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THE IMPACT OF A SPECIALIZED FITNESS PROGRAM ON SELECTED MORPHOLOGICAL, MOTOR, AND FUNCTIONAL PARAMETERS IN BOXERS

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(Original scientific paper)

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Abstract
This study aimed to evaluate the effects of a specialized strength fitness program on selected morphological, motor, and functional parameters in competitive boxers. A total of 24 variables were analyzed—10 morphological, 10 motor, and 4 functional—using standardized measurement protocols. eighty (80) participants were divided into an experimental group, which followed a 16-week combined standard training and strength fitness program, and a control group, which followed only the standard training regimen. Dependent sample T-tests were applied to compare initial and final measurements within groups. Results showed that the experimental group experienced statistically significant improvements in all anthropometric measures, including increases in body mass (2.01%), chest circumference (1.47%), and limb circumferences, alongside significant reductions in skinfold thicknesses. Motor abilities improved significantly in tests such as standing long jump (+3.09%), vertical jump (+9.51%), medicine ball throws, and balance. Functional capacity also improved, as indicated by enhanced Åstrand test results (+0.53%) and reduced resting heart rate (-0.92%). No significant changes were observed in systolic or diastolic blood pressure. In contrast, the control group showed modest but significant increases in some anthropometric measures (body mass +0.70%, chest circumference +0.60%) but no significant changes in motor or functional tests. The findings suggest that incorporating a structured strength fitness program alongside standard boxing training effectively enhances morphological, motor, and some functional parameters, thereby potentially optimizing athletic readiness and performance in competitive boxing.

Key words: *strength fitness program, boxers, functional parameters*

Introduction

Martial arts, athlete selection in combat sports, the morphological characteristics of boxers, and the physical fitness of martial arts practitioners as well as continuous efforts to exceed previous limitations in motor skill performance are gaining increasing attention from scholars and professionals in the field (Chaabene et al., 2015; Anilkumar, 2013). There is a growing interest in identifying new strategies to reach higher levels of performance and achievement. Although martial arts are a product of human innovation, various forms of combat and competitive behavior can be traced back to pre-human evolutionary stages. As such, martial arts may be viewed as a natural outcome of human evolutionary development. The instinct to engage in combat may be considered an inherent human trait. In ancient civilizations, martial arts served diverse purposes, including preparation for warfare, physical conditioning, and participation in entertainment, religious ceremonies, and other cultural rituals (Slimani et al., 2017; Jajčević, 2010; Stanković & Grubješić, 2020). Among all martial arts disciplines—such as judo, wrestling, kickboxing, and other modern combat sports boxing stands out as one of the most fundamental forms of hand-to-hand combat, with roots tracing back to ancient civilizations. Evidence suggests that boxing has been a part of human history since antiquity. The earliest depictions of this sport were discovered carved into stone in ancient Mesopotamia, dating back to the late fourth millennium BCE (Boddy, 2008). Since its origins, boxing has undergone continuous development and remains a dynamic sport with ongoing advancements in both technique and training methodologies (Liu et al., 2024; Campa et al., 2021). In this process of evolution, the role of the coach is considered pivotal**.** A qualified coach not only guides training but also serves as a leader, requiring both deep knowledge and high-level practical skills. Motor skills play a critical role in athletic success across all sports, and especially in boxing, where precise, coordinated, and explosive movements are essential (Wu et al., 2024; Bompa & Buzzichelli, 2019; Stanković & Grubješić, 2020). These skills form the foundation for the effective execution of sport-specific techniques and rational movement patterns (Markovic & Mikulic, 2010; Zouita et al., 2023). The influence of morphological characteristics is particularly evident in combat sports. Striking-based disciplines differ from grappling-based ones in terms of technical performance demands, which consequently shape morphological requirements through the process of athletic selection (Sertić, 2004). According to practical experience, height, arm length, and skeletal proportions must be appropriate for athletes across different weight categories. These anthropometric attributes enable fighters to reach opponents from a greater distance, maintain control at range, execute higher kicks (dynamic flexibility), and expand their tactical options (Katić, 2005). Therefore, it is reasonable to assume a strong correlation between these physical dimensions and competitive success. In boxing, excess subcutaneous fat represents unnecessary weight that can reduce speed and negatively impact the energy dynamics required for optimal performance (Katić, 2005). As a result, reducing body mass is a common practice among boxers—even those with ectomorphic or mesomorphic body types—as it enhances physical efficiency in lower weight categories. Overall muscle mass, as a component of body volume and weight (Bompa & Buzzichelli, 2019), plays a critical role in contact-based combat. It contributes to the execution of explosive and rapid movements essential for offensive, defensive, or counterattacking actions.

Method

Participants

The research sample consists of active athletes who voluntarily agreed to participate in the study, totaling 80 boxers. These participants were divided into two groups. The first, the Experimental Group (EGB), includes 40 younger boxers who participated in a four-month kinesiology-based training intervention, which consisted of one-hour strength training sessions held three times per week. The second group, the Control Group (KGB), also includes 40 boxers who continued with their standard training regimen without additional intervention.

Measurements

The only criterion for inclusion in the study was the athlete's voluntary consent to participate. A total of 24 variables were used in the research: 10 to evaluate morphological characteristics, 10 for motor abilities, and 4 for assessing functional capacities. The morphological measurements were conducted according to the standards of the International Biological Program (IBP) (Lohman, Roche, & Martorell, 1988). Anthropometric variables were organized into two categories: Body weight (AMAT), Chest circumference (ASOG), Upper arm circumference (AONA), Thigh circumference (AONK), Lower leg circumference (AOPK), Upper arm (AKNN), Back (AKNG), Abdomen (AKNC), Thigh (AKGN), Lower leg (AKNP). Motor abilities were assessed using standardized testing protocols (Tomkinson et al., 2007). The following tests were used: 20-meter sprint with a high start (T20M), Hand tapping (TARA), Leg tapping against the wall (TNOZ), Standing long jump (SKDM), Standing vertical jump (SCVM), 3 kg medicine ball chest pass – standing (FMGS), 3 kg medicine ball chest pass – seated (FMSE), Flamingo balance test (FLRA), Seated forward bend (Sit-and-Reach) (SNSP), Agility T-test (AGTT). Functional capacities were assessed based on parameters proposed by (Bangsbo et al. 2008)**:** Astrand cycling test (ASTT), Resting heart rate (PULSE), Systolic blood pressure (SIPR), Diastolic blood pressure (DBP).

Training Program

This study utilized **a** pretest-posttest experimental design with control and experimental groups. The training sessions lasted 16 weeks, during which the experimental group performed strength training sessions three times a week (every other day), for a total of 48 (forty-eight) training sessions. Each training session lasted approximately 60 minutes, starting with a 5-7 minute warm-up (easy jogging and dynamic stretching exercises) and ending with a 5-minute cool-down (static stretching for major muscle groups). Before starting strength training, participants were grouped based on their initial strength test results to ensure similarity between groups.

Table 1. Modified standard strength exercises. Presentation of the exercises that the respondents perform during the first eight weeks, the number of sets, the number of repetitions and the length of resting between sets (Nešić, 2014; according to Jukić and Marković, 2005)

Br	Lower, upper and body exercises	Exercises 1 – 4 Weeks	Exercises 5-8 Weeks
1	Machine for strengthening abdominal muscles (abdominal machine)	2 series 12 repetitions 1 min rest between sets	3 series 15 repetitions 30 seconds rest between sets. .
2	Hyperextension (lower back)		
3	Vertical thrust (shoulder press)		
4	upper back		
5	Seated horizontal press (chest press)		
6	Front pull (latpuley)		
7	Biceps (biceps curl)		
8	Triceps (lat pulley)		
9	The chest (pec deck)		
10	Extension (upper back)		
11	Squats (Smith)		
12	Flexion of the lower part of the leg (leg curl)		

All the respondents are familiar with the training method, that is, the order of performing the exercises (agonists, antagonists). The training method is mobile, load 7-12 weeks about 66 - 70% 1 RM max, 2 series of 12 repetitions and 1 min rest between sets (Table 2).

Table 2. Standard strength exercises. Presentation of the exercises that the respondents perform in the period of 9-12 weeks (Jukić and Marković, 2005)

Trainings 9 - 12week a		
Monday	Wednesday	Friday
6-9 muscle stretching exercises 5 min.	6-9 muscle stretching exercises 5 min.	6-9 exercises for stretching muscles 5 min.
Barbell press flat bench (bench press)	Exercise machine pull-up - wide grip (knneling chinning and dipping machine)	Seated press over the head (shoulder press)
Barbell push-up on an inclined bench (incline bench press)	Pulling stretches hands of the machine (uper back)	Pulling with outstretched arms of the machine (uper back)
Push-ups on the assisted pull-up machine (knneling chinning and dipping machine	Knelling chinning and dipping machine	Rowing on the Smith Machine while standing (Smith)
Stretching machine (peck deck)	Pulling behind the head of a lat machine - nathvat (lat pulley)	Standing deadlifts (bu č ice)
(Smith)	Bending of the forearms of Scott's machine (bicepscurl)	Stretching the lower legs machine while sitting (leg extension)
Bending of the lower part of the leg On the machine (lying leg curl)	Extension of the forearm on a lat machine with a standing rope (lat pulley)	Horizontal parallel leg press the squat (seated leg press)
Bending the body in the sitting tool (abdominal machine	lifting the leg on a hanging chair (abdominal flexor)	Pulling the legs to the chest from the shaft (Hanging leg raise)
30. exercises in tools (lower back)		
6-9 muscle stretching exercises 5 min	6-9 muscle stretching exercises 5 min	6-9 muscle stretching exercises 5 min

Table 3. Standard strength exercises. Presentation of the exercises that the respondents will perform in the period of 13 - 16 weeks (Jukić and Marković, 2005)

Trainings 13-16 week		
Monday	Wednesday	Friday
6-9 muscle stretching exercises 5 min.	6-9 muscle stretching exercises 5 min.	6-9 exercises for stretching muscles 5 min.
Barbell press flat bench (bench press)	Exercise machine pull-up - wide grip (knneling chinning and dipping machine)	Seated press over the head (shoulder press)
Barbell push-up on an inclined bench (incline bench press)	Pulling stretches hands of the machine (uper back)	Pulling with outstretched arms of the machine (uper back)
Push-ups on the assisted pulling machine (knelling chinning and dipping machine	Knelling chinning and dipping machine	Rowing on the Smith Machine while standing (Smith)

Stretching machine (peck deck)	Pulling behind the head of a lat machine - nathvat (lat pulley)	Standing deadlifts (bu č ice)
Back parallel squat on Smith's lying (Smith)	Bending of the forearms Scott's machine (bicepscurl)	Stretching the lower legs machine while sitting (leg extension)
Bending of the lower part of the leg On the machine (lying leg curl)	Extension of the forearm on a lat machine with a standing rope (lat pulley)	Horizontal parallel leg press the squat (seated leg press)
Bending the body in the sitting tool (abdominal machine)	Lifting the leg on a hanging chair (abdominal flexor)	Pulling the legs to the chest from the shaft (Hanging leg raise)
30. exercises in tools (lower back)		
6-9 muscle stretching exercises 5 min	6-9 muscle stretching exercises 5 min	6-9 muscle stretching exercises 5 min

All respondents are familiar with the training method, that is, the order of performing the exercises (agonists, antagonists). The training method is mobile, the load 13-16 weeks about 71 - 75% 1 RM max, 3 sets of 15 repetitions and 30 seconds rest between sets (Table 3.).

Statistical Analysis

To verify the difference between the groups at the beginning and end, after kinesiology treatment, t-test analysis was applied for the dependent and independent groups. The data are processed with statistical package of SPSS for Windows version 22.0.

Results

The initial and final measurement in the experimental group of boxers

In order to define the differences in morphological characteristics, motor and functional abilities between the initial and final measurement in the experimental group of boxers (boxers who, in addition to standard training, also follow a strength fitness program), T-tests for dependent samples were applied. The results of the tests are presented in Tables 4 to 6. From the inspection of Table 4, it can be observed that in the experimental group of boxing athletes (boxers who, in addition to standard training four days a week for 90 min., have also carried out a program of strength exercises within the framework of fitness).

Table 4. Significance of the differences in the arithmetic means of morphological characteristics between the initial and final measurement in the experimental group of boxers**.**

Variable	Initial state		Final state		%	R	T-test	Sig
	Mean	SD	Mean	SD				
AMAT	67,14	8,08	68,49	8,29	2,01	1,00	-12,25	**0,000**
ACOГ	83,44	3,38	84,67	3,83	1,47	0,91	-4,98	**0,000**
AOHA	26,35	1,60	26,80	1,63	1,71	0,99	-10,11	**0,000**
AOHK	48,35	1,14	49,30	2,03	1,96	0,79	-4,52	**0,000**
AOПK	34,42	1,69	35,26	1,71	2,44	0,84	-5,46	**0,000**
AKHH	6,24	2,34	5,85	2,30	-6,25	0,99	8,52	**0,000**
AKHГ	6,58	2,13	6,20	2,12	-5,78	1,00	11,93	**0,000**
AKHC	8,32	4,56	7,85	4,45	-5,65	1,00	9,14	**0,000**
AKГH	6,65	3,43	6,29	3,36	-5,41	0,99	4,49	**0,000**
AKHП	7,07	2,84	6,60	2,85	-6,65	0,99	6,11	**0,000**

The results obtained show that statistically significant differences were found between the first measurements (initial) and at the end of the program (final state) in all anthropometric parameters (body mass, average chest circumference, upper arm circumference, thigh circumference, calf circumference, subcutaneous adipose tissue of the arm in the triceps area, subcutaneous back fat, subcutaneous abdominal fat, subcutaneous thigh fat and subcutaneous calf fat). Based on the calculated percentage changes in the arithmetic mean values of anthropometric measurements between the beginning and end measurements, it can be said that after a 16-week experimental treatment (standard training and strength training program), the experimental group of boxers experienced an increase in body mass by 2.01%, average chest circumference by 1.47%, upper arm circumference by 1.71%, thigh circumference by 1.96%, and calf circumference by 2.44%. Also, subcutaneous fat tissue of the arm in the tricep area by 6.25%, subcutaneous fat of the back by 5.78%, subcutaneous fat of the abdomen by 5.65%, subcutaneous fat of the thigh by 5.41% and subcutaneous fat of the calf by 6.65%.

By inspecting Table 5, it can be observed that in the experimental group of boxers (athletes in the sport of boxing who, in addition to standard training, have also completed a strength training program within the framework of a fitness program), statistically significant differences were obtained between the first measurements (initial measurements) and the measurements at the end of the program (final measurements) in the following motor tests: long jump with legs raised from the place, vertical jump - high jump from the place, throwing a 3 kg medicine ball with two hands from chest level from a standing position, throwing a 3 kg medicine ball with two hands from chest level in a sitting position and the Flamingo balance test. In the experimental group, no statistically significant differences were obtained between the first (initial) and final (final) measurements in the following motor tests: 20-meter sprint with a high start, hand tapping, foot tapping on the wall, the flexibility test "bending from a sitting position" (Sit-and-Reach) and T-test for agility. Based on the calculated percentage changes in the arithmetic mean values of motor tests between the initial and final measurements, it can be concluded that after the 16-week experimental treatment (standard strength training and fitness program), the experimental group of boxers showed improvement in the following motor tests: standing long jump by 3.09%, standing vertical jump by 9.51%, throwing a 3 kg medicine ball with two hands from the chest in a standing position by 5.10%, throwing a 3 kg medicine ball with two hands from the chest in a sitting position by 6.69% and the Flamingo test by 19.01% (in this test, lower values indicate better performance).

Table 5. Significance of the differences in the arithmetic means of motor tests between the initial and final measurement in the experimental group of boxers.

Variable	Initial state		Final state		%	R	T-test	Sig
	Mean	SD	Mean	SD				
T20M	3,46	0,23	3,47	0,24	0,29	0,99	-0,37	0,717
TAPA	34,28	3,95	34,60	3,91	0,93	0,88	-1,08	0,286
THO3	23,05	3,10	22,60	2,39	-1,95	0,68	1,24	0,223
СКДМ	215,10	17,85	221,75	17,75	3,09	0,99	-21,09	**0,000**
СКВМ	46,80	6,71	51,25	7,90	9,51	0,69	-4,83	**0,000**
ФМГС	730,63	99,62	767,88	98,91	5,10	0,96	-8,26	**0,000**
ФМСЕ	683,75	104,14	729,50	98,84	6,69	0,95	-8,52	**0,000**
ФЛРА	7,10	1,34	5,75	1,37	-19,01	0,57	6,82	**0,000**
СНСП	26,28	3,09	26,63	3,31	1,33	0,93	-1,77	0,085
АГТТ	10,54	0,65	10,53	0,66	-0,09	1,00	1,23	0,226

Table 6. Significance of the differences in the arithmetic means of functional ability between the initial and final measurement in the experimental group of boxers.

Variable	Initial state		Final state		%	R	T-test	Sig
	Mean	SD	Mean	SD				
АСТТ	51,41	5,53	51,68	5,53	0,53	1,00	-6,77	**0,000**
ПУЛС	64,95	4,07	64,35	3,82	-0,92	0,92	2,40	**0,021**
СИПР	120,88	5,53	121,25	5,28	0,31	0,91	-1,00	0,323
ДИПР	75,88	5,30	75,13	5,00	-0,99	0,70	1,18	0,244

By inspecting Table 6, it can be confirmed that in the group of boxers who, in addition to standard training, also performed a strength training program within the framework of fitness (experimental group), statistically significant differences were obtained between the first (initial) and second (final) measurements in the functional indicators: Åstrand test and resting heart rate. Statistically significant differences were not obtained in the functional indicators: systolic blood pressure and diastolic blood pressure. Based on the calculated percentage differences in the arithmetic mean values of the functional indicators between the first (initial) and second (final) measurements, it can be concluded that after completing the 16-week experimental program (standard training and a strength training program as part of a fitness program), boxers in the experimental group showed a significant improvement in Åstrand test values by 0.53% and a decrease in resting heart rate by 0.92%.

The initial and final measurement in the control group of boxers

In order to define the differences in morphological characteristics, motor, and functional abilities between the initial and final measurement in the control group of boxers (boxers who follow only a standard training program), dependent sample T-tests were applied. Initial and final measurement results in the control group of boxers in morphological, motor and functional variables are presented in Tables 7 to 9.

Table 7. Significance of the differences in the arithmetic means of morphological characteristics between the initial and final measurement in the control group of boxers.

Variable	Initial state		Final state		%	R	T-test	Sig
	Mean	SD	Mean	SD				
АМАТ	66,88	6,70	67,35	6,86	0,70	0,99	-3,84	**0,000**
АСОГ	85,27	3,73	85,78	3,76	0,60	1,00	-12,74	**0,000**
АОНА	26,22	3,03	26,39	3,04	0,65	1,00	-4,87	**0,000**
АОНК	49,23	3,63	49,42	3,61	0,39	1,00	-7,54	**0,000**
АОПК	34,78	2,53	34,94	2,56	0,46	1,00	-4,15	**0,000**
АКНН	6,81	2,94	6,74	2,92	-1,03	0,99	1,34	0,189
АКНГ	7,14	2,59	7,06	2,58	-1,12	0,99	1,23	0,228
АКНС	8,43	3,23	8,40	3,32	-0,36	0,99	0,60	0,554
АКГН	7,84	3,25	7,56	3,31	-3,57	0,94	1,60	0,119
АКНП	7,39	2,41	7,38	2,46	-0,14	0,99	0,27	0,793

By inspecting Table 7, it can be seen that in the second group that did not undergo any specific kinesiology treatment, the control group of boxers (who underwent only a standard training program), statistically significant differences were observed between the first (initial) and second (final) measurements in the morphological parameters: body mass, average chest circumference, upper arm circumference, thigh circumference and calf circumference. In the same group, the control group of boxers, no statistically significant differences were observed between the first (initial) and second (final) measurements in the morphological parameters: triceps skinfold, back skinfold, abdominal skinfold, upper leg skinfold and calf skinfold. If we look at the percentage differences in the arithmetic mean values between the first (initial) and second (final) measurements, it can be concluded that after 16 weeks of standard training, the control group of boxers showed an increase in body mass by 0.70%, average chest circumference by 0.60%, arm circumference by 0.65%, thigh circumference by 0.39%, and calf circumference by 0.46%.

Table 8. Significance of the differences in the arithmetic means of motor tests between the initial and final measurement in the control group of boxers.

Variable	Initial state		Final state		%	R	T-test	Sig
	Mean	SD	Mean	SD				
Т20М	3,40	0,22	3,40	0,21	0,00	0,98	0,51	0,611
ТАРА	35,25	3,87	35,43	3,87	0,51	0,85	-0,52	0,609
ТНОЗ	22,65	3,38	23,15	3,71	2,21	0,81	-1,45	0,156
СКДМ	213,68	17,33	213,15	17,54	-0,25	0,99	1,35	0,185
СКВМ	47,90	6,70	47,48	7,27	-0,88	0,94	1,07	0,291
ФМГС	734,63	87,95	723,50	93,32	-1,52	0,88	1,55	0,130
ФМСЕ	682,75	89,36	682,13	94,89	-0,09	0,80	0,07	0,946
ФЛРА	7,50	1,22	7,45	1,81	-0,67	0,60	0,22	0,828

Table 9. Significance of the differences in the arithmetic means of functional ability between the initial and final measurement in the control group of boxers.

Variable	Initial state		Final state		%	R	T-test	Sig
	Mean	SD	Mean	SD				
АСТТ	51,07	9,31	50,89	10,83	-0,35	0,91	0,26	0,797
ПУЛС	66,13	4,71	66,40	3,64	0,41	0,84	-0,67	0,506
СИПР	120,75	4,88	120,00	4,08	-0,62	0,77	1,53	0,135
ДИПР	77,25	5,42	77,50	5,66	0,32	0,88	-0,57	0,570

From the review of Table 36, it can be seen that in the control group of boxers, between the initial and final measurement (after 16 weeks of standard training), no statistically significant changes occurred in any of the applied motor tests. From the review of Table 36, it can be seen that in the control group of boxers, between the initial and final measurement (after 16 weeks of standard training), no statistically significant changes occurred in any of the applied functional measures.

Discussion

The results of this study confirm the significant role of a special fitness program in improving morphological, motor and functional parameters in boxers. The observed positive changes in body composition, aerobic and anaerobic capacity, as well as increased efficiency of the cardiorespiratory system, emphasize the need for well-structured and scientifically based training. The obtained data show that the program led to improvements in parameters such as body mass, mean chest circumference, upper arm circumference and abdominal skinfold. This suggests a positive body transformation, which is due to the adaptive effect of resistance training, which causes an increase in muscle mass and a reduction in subcutaneous fat. These results are consistent with the research of (Kraemer et al. 2019; Peterson et al. 2018), which found that strength training leads to a redistribution of body tissues and optimization of body composition, without necessarily reducing total body weight. The primary mechanism behind improvements in morphological characteristics is hypertrophy of type II muscle fibers, stimulated by progressive loading (70-75% 1RM) and repetitions (3x15) in the last phase of the program. This is supported by the study of Schoenfeld (2010), who emphasized the importance of mechanical strain and metabolic stress for muscle adaptation. Increased aerobic endurance can be attributed to improved efficiency of the cardiovascular system, such as increased stroke volume and capillarization of the musculature (Bangsbo et al., 2008).The variety of tests allowed for a multi-dimensional analysis of the athletes' performance, which is a valuable contribution to the field of sports physiology, ucial for maintaining energy metabolism (Davis et al., 2015). This study has several strengths that make it significant for the field of sports science. In a functional context, the reduction in systolic blood pressure (SBP) in the experimental groups may be associated with improved vasodilation and reduced peripheral resistance, as a consequence of regular aerobic activities (El-Ashker, 2018). This adaptation is particularly relevant for athletes, as it reduces cardiovascular workload during competition. For example, Hanon et al. (2015) observed that boxers with improved aerobic endurance had lower blood lactate accumulation, which facilitated their recovery between rounds. The control group allowed for a clear distinction between the effects of the fitness program and the natural development of the subjects, which increases the validity of the findings. The long duration of the study (16 weeks) allowed for precise monitoring of adaptations over time, which provides more reliable data on the effects of the intervention. The variety of tests allowed for a multi-dimensional analysis of the athletes' performance, which is a valuable contribution to the field of sports physiology. This study contributes to the understanding of the effects of structured strength fitness programs on athlete performance.

Conclusions

This study evaluated the impact of a specialized strength fitness program on morphological, motor, and functional parameters in competitive boxers. The experimental group followed the strength program alongside standard training for 16 weeks, while the control group trained only with the standard regimen. Measurements included body composition, motor skills, and functional capacities assessed through standardized tests. Results revealed significant improvements in the experimental group’s body mass, limb circumferences, and reduced skinfold thickness, indicating positive morphological changes. Motor abilities such as standing long jump, vertical jump, medicine ball throws, and balance also improved significantly. Functional capacity was enhanced, evidenced by better Åstrand test results and lower resting heart rate, while blood pressure remained stable. The control group showed minimal morphological changes and no significant motor or functional improvements. These findings highlight that adding a structured strength training program to boxing routines significantly enhances physical performance and athletic readiness. In conclusion, integrating strength training into boxing practice effectively improves morphological, motor, and functional abilities, supporting athletes in meeting the rigorous demands of competitive boxing.

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