the control group, indicating a significantly positive effect of the applied training program.

The significance of flexibility for coordinating movements is evident, and various studies have emphasized the importance of developing flexibility (Ivanov and Bardina, 2021; Holoviichuk et al., 2022). Previous research indicates that beginners, after only a short period of training, demonstrate greater variability in their progress through functional stages compared to experts (Busquets et al., 2011; Williams et al., 2015). Roth et al. suggested that motor skill performance in preschool children can be enhanced with an appropriate training program for boys and girls aged between 4 to 5 years (Roth et al., 2010). The preschool period is considered an ideal age for the development of basic movement skills, including those in gymnastics (Krneta et al., 2015).

According to the study, the mean flexibility of various muscle groups was found to be higher in children during the post-test compared to the pre-test ($p<0.05$). However, children exhibited the lowest levels of flexibility in certain muscle groups after completing a 6-week gymnastics training program, with these differences being statistically significant compared to pre-training levels (Das et al., 2018). Incorporating a static stretching exercise regimen alongside specific training durations led to improvements in flexibility across different muscle groups in children. Static stretching is commonly used in gymnastics training and conditioning programs to enhance joint mobility and overall flexibility, crucial for executing gymnastics routines. Stretching exercises are simple and effective techniques for maintaining flexibility while reducing the risk of injuries (Worrell et al., 1994).

Gymnasts typically commence training in early childhood, with specialization occurring soon afterward. The nature of acrobatic skills necessitates spine mobility, with serious stretching often beginning as early as 4 or 5 years old. Research specifically addressing flexibility in young children (i.e., 4–11 years) is limited, although literature on this topic is increasing. Exercises that develop children into backbend positions emphasizing hyperextension of the thoracic spine and shoulder hyperflexion are commonly used in gymnastics training to improve flexibility.

Notable developments in flexibility were observed in the experimental group in our study, aligning with the findings in existing literature regarding Sit and Reach Flexibility (SF) results.

Numerous studies, reviews, and meta-analyses have documented that pre-adolescents possess the capacity to enhance muscle strength through physical resistance exercise (Behringer et al., 2010; Chaouachi et al., 2014; Granacher et al., 2016). Studies demonstrate that after 6–8 weeks of resistance training, muscle strength can increase by 30–40%. Artistic gymnastics (AG) is a multifaceted sport involving technical skills across various events, necessitating repetitive and prolonged training in fundamental elements and basic positions. This demands coordination and the development of muscle strength, power, endurance, and a broad range of motion, particularly for executing uncommon positions seen in AG events.

During the performance of technical movements requiring significant force and static holds, the development of arm, abdomen, and hip flexor muscle strength is crucial. The experimental group likely experienced a positive increase in Sit-Ups in 30 seconds (SUC) and Bend Arm Hang (BAH) values due to enhanced arm, abdomen, hip flexor, and leg muscle strength from training. Long-term gymnastics training has been associated with increased torque of knee extensors but not knee flexors in prepubertal boys, consistent with our findings (Basa et al., 2002). Cross-sectional studies have also shown that long-term exercise loading induces muscle hypertrophy in trunk and upper extremity muscles in preadolescent athletes (Daly et al., 2004; Sanchis-Moysi et al., 2017).

Our study revealed a positive increase in Standing Long Jump (SLJ) values as a result of increased muscle strength from training. Plyometric training during preadolescence is suggested to be more beneficial for developing jumping performance compared to adolescence, indicating higher potential for improvements in muscle-tendon interaction during preadolescence (Moran et al., 2017). Long-term artistic gymnastics training during preadolescence is associated with increased muscle strength and jumping performance, with athletes benefiting more from muscle strength for improved jumping performance (Pentidis et al., 2020).

It's important to note that muscle strength can be influenced by body size, and children in the Control Group (CG) were taller and heavier. Individuals with higher body mass typically exhibit greater absolute strength. However, our study revealed that relative muscle strength was higher in children with lower body masses. Additionally, the increase in body weight in the control group negatively impacted their anthropometric structure.

Despite its contributions, this study has several limitations. Firstly, we did not track the children's daily unorganized activities and movements/inactivity, which could potentially influence their mastery of motor skills and skill development. Additionally, the number of participants in the study was relatively small, which may limit the generalizability of the findings. However, given the scarcity of information on the effectiveness of developmental gymnastics programs for varying skill levels and optimal motor characteristic development in children, this study and its results remain critical in filling this gap in the literature.

CONCLUSION

In conclusion, there was a significant improvement in the strength and flexibility characteristics of the children in the experimental group compared to the control group. The training program also played a significant role in fostering the development of coordinated movements in children. Specifically, the experimental group exhibited enhancements in explosive power and upper extremity movement speed. While natural growth in the control group positively influenced motor development, its impact was not as pronounced as that of the structured training program. This underscores the importance of organized exercise programs in promoting motor development. Consequently, the effectiveness of preparatory programs on developmental levels will be crucial in shaping trainers' expectations and enhancing the performance development of children in gymnastics.

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