



## THE EFFECT OF PERFORMANCE ABILITY EXERCISES ACCORDING TO THE LIMB SYMMETRY INDEX (PREFERRED AND NON-PREFERRED LIMB) ON SOME TYPES OF MUSCLE STRENGTH, MECHANICAL VARIABLES AND PERFORMANCE OF YOUNG SHOT PUT THROWERS

**Saad Jassim Jilab**

University of Wasit  
IRAQ

Corresponding Author: [saad.alghereebawi@uowasit.edu.iq](mailto:saad.alghereebawi@uowasit.edu.iq)

**Ammar Makki Ali**

University of Kufa  
IRAQ

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### ABSTRACT

**Background.** To identify the effect of the performance ability exercises according to the limb symmetry index (preferred and non-preferred limb) on some types of muscle strength, mechanical variables and achievement for young shot put. **Objectives.** The purpose of this paper is to preparing performance ability exercises according to the limb symmetry index (preferred and non-preferred limb) for young shot put throwers. **Method.** Performance ability exercises (strength and speed) were applied, which were built according to the limb symmetry index for the preferred and non-preferred limb (through a test in the exploratory experiment) for two months at a rate of three training units per week on the research sample of 10 young throwers from the Middle Euphrates region who compete in the races held by the Iraqi Athletics Federation for the 2024 sports season. They were randomly divided into two equal groups, and some types of strength and achievement were measured for the effectiveness of the shot put lifting and photographed to extract some biomechanical variables through photography. **Results.** The results showed that the performance ability exercises according to the limb symmetry index (preferred and non-preferred limb) used by the experimental group and the regular training used by the control group led to the development of some physical abilities, mechanical variables and achievement for young shot put, and that the development of some abilities for the two groups led to the positive impact on the development of some mechanical variables for young shot put throwers and thus the impact on the achievement of the two groups and the superiority of the experimental group over the control group in the impact on the development of some abilities and some mechanical variables and achievement for young shot put throwers through the results achieved as a result of training based on the limb symmetry index, which gave more training to the non-preferred limb, which gave preference and final achievement. **Conclusion.** The researchers recommend emphasizing that throwing and jumping activity training be directed to developing the achievement ability in its various forms, especially activities that depend on the ability element because it directly affects the mechanical variables associated with the skill performance of the activity and thus the positive impact on achievement.

**Keywords;** achievement ability exercises, limb symmetry index, mechanical variables, young shot put throwers.



## A. INTRODUCTION

Sports have become the face of the country's civilizational scale, and many countries are known through their sporting achievements in various sporting events (Hamzah, 2026; Fufu et al., 2026). Scientific progress is one of the features of our present era, as it includes all aspects of life, including the sporting aspect, which interacted with many natural and human sciences to prepare the individual comprehensively and balanced in preparation for reaching the highest levels in the chosen sporting event. Since preparing the individual cannot be achieved without these sciences, it is necessary to research and experiment with modern ideas that contribute to the development of all sports, especially track and field, which requires high physical and skill preparation (Mduwile et al., 2026). The performance improvement process follows very complex procedures, and involves precise knowledge in order to determine a set of specific factors, represented in the ability to control training procedures, mechanical analysis, tests and measurements, and familiarity with knowledge in the biomechanical field and the ability to use training principles and program its intensity.

Since sports training is a means of raising the level of players physically and mentally, so that they can practice sports events and games effectively and efficiently to achieve the best results and achievements, whether on Individual or team level, there are several training methods and the difference in their effects has motivated trainers to choose the training methods and ways that may be the most influential in developing achievement (Hassan & Al-Thar Abd, 2026). It is worth noting that the training aspect has witnessed a remarkable development in the methods and means used in the training process, and in a manner that is consistent with the nature and ability of the player by seeking to choose everything that is appropriate for the specialized sport, especially if the training is based on scientific foundations to determine and diagnose important points for building training in a way that contributes to developing the weakness or defect that was previously identified, and the effectiveness of the shot put is one of the activities with complex technical performance, as it depends on the kinetic transfer of body parts with explosive speed and strength and in a coherent and specific manner with certain conditions for technical performance to create a kinetic path with general characteristics that apply to all throwing activities in athletics (Ali et al., 2026 ; Balore et al., 2026; Abdulloh, 2026).

Through the researchers' experiences as former national team players and current coaches for throwing activities, I noticed a lack of interest in achievement ability training (training characterized by maximum speed and different proportions of strength depending on the amount of force that is overcome) for throwing activities, especially for the non-preferred party or the opposite side of throwing, because the limb symmetry index It gives a clear idea to the trainers about the type of training that the player needs, and from a scientific point of view, it is the transfer of the effect of learning in the learning processes and the transfer of the effect of training in the sports training processes. In addition, the development of physical aspects directly affects the mechanical variables, as the level of kinematic variables represents one of the basic features that reflect the development of the level of performance in most sports skills and activities.

The effectiveness of the shot put is one of the activities affected by these variables, and the final speed of the tool's launch is the result of the sum of the different body speeds during the different stages of performance, which are performed in a rotating manner, which means the transfer of the amount of push from one part to another through the different joints of the body according to the motor performance of this activity. This is because some

variables are influential in achieving the final speed according to the starting angle as well as the starting point height and some other kinematic variables such as the length of the rotation distance and the height of the body's center of mass and the body's tilt angle in the power position and the disposal position, so the importance of this study came in developing the performance ability training (strength and speed) according to the limb symmetry index for the preferred and non-preferred limb in some different types of strength and mechanical variables that the shooter needs in different proportions to achieve the best achievement, and the research aims to prepare performance ability exercises according to the limb symmetry index (preferred and non-preferred limb) for young shot put throwers. In addition, to identify the effect of performance ability exercises according to the limb symmetry index (preferred and non-preferred limb) on some types of muscle strength, mechanical variables and achievement for young shot put throwers

## B. METHOD

### *Participant*

The research community was determined by track and field runners for the push activity in the Middle Euphrates region (Najaf Governorate, Babylon, Karbala, Qadisiyah) youth under the age of 20 for the 2023-2024 sports season, numbering (11) shooters who compete in the championships held by Iraqi Athletics Federation, and they were taken in full by the comprehensive enumeration method, with the exception of one player because he throws with the sliding technique and the rest of the players perform the rotation technique, as the researchers divided them into two groups with (5) shooters for the experimental group and (5) shooters for the control group, and the process of distributing them was random, and homogeneity was carried out for the sample members as shown in Table (1)

**Table 1.** Shows the homogeneity of the sample individuals.

Variables	Measuring unit	Mean	Median	Std. Deviations	Skewness
Length	Cm	1.82	1.81	0.04	0.75
Mass	Kg	87.2	87	6.75	0.09
Chronological Age	Year	17.3	17	0.92	0.97
Training Age	month	54.4	55	2.38	0.75

### *Research Design*

The experimental method was used by designing two equivalent experimental groups.

1. Bench press level number
2. Field and square stadium
3. PANASONIC cameras
4. Bear hanger number 1
5. Olympic iron shaft weighing 20 kg
6. Genometer device number 1
7. Legal shot puts weighing 7.260 grams number 4
8. Multi-shot put dumbbells
9. Metal measuring tape length (40) meters
10. Data entry form

11. Motion analysis software (TRACKER, KINOVEA)
12. Manual stopwatch number 1
13. Iron chairs with a height of 50 cm number 1
14. Barrier with a height of 50 cm number 2
15. Electronic scale to measure the mass of players (KETECTO) made in Germany.
16. Medicine balls weighing 3 kg, 2 pieces
17. Scientific hand calculator, type (CASIO).
18. Jump boxes
19. Iron discs in pairs weighing 2.5 kg + 5 kg + 10 kg + 15 kg + 20 kg + 25 kg

### *Field research procedures*

Determining some types of strength and testing them.

First: Testing the legal achievement in the shot put- activity and photographing it to extract some mechanical variables from the best attempt in terms of achievement (International Athletics Law (translation) Sarih Abdul Karim Al-Fadhli, 2011, p. 211). The aim of the test/Identifying the achievement of each player and each throw.

The tools used/The shot put- activity field in athletics, Al-Najaf Sports Club stadium, which is a legal throwing circle with a diameter of 2.13 m in addition to using four legal shot puts in terms of their mass and diameters, a measuring tape with a length of 25 meters in addition to the presence of two cameras distributed next to and in front of the legal circle to photograph the entire performance and then analyze it. Performance method/the players alternate their throws, each player has six attempts.

Measurement method/Each throw is measured through the first trace left by the tool in the throwing field to the beginning of the throwing circle hoop from the outer edge. The researchers also installed the power platform in the discus throwing circle and then installed it in the shot put circle, where the researchers were keen for the circle to be in the appropriate shape for the throwing process in terms of the law and the safety of the players, and six throws were given to each thrower according to the game law and a picture of each of these throws, and the achievement of each throw was recorded. The purpose of photographing the shot put for all throws for the research sample is to extract the results of the mechanical variables under study, as the researchers used two PANASONIC video cameras with a speed of 400 frames/second, placed on a tripod. The first camera was fixed next to the throwing circle field from (the right side) on the side of the throwing hand and at a height of (1.20) meters, and it is (4) meters away from the middle of the throwing circle, so that it is perpendicular to the middle and at a height that is perpendicular to the hand holding the tool. As for the front camera, it was from the front side of the throwing circle (the side of the cutter) and it is perpendicular at a 90-degree angle with the first camera and at a height of (1.20) meters, and it is (4) meters away from the middle of the throwing circle, and the process is recorded Throwing and a one-meter scale was used, which was photographed at the midpoint of the performance's kinematic path and given.

Second: Some types of strength, including:

Explosive strength for each of

1. The body as a whole, measured by a test of throwing a shot put with the hands backwards, weighing (7.260) kg (Kamal Abdul Hamid, Muhammad Subhi Hassanein, 1997, p. 244). The aim of the test / measuring the explosive strength of the legs, trunk, arms and shoulders. The tools used / shot put weighing (7.260) kg, a suitable place to

throw the shot put (throwing circle), measuring tape. Performance method / The tester stands with his back facing the throwing sector, holding the shot put with both hands and feet slightly apart, so that the heels of the feet touch the outer edge of the stop board of the shot put throwing circle, from this position, swing the arms down with the knees bent, then throw backwards with maximum force. Measurement method / The measurement is made from the outer edge of the throwing circle to the last part of the shot put that touches the ground from the direction of the starting line, and the measuring line is included in the distance and the measurement is made to the nearest cm. The tester has three attempts, all of which are recorded.

2. The arms were measured by a test of throwing a 3 kg medicine ball from above the head while sitting on a chair and tying the trunk
3. The legs were measured by the horizontal Sargent test.

Maximum strength for each of

1. for the arms and was measured by the flat bench press test (chest pressure)
2. for the legs and was measured by the posterior tibial test
3. the trunk and was measured by the dynamometer test

Speed-specific strength for each of

1. for the arms and was measured by the arm flexion and extension test within 10 seconds (front leaning)
2. for the legs and was measured by the jabbing test over a 50 cm high barrier with both feet within 10 seconds. Note (All tests were conducted with the same specifications mentioned for testing the explosive strength of the body).
3. Determining some of the mechanics involved in the effectiveness of the shot put by rotation and the method of measuring it (Qasim Hassan Hussein, Iman Shaker, 1998, p. 28) (Qasim Hassan Hussein, Iman Shaker: 2000, 267) (Sulaiman Ali Hassan, Ahmed Al-Khadem: 1998, p. 97) (Regional Development Center for Athletics, 2004, p. 15) The method of calculating the variables specific to the research is through the steps of the kinematic analysis of the movement, which included the use of the TRACKER program and (KINOVEA) version 14, which are advanced programs in kinematic analysis, especially for calculating displacements, times, angles, and other variables. The research variables were determined after referring to the scientific sources and references in a manner consistent with the goal and topic for which they are:
  - a. Total throwing time:
  - b. Preparation phase time (from the moment the movement begins until the moment of placing the push):
  - c. Throwing phase time (time of the push and disposal movement):
  - d. Trunk inclination angle at the moment of placing the push:
  - e. Trunk inclination angle at the moment of disposal:
  - f. Shot put launch angle:
  - g. Knee angle of the back leg during the throwing position:
  - h. Height of the body's center of gravity at the moment of disposing of the tool:
  - i. Height of the shot put launch point:
  - j. Length of the throwing step:

- k. The lost distance between the supporting leg's foot and the inner edge of the stop plate:
  - l. Linear distance of the tool during the dual support position:
  - m. Shot put launch speed.
4. Exploratory experiment: It was implemented on Wednesday (3/1/2023) in order to identify the test and the validity of the research measurements. As well as conducting limb symmetry tests for the lower limbs and upper limbs in order to build training for the ability to perform according to the results of the limb symmetry test, and to develop appropriate exercises for the research sample, the experimental group. As follows:
- a. Arm tests, including throwing a medicine ball for each arm separately
  - b. Leg tests, including jumping for each leg separately, and the results were
  - c. Iron tests for the legs and arms, which are individually, as follows

**Table 2.** Shows the results of the sample in the test of the preferred limb and the non-preferred limb for the upper limbs (arms) and lower limbs (legs)

Part	Tests	Unit of measure	Favorite party	unfavorable party	Percentage of difference according to the limb symmetry index
Jump legs	Jump 5 hops per leg	meter	13.20	12.20	7.5
	Jump 5 hops sideways	meter	7.20	6.30	12.5
Throw arms	Push 3kg medicine ball in front of chest	meter	14.80	13.40	9.45
	Throw 1kg medicine ball over head	meter	16.60	13.20	20.48
Iron legs + arms	Dumbbell snatch	meter	45	37.5	16.67
	One Leg Squat Machine	kg	115	100	13.04

A second pilot experiment was conducted on (7/1/2023) corresponding to Sunday to experiment with the performance ability exercises set according to the results of the limb symmetry and determine the maximum intensity for each exercise.

*Pre-tests for the research sample*

The test (is a means of evaluation, measurement, diagnosis and guidance in curricula, programs and various plans for all levels and age groups. It clearly indicates the extent of progress and success in achieving objective goals) (Kamal Abdel Hamid, Muhammad Subhi Hassanein, 1997, p. 267). The researchers conducted, with the help of the pre-test for one day on Thursday, corresponding to 11/1/2024 at exactly five o'clock in the evening, at the Najaf Sports Club stadium, as follows:

1. First: Achievement and photography
2. Second: Physical abilities test (achievement ability and strength characterized by speed and maximum strength)

### *Designing achievement ability training*

The researchers conducted limb symmetry tests to build exercises specific to achievement ability according to the results of this test, the limb symmetry index with strength tests for distances for the limbs and using Newton's second law

1. Calculate the lower limb symmetry index
2. In terms of distance: =Distance of the unfavorable side / Distance of the favored side x 100%
3. When calculating force in terms of distance traveled, we use Newton's second law
4. In terms of more force, more distance
5. Force =  $K \times m / N^2$
6.  $m = \text{Force} \times N^2 / \text{mass}$
7.  $N = K \times m / \text{Force}$

The exercises used in the training program fall within the special preparation phase. The training was implemented on Saturday (13/1/2024) until Thursday (7/3/2024). The (repetitive) training method and the high-intensity training method were used to develop the explosive strength of the arms, legs and body as a whole, the maximum strength and the speed-specific strength of the arms and legs. The intensity of the training units ranged from (75%-105%).

An example of the method used to calculate the difference in repetitions and intensity between the two sides of the body (the preferred side and the non-preferred side) through iron training is to increase the load in repetitions or shot put in individual exercises. We take into account the difference between (1RM) for each side, divided by (1RM) for the stronger side, multiplied by 100 to find out the percentage of the difference between them, multiplied by the number of repetitions, then divided by 100, and the result is the added repetition.

For example, a single dumbbell snatch.

Right (40) kg, left (35) kg.  $40-35=5$  kg If we want to know the percentage of difference using the following equation.  $40 \div 5 \times 100 = 12.5$  percentage of difference

Knowing the repetition added to the left side if the right side was 10 repetitions:  $10 \times 12.5 \div 100 = 1.25$  repetitions added (1) approximate. However, if the training load is increased by shot put (mass) for the lesser side if the intensity is 85%, the lifted mass =  $35 \times 85 \div 100 = 29.75$  kg.  $29.75 \times 12.5 \div 100 = 3.7$  kg and divided by the number of repetitions to extract the mass added to the lesser side. (Ali Kazem Hussein Al-Jawrani, 2019, p. 67)

However, if the jumping and throwing exercises depend on distance, for example, 5 hops for the right leg 12.5 meters and for the left leg 11.5 meters, the difference is 1 Meter.  $1 \div 12.5 \times 100 = 8$  percentage difference. To know the repetition added to the left side if the right side was 10 repetitions.  $10 \times 8 \div 100 = 0.8$  repetition added (1) approximately. Also, when increasing the throwing distance or the number of repetitions for the non-preferred side.

The jumping exercises used by the experimental group according to the limb symmetry index (hopscotch, landing from a box at a height of 1 meter, lateral jump with one leg) for iron exercises trained with one arm with dumbbells (snatch, trapezius, press, pull,

bench press) for throwing exercises with one arm 2 kg, 3 kg, 4 kg, 5 kg ball (force position, overhead, sideways, backwards)

1. Duration) of the exercises) experimental training method (8) weeks.
2. Number of (doses) of total training units (24) training doses.
3. Days of application of training doses: Sunday - Tuesday - Thursday.
4. Time of (dose) (training unit) total (120) minutes allocated for research or experimentation ranges between (45-60 minutes) and as shown in the details of some training dose models
5. Rest times are graded according to the type of exercise, intensity and goal between the training unit of the training week
6. Nature of the undulation: (2-1) during the week and between weeks, but the last two weeks were undulating (1-1) as the researcher relied on the principle of gradual load gradation in a regular manner so as not to lead to the phenomenon of overload that negatively affects the players, as shown in the following table.

**Table 3.** Shows the intensity and undulation and represents 2:1.

Weeks	intensity used	Saturday Date		Monday Date		Thursday Date	
		Adjective: Top Speed		Adjective: Hastening		Adjective: Speed Endurance	
First week	80%	80%	13/1	85%	15/1	75%	18/1
Second week	90%	90%	20/1	95%	22/1	85%	25/1
Third week	85%	85%	27/1	90%	29/1	80%	½
Fourth week	90%	90%	3/2	95%	5/2	85%	8/2
Fifth week	95%	95%	10/2	100%	12/2	90%	15/2
Sixth week	100%	100%	17/2	105%	19/2	95%	22/2
Seventh week	95%	95%	24/2	100%	26/2	90%	29/2
Eighth week	100%	100%	2/3	105%	4/3	95%	7/3

*Post-tests*

After completing the training for the research group, the post-tests were conducted on Sunday (10/3/2024), taking into account the same time and place conditions in which the pre-tests were conducted.

*Statistical methods*

The search data was processed through the Statistical Package for the Social Sciences (SPSS).

**C. RESULTS AND DISCUSSIONS**

**Results**

Presentation the pre- and post-test results of some types of muscle strength, mechanical variables, and achievement of the shot put- activity of the youth of the control group:

The results in Table (4) show that the calculated (t) values for the control group for all study variables (for some types of muscle strength, mechanical variables and achievement) were statistically significant at an error level of less than 0.05 and a degree of freedom of (4). This indicates a significant development in the results of these variables in

favor of the post-test, with the exception of the variable of the throwing phase time, the variable of the trunk tilt angle at the moment of disposal, the variable of the shot put starting point height, the variable of the throwing step length, and the variable of the linear distance of the tool during the position of the bilateral support, which were not significant.

**Table 4.** Shows the arithmetic means, standard deviations and calculated (T) values for some types of muscle strength, mechanical variables and achievement of the shot put effectiveness of the youth of the control group.

variables	Tests	Unit of measure	Pre-test		Post-test		Calculated value of (t)	level sig	type sig
			Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation			
Explosive Power	Back shot put throw (for the body)	meter	15.81	0.09	16.11	0.11	4.44	0	sig
	Medicine ball throw (for the arms)	meter	9.51	0.19	9.89	0.26	3.11	0.01	sig
	Horizontal Sargent (for the legs)	meter	2.86	0.08	2.88	0.09	2.56	0	sig
Maximum Power	Bench press (for arms)	kg	126.8	3.89	130.6	4.08	4.28	0	sig
	Back press (for legs)	kg	147.5	5.25	152.3	5.78	5.02	0	sig
	Genometer (for trunk)	number/second	229.5	10.78	241.1	11.15	6.16	0	sig
distinctive strength of speed	Bend and extend your arms for 10 seconds (arms)	meter	10.3	0.26	11	0.25	3.01	0.08	sig
	Jump over a 50cm high barrier with both feet for 10 seconds (legs)	Number/second	13.25	1.08	14.45	1.13	2.87	0.01	sig
Some mechanical variables	Total throw time	second	1.56	0.12	1.53	0.11	2.35	0.04	sig
	Preparation phase time	second	1.35	0.09	1.33	0.1	2.27	0.03	sig
	Throw phase time	second	0.21	0.01	0.2	0.02	1.36	0.37	Non Sig
	Trunk inclination angle at the moment of the push position	degree	23.5	2.11	24.8	2.21	2.88	0.04	sig
	Trunk inclination angle at the moment of release	degree	7.98	0.65	8.03	0.59	1.04	0.08	Non Sig
	Shot put release angle	degree	33.72	2.87	36.71	3.33	2.91	0	sig
	Back leg knee angle during the throw position	degree	113.4	5.78	110.9	5.13	3.01	0	sig

	Height of the body's center of gravity at the moment of releasing the tool	second	1.06	0.03	1.06	0.02	1.04	0.34	Non Sig
	Height of the starting point of the shot put	meter	1.91	0.06	1.92	0.05	1.13	0.21	Non Sig
	Length of the throwing stride	meter	0.51	0.08	0.5	0.07	0.78	0.37	Non Sig
	Distance lost between the foot of the supporting leg and the inner edge of the stop plate	meter	0.12	0.02	0.1	0.03	2.69	0	sig
	Linear distance of the tool during the bi-pivot position	meter	1.06	0.12	1.07	0.11	1.34	0.23	Non Sig
	Velocity of the shot put's release	m/s	9.32	0.411	9.45	0.399	2.76	0.03	sig
Achievement	Achievement test	meter	13.78	0.97	13.97	0.92	3.01	0.01	sig
Significant has a degree of freedom of 4 and is below a significance level equal to or smaller than 0.05									

Presentation the pre- and post-test results of some types of muscle strength, mechanical variables, and achievement of the shot put- activity of the youth of the experimental group.

The results in Table (5) show that the calculated (t) values for the experimental group for all study variables (for some types of muscle strength, mechanical variables and achievement) were statistically significant at an error level of less than 0.05 and a degree of freedom of (4). This indicates a significant development in the results of these variables in favor of the post-test, with the exception of the variables of the trunk tilt angle at the moment of disposal and the length of the throwing step, which were not significant.

**Table 5.** Shows the arithmetic means, standard deviations and the calculated (T) value for the values of some types of muscle strength, mechanical variables and the achievement of the shot put- effectiveness of the youth of the experimental group.

variables	Tests	Unit of measure	Pre-test		Post-test		Calculated value of (t)	level sig	type sig
			Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation			
Explosive Power	Back shot put throw (for the body)	meter	15.95	0.1	16.36	0.18	5.19	0	sig
	Medicine ball throw (for the arms)	meter	9.42	0.18	10.37	0.21	7.19	0	sig
	Horizontal Sargent (for the legs)	meter	2.87	0.09	2.94	0.07	8.11	0	sig
Maximum Power	Bench press (for arms)	kg	125.9	3.92	134.2	4.28	4.22	0	sig

	Back press (for legs)	kg	149.1	5.98	158.2	6.02	5.29	0	sig
	Genometer (for trunk)	number/second	233.2	11.27	254.7	13.78	7.21	0	sig
distinctive strength of speed	Bend and extend your arms for 10 seconds (arms)	meter	10.1	0.24	11.51	0.22	5.27	0	sig
	Jump over a 50cm high barrier with both feet for 10 seconds (legs)	Number/second	13.76	1.1	15.88	1.11	6.27	0	sig
Some mechanical variables	Total throw time	second	1.55	0.11	1.5	0.11	3.22	0	sig
	Preparation phase time	second	1.33	0.08	1.3	0.07	2.9	0.03	sig
	Throw phase time	second	0.22	0.01	0.2	0.01	3.02	0	sig
	Trunk inclination angle at the moment of the push position	degree	24.8	2.16	29.1	2.57	3.96	0	sig
	Trunk inclination angle at the moment of release	degree	8.13	0.57	7.32	0.48	1.28	0.32	non sig
	Shot put release angle	degree	34.09	3.01	37.22	3.38	3.95	0	sig
	Back leg knee angle during the throw position	degree	114.6	6.04	106.1	5.89	4.23	0	sig
	Height of the body's center of gravity at the moment of releasing the tool	second	1.05	0.02	1.08	0.01	3.71	0	sig
	Height of the starting point of the shot put	meter	1.9	0.06	1.97	0.04	4.02	0	sig
	Length of the throwing stride	meter	0.54	0.09	0.53	0.08	2.23	0.04	non sig
	Distance lost between the foot of the supporting leg and the inner edge of the stop plate	meter	0.11	0.02	0.08	0.04	2.77	0.03	sig
	Linear distance of the tool during the bi-pivot position	meter	1.07	0.11	1.14	0.1	3.27	0.01	sig
	Velocity of the shot put's release	m/s	9.34	0.465	9.92	0.41	4.49	0	sig
Achievement	Achievement test	meter	13.81	0.99	14.38	0.82	5.31	0	sig
Significant has a degree of freedom of 4 and is below a significance level equal to or smaller than 0.05									

**Table 6.** Shows the arithmetic means, standard deviations and the calculated (T) value for the values of some types of muscle strength, mechanical variables and the achievement of the effectiveness of shot put- for the youth of the control and experimental groups for the post-test.

variables	Tests		Pre-test	Post-test			
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		Unit of measure	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation	Calculated value of (t)	level sig	Type sig
Explosive Power	Back shot put throw (for the body)	meter	16.11	0.11	16.36	0.18	2.64	0.01	sig
	Medicine ball throw (for the arms)	meter	9.89	0.26	10.37	0.21	4.02	0	sig
	Horizontal Sargent (for the legs)	meter	2.88	0.09	2.94	0.07	3.32	0	sig
Maximum Power	Bench press (for arms)	kg	130.6	4.08	134.2	4.28	2.61	0.02	sig
	Back press (for legs)	kg	152.3	5.78	158.2	6.02	3.09	0	sig
	Genometer (for trunk)	number/second	241.1	11.15	254.7	13.78	6.98	0	sig
distinctive strength of speed	Bend and extend your arms for 10 seconds (arms)	meter	11	0.25	11.51	0.22	2.78	0.03	sig
	Jump over a 50cm high barrier with both feet for 10 seconds (legs)	Number/second	14.45	1.13	15.88	1.11	5.21	0	sig
Some mechanical variables	Total throw time	second	1.53	0.11	1.5	0.11	2.97	0.02	sig
	Preparation phase time	second	1.33	0.1	1.3	0.07	3.01	0	sig
	Throw phase time	second	0.2	0.02	0.2	0.01	1.05	0.17	non sig
	Trunk inclination angle at the moment of the push position	degree	24.8	2.21	29.1	2.57	2.92	0	sig
	Trunk inclination angle at the moment of release	degree	8.03	0.59	7.32	0.48	4.14	0	sig
	Shot put release angle	degree	36.71	3.33	37.22	3.38	2.61	0.03	sig
	Back leg knee angle during the throw position	degree	110.9	5.13	106.1	5.89	4.89	0	sig
	Height of the body's center of gravity at the moment of releasing the tool	second	1.06	0.02	1.08	0.01	3.12	0	sig
	Height of the starting point of the shot put	meter	1.92	0.05	1.97	0.04	4.01	0	sig
	Length of the throwing stride	meter	0.5	0.07	0.53	0.08	2.76	0.02	sig
Distance lost between the foot of the supporting leg and the inner edge of the stop plate	meter	0.1	0.03	0.08	0.04	2.09	0.01	sig	
Linear distance of the tool during the bi-pivot position	meter	1.07	0.11	1.14	0.1	3.11	0	sig	

	Velocity of the shot put's release	m/s	9.45	0.399	9.92	0.41	4.0 2	0	sig
Achievement	Achievement test	meter	13.9 7	0.92	14.3 8	0.82	4.1 9	0	sig
Significant has a degree of freedom of 4 and is below a significance level equal to or smaller than 0.05									

The results in Table (6) show that the calculated (t) values between the experimental groups that used the performance ability training according to the limb symmetry index and the control group that used the trainers' training for the dimensional measurements of the study variables (for some types of muscle strength, mechanical variables and achievement) were statistically significant at an error level of less than 0.05 and a degree of freedom of (8). This indicates that there are significant differences in the results of these variables in favor of the experimental group, with the exception of the mechanical variable (trunk tilt angle now of release) which was in favor of the control group and the mechanical variable (throwing phase time) was insignificant.

### Discussion

The researchers attribute this development in the results of the post-measurements of the two groups to the continuation By training in a scientific manner based on a specific goal, the trainers work to achieve it according to their own goals, as training for throwing activities, especially the shot put- activity, for the specificity of performance, especially the rotation technique, which requires physical elements and high skill performance. One of the most important physical elements that shooters focus on is strength training, especially explosive strength training, as explosive strength training has a special importance within the training curricula for various sporting activities, as it is one of the main factors of performance, the most important of which are throwing activities, as the use of appropriate training plays an important role in the training process by contributing to increasing motivation and improving the physical variables under study that gain the player muscle strength, which in turn leads to reaching the kinetic path (mechanical variables) associated with optimal performance in the race.

This was achieved with the two groups and confirmed by (Muhammad Al-Disti, 2015, p. 47) "that using training based on the existing defect or weakness is one of the most important ways to increase the effectiveness of the training process, which contributes to developing areas of deficiency," as well as taking into account the principle of repetition and repetition and the complexity of appropriate training loads to create a state of adaptation for the working muscles of the individuals of the two groups. The training was applied regularly and scientifically, taking into account the components of the training load, which was confirmed by (Mohammed Reda Ibrahim, 2008, p. 88) who indicated that "all components of the training load must increase in proportion to the overall improvement achieved by the athlete, i.e. the higher the player's level of improvement, the more the need to increase the components of the training load."

The researchers also made sure that these trainings were in multiple and varied directions in movement because this would contribute to the player's ability to perform the skill better. The researchers also attribute the reason for the development of the two groups to the exercises that he focused on preparing and applying, as he was keen to develop different types of strength. Also, following the principle of undulation in implementing

training loads was one of the most important factors that helped in the clear development of the physical qualities studied, as the training loads are not at a single pace (high or low intensity), but rather following the principle of undulation between the rise and fall in training intensities, and this is consistent with what was indicated by (Mohammed Reda Ibrahim, 2008, p. 112) quoting Bomba. "The coach must gradually progress in his training curriculum by using a variety of intensity on an ongoing basis. Researchers believe that advancing the level of abilities specific to performing any sports skill or activity will inevitably contribute to improving the level of achievement of that skill or activity in a positive and effective way, and this is a goal that every coach seeks to achieve. Explosive strength training is also of special importance within the training curricula for various sports activities as it is one of the main factors of performance, as most training theories emphasize the importance of preparing the achievement ability in a special way through exercises that approach the real form of the skill performance of the practiced activity.

Jamal Sabry, (2008) states that (the orientation of the training process to develop physical and motor qualities that work to develop the technical performance of the activity is important in achieving the best achievements). Sarih Abdul Karim Al-Fadhli, (2010) states that "to develop muscle strength, the muscles must work against greater resistance than they are accustomed to, and these resistances must increase in direct proportion to the increase in muscle strength, taking into account the principle of overload for the muscles to work regularly against resistances greater than their strength, in addition to the principle of increasing resistance by gradually increasing resistance according to the increase in muscle strength." The way to develop the element of strength is to increase the external force that the muscle meets, and shot puts or other means are used for this purpose. This is what shooters must develop because it is one of the important and essential qualities to achieve accomplishment. The researchers agree with (Qasim Hassan Hussein, 1998, p. 676) "as mastering the art of motor performance is done through training in the art of motor performance, which prepares the athlete to reach the goal, and is based on a successful organization to invest the mutual influence between the internal and external forces of the athlete in order to place all the forces in a useful way to obtain high athletic results in specialized sports."

The researchers also agree with what (Peter Thompson, 2009, p. 104) (Abdel Rahman Abdel Hamid Zaher. 2009) stated: "That type of speed of movement and strength that leads to an increase in the total power must be developed once the maximum speed and strength are established and developed." The ability has a remarkable importance in endurance competitions such as throwing, as well as that each point of the shot put thrower's body, especially the performance in the rotational manner, is successive in the throwing movement and has a certain speed, and the amount of momentum depends entirely on the neuromuscular coordination, and according to Newton's second law, the acceleration in any part is proportional to the force used, so the overall appearance of the throw appears through the sequence of the muscle force resulting from the throwing movement of the neuromuscular system, where it appears that the speed of the last part of the body is the highest value before the launch, as this speed is obtained through the succession of the speed of one part to another before the throw (launch) (Sareeh Abdul Karim, Wahbi Alwan Al-Bayati 2007, 48), and this requires the thrower to make the arm carrying the tool the last part to move to increase its speed by adopting the appropriate mechanical positions for the rest of the body's organs and thus achieve the best possible achievement, and this is what

was achieved for the two groups, as the development of the physical abilities specific to the event has a direct impact on the mechanical variables associated with the performance and thus achieve the best possible achievement, and the muscle ability is the ability to exert a high level of work (the result of force and distance) at a high level of speed, so the ability It is the product of strength and speed, and physical efficiency based on ability represents great importance in most sports activities and is a field for distinguishing athletes from each other.

Many studies have confirmed the importance of resistance training in developing muscular ability, especially those trainings that depend on the use of shot puts and plyometric training. (12:15,16) This is consistent with what was also indicated by (Abdel Aziz Al-Nimr and Farhan Al-Khatib. 1996, p. 119) that there are four principles that require special considerations when developing programs to develop muscle strength. These principles are SPECIFICITY, OVER LOAD, ADAPTATION, and PROGRESSION. The principle of specificity is summarized in that performance improves better if the training is specific to the type of activity practiced and includes the most important muscles working in this activity, and they are developed in special ways according to how they are used in competition and that the same energy systems used are developed and that the exercises are similar in their motor composition to the skill movements specific to the game. (14: 201) Where when the body moves in a transitional movement resulting from a rotational movement, there is a role for the mass in resisting this movement as is the case when using different jumping movements. In this case, there is a role for the force of gravity directly on the body mass, and this is the real principle of strength training with body mass, which plyometric training depends on, which causes a change in Muscle contraction between central and eccentric, and the more the body mass increases, the more the body resists the transitional movement.

Developing muscle strength and ability, as it is possible to achieve a better level of muscle strength and ability depends mainly on choosing the appropriate training method (Talha Hossam El-Din et al., 1998, p. 59). When the body moves in a transitional movement, there is a role for the mass in resisting this movement, as is the case when using different jumping movements, and in this case there is a role for the force of gravity directly on the body mass, and this is the real principle of strength training with body mass, which plyometric training depends on, which causes a change in muscle contraction between central and eccentric, and the more the body mass increases, the more the body resists the transitional movement. Bastawisi Ahmed, (1997) Deep jumping exercises are an effective method of training explosive power and developing the ability of the neuromuscular system to change quickly, and one-legged jumping exercises can be used with all levels of athletes. And deep jumping affects the increase in reaction and explosive power of the legs (Suleiman Ali Hajar, Khairiya Ibrahim Al-Sakri. 1997, p. 81). As this characteristic is important in many sports activities or events, including the effectiveness of shot puts, as they must have high muscle strength and motor speed during performance, and thus they need these two elements to produce ability, and the training method of jumping and throwing medicine balls focuses greatly on developing ability and embodying the gap between strength and speed. Because these exercises are the link between both muscle strength and ability because it improves the level of performance through these two qualities because muscle strength is a basic quality, while training medicine balls is directing these forces in their appropriate paths to raise the level of speed of performance.

Therefore, it must be available to the shooters, and the weakness of this ability has a major role in the weakness of achievement, as shown by (Amr Allah Ahmed Al-Basati, 1998, p. 18) that training cases depend on the degree of its components, the higher the level of components, the higher the level of achievement, taking into account the coordination between the degree of development and advancement of these components according to the level of competition, and therefore This feature can be used in training to develop performance first by emphasizing increasing the vertical distances between the centers of gravity of the leg parts and the axes of rotation (joints). This means emphasizing the adoption of the correct technical positions that provide the least resistance and obtain high fluidity in speed, strength and motor transfer. Or this feature can be exploited to develop strength by increasing the mass of the body parts (for each part), i.e. adding shot puts such as shot puts to the body or body parts. Thus, we will increase the value of resistance and the value of the muscle strength required to overcome it in the shortest possible time. This increase is considered as resistance forces that the athlete tries to overcome gradually through training.

Thus, the efficiency of the working muscles will increase in two directions: the first is if the performance is applied without added shot puts, and the second is if the performance is applied by adding shot puts. What is applied to the leg can be applied to any other part (arms - trunk) (GUNTER TIODOW LMODEL, 1993), provided that the application is with the highest strength and the shortest possible time to ensure the development of explosive strength, which positively affects the mechanical variables accompanying the performance and thus affects the achievement achieved. As for the variables that were not The significant variables are the time of the throwing phase, the variable of the trunk tilt angle at the moment of release, the variable of the shot put starting point height, the variable of the throwing stride length, and the variable of the linear distance of the tool during the dual support position for the control group, and the variables of the trunk tilt angle at the moment of release and the length of the throwing stride for the experimental group. The researchers believe that the reason for the lack of significant development in these variables is that the training that they used in both groups does not focus on these variables primarily, and the second reason requires more time for significant development to occur.

The researchers believe that the preference of the control group for the mechanical variable (trunk tilt angle at the moment of release) indicates that the control group did not benefit from the speed it obtained during the final throwing position, unlike the control group that did not benefit from this variable because it benefited from the trunk tilt angle variable during the force position and also benefited from the linear distance variable of the tool during the dual support position with a constant time taken, which affected the increase in the speed of launching the tool, which is the most important variable. The mechanical variables affecting achievement, as for the absence of significant differences between the two groups for the mechanical variable (throwing phase time), it indicates that the two groups are almost equal in this variable, but the preference is for the control group because it benefits from the length of the distance covered by the tool during this time and thus the increase in the final speed result because the speed is equal to the distance covered over the time taken, meaning that the speed is directly proportional to the distance and inversely proportional to time. This is what happened to the experimental group, which is the increase in the distance during the time taken, which gave the advantage to the experimental group. Therefore, the researchers believe that the advantage of the experimental group over the

control group is due to the fact that the goal of applying the appropriate exercises for the non-preferred party at a rate that is compatible with the difference between the two parties according to a prior scientific training plan and by adopting a scientific training intensity standardized according to specific goals that they are trying to achieve, helped the members of the experimental group to increase the sense of the rhythm of throwing during training and to maintain this rhythm with standardizing the distances for throwing that were prepared during the training units as much as the competitor's physical capabilities allow him to determine the ideal achievement for the race, and this is what made the achievement develop in the post-tests in favor of the experimental group, as the achievement in Throwing activities depend on a set of physical and mechanical variables that, if combined, enable the thrower to achieve the best throwing distance at the level of those variables.

The more his athletic ability develops, the better level he can achieve in mechanical, physical or functional variables. We notice that this is directly reflected in the distance achieved in throwing. Accordingly, the association of mechanical or physical variables with the achievement distance is not new evidence, but it indicates that the research results are moving in the correct scientific direction, as well as the extent of the suitability of the training exercises that were prepared for the non-preferred party based on the results of the tests that took it upon themselves to raise the level of variables according to the specialized direction of training. This is what happened for the experimental group, which led to outperforming the control group. (P87. CANOLA VITTONI, 1995) indicates that muscular capacity must be developed through specialized movement training. In activities that are performed by lifting with one foot, such as handball, their training must depend on performing on one side (one foot). As for activities that depend on lifting with both feet, such as volleyball, training on these exercises must be dual, i.e. with both feet together.

The researchers also attribute this development in the maximum strength of the targeted muscles on both sides of the body in the post-test, especially the less powerful muscles, to the training method followed by the researcher in implementing the special exercises and taking into account the principle of gradualism, as he began by using the high-intensity interval training method, then gradually increasing the components of the training load, and then using the repetitive training method to develop different types of strength. Given these intensive training loads on each side, especially the less powerful muscles, which may extend to three days a week, they must receive a sufficient amount of recovery; To get rid of the effects of training doses and their accumulation in the muscle, because "the muscle needs to gradually increase the amount of resistance it faces in order to continue the process of acquiring and growing muscle strength, and this is done by increasing the amount of shot put or resistance used in training; so that the muscle adapts to it and is usually used three times a week; in order to recover and get rid of the effect of the previous dose (Ali Kazem Hussein Al-Jourani. 2019, 85), and (A. ÖSTENBERG, A. H., BJÖRKLUND, G, & ALRICSSON, M, 2017 05, P 157) states that "the ideal technique for performance in the shot put- activity requires correct motor coordination between the different parts of the body in addition to the muscle synergy of the muscle groups participating in the motor performance has greatly participated in investing strength and speed and linking them within a harmonious motor framework and achieving the principle of rapid application of the vector force based on the law of propulsion in order to improve the dynamic time distribution and achieve a high amount of movement for the thrown tool at the moment of leaving the thrower's hand, as the law of propulsion states that The force of any object during a period of time equals the

resulting change in the amount of motion of that object during that period of time, which leads to achieving the farthest possible horizontal distance for the projectile.

Therefore, (Talha Hussam El-Din, 1994, p. 69) believes that muscle strength must be developed according to the momentary uses or muscle groups within the skill performance, as it is considered a decisive factor in the success of the process of employing the nervous work for this performance. Researchers also believe that the lack of equality of muscle strength on both sides of the body may result in a technical error in the performance, which is the lack of synchronization and regularity of the process with both arms, which leads to the extension of one arm before the other, and this common error is called successive extension, which in many cases leads to the optimal exploitation of the force produced during the performance. (Abdul Aziz Al-Nimr, 2010, 158) indicates that it is important to provide exercises that work to strengthen muscle groups on both sides of the body when designing training curricula to develop muscle strength, by influencing the less powerful muscles by increasing the training intensity and according to the need of the muscle and the percentage of difference with its counterpart on the other side; Therefore, the development rates for the left side appear higher than the right side, and this is what was confirmed by (LEONARD JUSTIN, 2001, P 28) that training should be done according to the principle of priority, which means training the less powerful muscle first or training it with higher training loads than the stronger muscles. The goal of explosive power training is to transform or change the time component in favor of applying force in skill performance. Power training, by its nature, focuses on the power component in movement, as explosive muscular power (performance power) depends on the interaction between force and speed, which means that any increase in force or speed leads to a subsequent increase in explosive power. However, power plays a simple role unless the athlete is able to apply it explosively over a short period of time (Mohammed Jaber Briqa and Ihab Fawzy Al-Badawi, 2004, p. 98).

Plyometric training and throwing training with shot puts and medicine balls, especially for the non-preferred limb, are among the best methods of power training. The reason for this is to avoid the problem of slowing down that occurs during traditional shot put training, which negatively affects the power output because it trains the muscle to slow down, especially for the preferred limb. And that training based on correct scientific foundations has the ability to increase muscle contraction, which makes better production of muscle work by recruiting the largest number of muscle fibers. Continuing with these training loads makes the muscle stronger as a result of the adaptations that occur in these fibers, which in turn works to improve muscle balance through the ability of the nervous system to send nerve impulses to produce equal muscle strength for the muscles on both sides of the body to overcome different resistances with fluidity and ideal muscle movement coordination. The researchers agree with (Wissam Yassin Burhan Al-Qasir, 2016, p. 89) (Amira Hassan Mahmoud, Maher Hassan Mahmoud. 2008) (Adel Abdel Basir and Ihab Adel. 2004.). Also with (Abu Al-Ala Ahmed Abdel Fattah, 1997, p. 76), the neuromuscular system is responsible for moving the body's organs, as the skeletal muscle receives nerve signals from motor neurons and performs its function to perform muscle contraction, in that it "regulates the work of neuromuscular communication by the motor unit system, which is the basic unit of the motor nervous system, as each motor unit consists of a nerve cell and a group of muscle fibers, the number of which is estimated according to the number of nerve branches branching from the axis of the nerve cell controlling these fibers", as for balance exercises, the nerve cells on the right side of the brain control the movement of the muscles

on the left side of the body, and vice versa, and the reason for this is that the nerve fibers extend from the motor area to pass to the other side when they extend down to reach the spinal cord. Some of them have decreased values of the averages, which is what is required, and some of them have increased, depending on the size of the muscles or the working muscle group in particular, as most of the relevant sources mention.

These values and their variation confirm the existence of an imbalance in the muscle strength on both sides of the body, and this is what (DAVID FERING., ET AL., 1997, P. 7) confirms that when the muscle groups on one side of the body are relatively stronger than the muscle groups on the opposite side, this will result in an imbalance of muscle strength on both sides. Researchers also attribute the lack of equality in the values of maximum strength between the corresponding muscles on both sides of the body and the lack of muscle balance to training aspects resulting from the lack of performance of exercises with a single lever (dumbbells or other devices) to develop and strengthen the muscles of each side separately (under the name of the single separation strategy), which in turn leads to irregularity and synchronization of the process. This was confirmed by (Wissam Yassin Burhan Al-Qasir, 2016, p. 88) that any weakness in the muscles on one side of the body causes an imbalance in the muscle balance as a result of the shooter focusing on the strong muscles, as well as performing exercises for both arms without regulating the muscle balance in a sound scientific manner.

The researchers attribute the reason for obtaining this result to the fact that the experimental group was better in the types of strength as a result of the exercises that were built according to the symmetry of the limbs in developing the achievement strength (explosive power and the power characterized by speed), which led to a better development in the achievement because these variables have a direct impact on the achievement. Accordingly, it is inferred from the above and the results presented that the increase in the variable of explosive power is accompanied by an increase in the level of speed of the body parts, which is reflected in the instantaneous launch speed, and that these forces affect in one way or another the rest of the other variables. This means that there is a good exchange in the influence between the internal and external forces, which affects the final path of the center of gravity of the body and the path of the center of gravity of the tool. This is a result of regulating the load and gradualness with it and stopping at an appropriate limit that does not exceed the increase that causes the opposite effect in the functional and health condition of the player, which has its effect in achieving the correct motor performance with high fluidity and achieving a base of support that achieves for the player a high and required motor balance to ensure continuity of speed in the body parts. This indicates the integration of the push in the working joints and muscles of the body and thus the launch of the tool at high speed and achieving the required achievement (Ali Mustafa Taha, 1999, p. 257)

#### **D. CONCLUSION AND RECOMMENDATIONS**

The exercises of the achievement ability according to the index of symmetry of the limbs (the preferred and non-preferred limb) used by the experimental group and the regular exercises used by the control group led to the development of some physical abilities, mechanical variables and achievement of young shot put. The development of some abilities for the two groups led to a positive impact on the development of some mechanical variables for young shot put and thus the impact on the achievement of the two groups. The

superiority of the experimental group over the control group in influencing the development of some abilities and thus the advantage of developing some mechanical variables and achievement for young shot put through the achieved results. The superiority of the experimental group over the control group in influencing the development of some abilities and some mechanical variables and achievement for young shot put through the achieved results as a result of the exercises based on the index of symmetry of the limbs, which gave more training for the non-preferred limb, which gave the advantage and final achievement.

Recommendations: Researchers recommend using the research results they reached according to the theory of limb symmetry in other throwing events, whether with one arm (javelin, discus) or with two arms (hammer). Researchers recommend using unilateral training (preferred and non-preferred) according to the theory of limb symmetry, which gives a clear picture of the difference between the strength level of the two parties and how to reduce this difference. Researchers recommend that throwing and jumping event training be directed to developing the ability to achieve in its various forms, especially events that depend on the ability element because it directly affects the mechanical variables associated with the skill performance of the event and thus the positive impact on achievement. Continue training the experimental research sample in order to quickly raise their levels to high and distinguished levels if the training is done for a longer period with good monitoring of the training components.

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## **F. AUTHOR CONTRIBUTION STATEMENT**

Dr. Saad Jassim Jilab & Prof. Dr. Ammar Makki Ali is responsible for the manuscript in this study.

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