Vol. XXVI, Issue 1/ 2025

G Y M N A S I U M

Scientific Journal of Education, Sports, and Health

Original Article

Evaluating the Impact of CrossFit on Sambo Athletes: A 10-Week Intervention Study with Statistical Insights and Future Directions

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DOI: 10.29081/gsjesh.2025.26.1.2

Keywords: *CrossFit training, sambo athletes, performance assessment, 10-week intervention, strength.*

Abstract

This study investigates the effects of a 10-week CrossFit training program on the physical fitness of sambo athletes, focusing on strength, endurance, agility, and reaction speed. Twenty-one athletes, aged 18-24, were divided into two groups: a control group continuing their traditional training and an experimental group completing CrossFit three times a week. Both groups underwent 8 performance tests assessing general and special fitness, strength, endurance, and agility, before and after the intervention. Statistically significant improvements ($p < 0.05$) were observed in three out of eight tests for the experimental group, specifically in abdominal strength ($p<0.05$), general fitness ($p<0.02$), and grip strength ($p<0.04$). While the experimental group showed positive trends, the overall impact was partial, with only three tests showing significant improvement. These results suggest that extending the training program to 6-8 months could lead to more substantial gains in physical performance.

1. Introduction

Incorporating CrossFit elements into the training for various combat sports branches is very current (Stanciu & Ene-Voiculescu, 2023), it is in line with the diversification of training methods and can bring added value to the physical training

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of athletes from all categories of age and weight. General and specific physical training plays a crucial role in the training process of combat sports, serving as a key factor in achieving peak performance. Sports performance in individual sports also depends a lot on intrinsic motivation (Stanciu, Ene-Voiculescu & Pomohaci, 2023). Integrating CrossFit elements into combat sports training lays the foundation for developing motor capacity, essential for athletes to perform effectively, while also enabling a significant improvement in fitness levels, particularly for specialized physical demands (Osipov, Kudryavtsev, Iermakov, & Budo, 2018).

The anthropometric characteristics, body composition, and somatic type of athletes undergoing CrossFit training impact the sports performance they achieve (Menargues-Ramírez, Sospedra, Holway, Hurtado-Sánchez, & Martínez-Sanz, 2022).

The CrossFit training model includes physical skills and capabilities, cardiovascular, strength, endurance, flexibility, speed, power, balance (De Souza, Rabello, Da Rocha, & Rodrigues, 2023; Dominski, Serafim, Siqueira, & Andrade, 2021), coordination, precision and agility (Durkalec-Michalski, Nowaczyk, Kamińska, Saunders, Łoniewski, Czubaszek, Steffl, & Podgórski, 2023). Each workout includes a blend of gymnastics, weightlifting, and aerobic exercises (Caetano, Souza, Loureiro, & Capistrano Junior, 2023). CrossFit combines intense training with resistance training, helping to increase physical capacity (Menargues-Ramírez et al., 2022).

CrossFit workouts vary in mode, frequency, duration, rest intervals, and exercise variation (McDougle, Mangine, Townsend, Jajtner, & Feito, 2023). This type of training is primarily aimed at achieving maximum performance (Laynes, Fagundes, Barbosa, De Souza, & Lombardi Júnior, 2022)

Success in combat sports depends on athletes' technical abilities, tactical training, and, above all, their physical fitness. This in turn depends on training intensity, competitive tasks and work techniques used in functional training. Combat Sambo demands various training requirements from an athlete, including advanced striking and throwing techniques, as well as a high level of both anaerobic and aerobic fitness, good strength and power characteristics (Kudryavtsev, Osipov, Guralev, Ratmanskaya, Aldiabat, Aldiabat, Kolokoltsev, Davidenko, Glukhov, & Karpenko, 2023)

Through the selection of physical exercises performed during circuit training, all muscle groups are intervened upon, either as continuous or interval training, they can be used for an entire cycle of physical training (Osipov et al., 2018).

Accurately measuring the workload and intensity of workouts that incorporate CrossFit elements provides coaches, athletes, and sports scientists with a practical way to assess any physiological responses to training. Without such measurements, it is difficult to determine whether changes in programming have a small or large positive or negative impact, or to make proper comparisons between different workouts. As a result, only a limited number of practical methods have been proposed to quantify CrossFit training performance (Mangine & Seay, 2022).

The specialized scientific literature presents very little evidence of the results obtained by introducing CrossFit elements into combat sports, hence the need to

study these topics. In this context, the present research evaluates the effectiveness of a 10-week CrossFit training on sambo athletes, in order to draw perspectives for future training approaches of this type

2. Material and methods

The aim of the research is to evaluate the impact of a CrossFit training program on the physical performance of sambo athletes, using a series of specific tests to measure various components of physical fitness.

The research hypothesis is that the implementation of a CrossFit training program will lead to significant improvements in the general and specific physical fitness of sambo athletes, contributing to the enhancement of their performance in sport-specific activities and techniques.

The research methods used in this research are:

- Experimental Study: The research followed an experimental design, with two groups of athletes (an experimental group undergoing a CrossFit training program and a control group maintaining traditional training) to assess the impact on physical performance.
- Pre-test / Post-test Method: Physical evaluations were conducted before and after the 10-week intervention to analyze changes in athletes' physical fitness, allowing for direct result comparisons;
- Physiological Monitoring: Heart rate measurements were recorded pre-, during-, and post-exercise to assess cardiovascular response and recovery. Additionally, body composition analysis, including fat and muscle percentage, was conducted to evaluate physiological adaptations resulting from the CrossFit intervention.
- Direct Observation: Coaches and researchers observed and documented athletes' performance, fatigue levels, and adaptation to the CrossFit training program throughout the study.
- Statistical Analysis: The collected data were analyzed using the Kolmogorov-Smirnov test to assess data distribution and the t-parametric test to determine significant differences between the experimental and control groups.

Study group

The study included 21 sambo athletes, aged 18 to 24. All participants were in good health condition, free from any injuries or medical conditions that could affect their performance or participation in the training program. They were experienced athletes, each with an average of 12.6 years of background in combat sports and participating in approximately 6.9 training sessions per week.

For this study, participants were randomly divided into two groups: an experimental group and a control group. The experimental group, consisting of 11 athletes, followed a CrossFit training program three times a week alongside their regular sambo training. The control group, made up of 10 athletes, maintained their usual sambo training regimen without any CrossFit intervention.

Before the study began, all participants gave informed consent, confirming their voluntary participation and understanding of the study's procedures and

objectives. The research protocol was reviewed and approved by the appropriate ethics committee to ensure compliance with ethical standards for research involving human subjects.

The random assignment of participants was intended to reduce selection bias and ensure that both groups were comparable in age, experience, and physical condition. This approach enhances the validity of the study by attributing any observed differences in performance outcomes to the CrossFit intervention rather than other variables. For the duration of this research the athletes did not participate in any competition and did not report any injuries.

Morphological Characteristics of the Subjects

The average training experience of the subjects is 12.7±3.9 years. They have consistently trained 1.5 to 2 hours 6 to 8 times a week. The average age of the study participants is 20.8±2.39, body weight was 77±12.10 kg, height 1.74±0.072 cm, body fat was 17.7±6.43% and muscle tissue 41.06±5.03%. Body weight and body composition were measured using Omron BF508 Body Analizer before the initial and the final tests.

Research Program and Methodology

This study employed a randomized controlled trial design to assess the impact of a 10-week CrossFit training program on the physical performance of sambo athletes. The research was conducted over ten weeks, from 6th of June 2024 to 15th of July 2024, allowing sufficient time to observe physiological adaptations.

To assess the effect of the CrossFit training program on the sambo athletes, a comprehensive set of 8 performance tests was conducted on all participants before (pre-test) and after (post-test) the 10-week intervention. These tests were specifically selected to assess various components of physical fitness relevant to sambo, including strength, endurance, agility, and both general and special physical fitness.

Principles of the Experimental Training Program

A training program was developed to enhance the general physical fitness of the athletes by incorporating the principles of CrossFit training methodology and techniques from martial arts that involve throws, such as wrestling and judo (Table1 and 2).

Table 1. *Methodology of the experimental training intervention week 1-5*

Experimental training intervention	
Number of exercises	3
Method and duration	EMOM – 15 minutes
External resistance	Body weight
Exercise intensity	Submaximal
Rest	Average of 15-20 seconds between each exercise

EMOM stands for "Every Minute on the Minute"

Table 2. *Methodology of the experimental training intervention week 6-10*

Experimental training intervention	
Number of exercises	4
Method and duration	EMOM – 24 minutes
External resistance	Body weight + partner in full sambo gear
Exercise intensity	Submaximal
Rest	Average of 15-20 seconds between each exercise

EMOM stands for "Every Minute on the Minute"

EMOM, which stands for "Every Minute on the Minute", is a original CrossFit training technique where the athlete starts a specific exercise or set of exercises at the beginning of every minute. After completing the prescribed number of repetitions, the athlete rests for the remainder of the minute. This cycle repeats for a set number of minutes.

Each workout was precedented by an individual warm-up and after week 5 the program was adjusted by adding an extra exercise and increasing the total length of the intervention (Table 3 and 4).

Table 3. *Methodology of the experimental training intervention week 1-5*

Monday	**Wednesday**	**Friday**
1. 12x Burpees	1. 12x Burpees	1. 12x Burpees
2. 12x Box jumps	2. 12x Box jumps	2. 12x Box jumps
3. 20x sit-ups	3. 20x sit-ups	3. 20x sit-ups
Repeate the cycle 5 times	Repeate the cycle 5 times	Repeate the cycle 5 times

Table 4. *Methodology of the experimental training intervention week 5-10*

Monday	**Wednesday**	**Friday**
1. 12x Airsquats	1. 12x Airsquats	1. 12x Airsquats
2. 12x Dumbell Clean&Jerk	2. 12x Dumbell Clean&Jerk	2. 12x Dumbell Clean&Jerk
3. 16x Clap push-ups	3. 16x Clap push-ups	3. 16x Clap push-ups
4. 20x Sambo techniques/ with partner	4. 20x Sambo techniques/ with partner	4. 20x Sambo techniques/ with partner
Repeate the cycle 6 times	Repeate the cycle 6 times	Repeate the cycle 6 times

Physical Fitness Tests

The subjects were evaluated pre and post intervention with the following test battery:

1. Kern Map 80k1 dynamometer testing of flexor strength of both hands - Evaluation of the grip strength tests;
2. Hanging by the pull up bar - Evaluation of the grip strength tests;
3. Dynamic sit-ups for time – 60 seconds- evaluation of abdominal strength: the subject begins by lying on his back, on a mat, with his knees bent at roughly 90 degrees and his feet flat on the ground, either by a partner or with the help of a support, to prevent them from lifting during execution. The execution of the movement must be complete and controlled, with the trunk rising from the ground so that the shoulders exceed the line of the knees, followed by a return to the initial position. The test was timed exactly for 60 seconds, and the subject was informed of the remaining time
4. Push-ups for time – 60 seconds – evaluation of pressing power: the subjects started with the body in a straight line, supported on the palms and the toes, with the arms outstretched and the hands positioned at shoulder width. The execution of the movement involves the controlled lowering of the body until the chest almost touches the ground, followed by a full return to the starting position with the arms fully extended.
5. Bar pull-ups – evaluation of the pull-up strength - the subject begins the test by hanging onto the bar with palms facing forward and hands slightly wider than shoulder width apart. Correct execution involves raising the body until the chin passes the level of the bar, followed by a controlled lowering until the arms are fully extended.
6. Matorin test – testing to assess balance and motor coordination - the subject starts by standing, legs slightly apart and arms by the body. At the signal, the subject performs a jump on the spot, turning in the air as much as possible (usually 360 degrees), on both sides (right and left). After landing, the angle of rotation is measured using a goniometer or by observing the final position of the body relative to the starting position. The angle is measured in degrees and noted separately for right and left rotations.
7. Ruffier-Dickson testing – evaluation of the cardiovascular fitness - heart rate measurement at rest: The subject is in a sitting and relaxed position. The pulse is measured for 15 seconds and the lowest value obtained is noted as P1. The subject performs 30 squats in 45 seconds, keeping a constant pace. Immediately after exercise the pulse is measured again and noted as P2. One minute after the end of the exercise, the pulse is measured for the third time and is noted as P3. The Ruffier-Dickson Index (RDI) is calculated using the following formula:

$$\text{RDI} = \frac{\text{P1}+\text{P2}+\text{P3}-200}{10}$$

8. The Special Judo Fitness Test (SJFT) is a specialized assessment designed to evaluate the physical condition of judo athletes, focusing on the demands of this

sport. This test was developed to measure anaerobic capacity, muscular endurance and the ability to repetitively perform specific judo or sambo techniques under fatigue conditions like those encountered during a competition.

The athlete being tested must perform a maximum number of throws on the two partners in quick succession, alternating between them. The test is divided into three rounds, each with a different duration: The first round lasts 15 seconds, the second and third rounds last 30 seconds each and between each round, there is a 10 second break.

The researcher records the following data: the total number of throws completed in all 3 rounds, the heart rate measured immediately after the test (P1), and the heart rate one minute after the test (P2). The SJFT results were interpreted according to Table 5.

The SJFT score is determined using the following formula:

$$SJFT = \frac{\mathrm{P1} + \mathrm{P2}}{total\ number\ of\ throws}$$

Table 5. *Interpretation of SJFT test results*

Classification	Variables			
	Total number of throw	**HR after the exercise**	**HR 1 min. after the exercise**	**Index**
Excellent	≥29	≥173	≤143	≤11.73
Good	27-28	174-184	144-161	11.74-13.03
Average	26	185-187	162-165	13.04-13.94
Poor	25	188-195	166-174	13.95-14.84
Very poor	≤24	≥196	≥175	≥14.85

HR – heart rate

Statistical analysis

The Kolmogorov-Smirnov statistical test was used to analyze the distributions. The result of this test shows us whether the analyzed distribution is normal (when the calculated p is greater than 0.05, $p>0.05$) or abnormal (when the calculated p is less than 0.05, $p<0.05$). Whenever both distributions are normal the parametric Independent t test is used and whenever one or both distributions are abnormal the non-parametric Mann Whitney U Test is used.

3. Results and Discussions

Statistical analysis of the initial tests

All 8 initial tests have concluded the same end result which is statistically insignificant difference which translates to the fact that both groups have a comparable base level in terms of the studied variables. This suggests that any differences that might emerge later in the intervention or treatment process can be attributed to the effects of the intervention, rather than to initial between-group variations.

Table 6 *Comparison of normal statistical distributions at initial testing*

Parameters	Mean	SD	t	df	Sig.2	Semnification	Result
Dynamometer right C (kg)	43.63	10.587	-2.075	19	.052	p>0,05	Statistically insignificant difference
Dynamometer right E (kg)	53.73	11.708					
Dynamometer left C (kg)	40.67	11.096	-1.762	19	.094	p>0,05	Statistically insignificant difference
Dynamometer left E (kg)	49.54	11.964					
Push-ups C (n)	63.64	17.235	.214	19	.833	p>0,05	Statistically insignificant difference
Push-ups E (n)	61.90	19.891					
Pull-ups C (n)	16.00	7.403	1.786	19	.090	p>0,05	Statistically insignificant difference
Pull-ups E (n)	11.00	5.077					
Matorin right C (degrees)	285	45.111	-.595	19	.559	p>0,05	Statistically insignificant difference
Matorin right E (degrees)	294	16.296					
Ruffier Dickson C (index)	7.70	2.627	-5.000	19	.000	p<0,05	Statistically insignificant difference
Ruffier Dickson E (index)	14.67	3.710					
SJFT C (index)	12.63	1.775	-.812	19	.427	p>0,05	Statistically insignificant difference
SJFT E (index)	13.25	1.721					

E—experimental group, C—control group, SD—standard deviation, df - degrees of freedom,

Statistical analysis of post intervention tests

Table 7 *Comparison of normal distributions by independent t-test*

Parameters	Mean	SD	t	df	Sig.2	Semnification	Result
Dynamometer left C (kg)	39.836	11.1926	-2.297	19	*.033*	*p<0,05*	*Statistically significant difference*
Dynamometer left E (kg)	39.836	11.1926					
Hanging C (seconds)	56.91	17.283	-.206	19	.839	p>0,05	Statistically insignificant difference
Hanging E (seconds)	58.40	15.749					
Push-ups C (n)	62.91	15.070	-.582	19	.568	p>0,05	Statistically insignificant difference
Push-ups E (n)	66.90	16.374					
Pull-ups C (n)	16.36	7.018	1.464	19	.160	p>0,05	Statistically insignificant difference
Pull-ups E (n)	12.30	5.519					
Sit-ups C (n)	58.73	6.901	-2.227	19	*.038*	*p<0,05*	*Statistically significant difference*
Sit-ups E (n)	64.80	5.412					
Matorin test C (degrees)	290.45	41.920	-.753	19	.461	p>0,05	Statistically insignificant difference
Matorin test E (degrees)	301.50	20.690					
Ruffier Dickson C (index)	7.936	2.2191	3.798	19	*.001*	*p<0,05*	*Statistically significant difference*
Ruffier Dickson E (index)	5.130	.7528					
SJFT C (index)	12.06	1.443	.521	19	.608	p>0,05	Statistically insignificant difference
SJFT E (index)	11.81	.486					

Statistically significant data are in italic.

Discussions

The results of the study confirm that when planning workouts that use elements of CrossFit, coaches must consider body composition, body strength, and

competition experience (Meier, Schlie, & Schmidt, 2023) and provide different strength loads for each workout (Oliver-López, García-Valverde, & Sabido, 2023).

A published study demonstrates that incorporating CrossFit-style exercises into the specialized physical training of sambo practitioners enhances their functional fitness levels (Osipov, Kudryavtsev, Jagiełło, Iermakov, & Wiesław, 2020). Our results demonstrated significant improvements in abdominal strength, general physical fitness, and grip strength among the athletes.

4. Conclusions

The study found that the 10-week CrossFit intervention had a partial impact on sambo athletes' physical fitness. While the program led to significant improvements in specific areas, such as abdominal strength, general fitness, and grip strength, only three out of eleven performance tests showed statistical significance. This suggests that the intervention was effective in certain aspects but did not produce widespread changes across all areas of physical conditioning.

The duration of the intervention was identified as a critical factor. The results imply that extending the program to 6-8 months could allow for more significant and consistent improvements. A longer training period would provide the athletes with enough time for deeper physiological adaptations and gradual increases in exercise intensity, potentially leading to greater performance gains.

Furthermore, the study highlights the relevance of functional training methods like CrossFit in improving strength, endurance, and agility for sambo athletes. However, tailoring the training to address the specific needs of sambo could enhance its effectiveness and better align with the sport's demands.

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