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EFFECTS OF IMPULSE-ORIENTED EXPLOSIVE EXERCISES FOR ARMS AND LEGS ON BIOMECHANICAL EFFICIENCY AND PERFORMANCE OUTCOMES IN U-20 JAVELIN THROWERS

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Abstract
The results of the javelin world championships witnessed a remarkable improvement in the level of digital achievement by young throwers. This improvement is attributed to the development of throwers' special physical capabilities. Various training methods have been used in order to compete to get the farthest distance possible in this event. Therefore, this study was conceived to prepare explosive power exercises according to the principle of impulse and its effect on some biomechanical variables and the achievement of the youth-level javelin throw. We prepared these exercises and applied those to (8) U-20 throwers of the Iraqi Athletics Federation.
The researchers tests measured some biomechanical variables, which run as follows: the strength of the driving leg; the strength of the propelling leg; the impulse time of both the driving leg and the propelling leg; the force exerted by the throwing arm; the starting speed; the angle of performance; and the distance of achievement, The research problem was that the exercises used did not take a number of things into account. These include many variables in addition to what the athlete needs from explosive power exercises according to the principle of impulse in order to achieve appropriate technical performance, which is directly reflected on this achievement. The result shows noticeable development in the values of the measured biomechanical variables as well as achievement.
Keywords: Explosive power, Impulse training, Biomechanical variables, Performance improvement

1-1 Introduction and significance of research

The javelin throw is one of the events that need high physical capabilities to perform its movements. This requires an increase in the training effort and entails coaches to use mechanical indicators to identify the level of physical development of the throwers, especially since all of these capabilities are linked to mechanical indicators such as the impulse time of the legs and arms, the throwing angle and other indicators. This is manifested in the development taking place in the training techniques by many experts and trainers. This in turn is demonstrated in the use of modern and appropriate performance training methods to show their value and impact on the level of development that the thrower gets in training. This development depends primarily on the level of impulse of all kinds, which is prerequisite for the player at a high speed and with a very short time and in accordance with what is expected to achieve at a high level.
Scientific experiments on the increase of the exerted strength and its impact on the level of technical performance referred to the importance of the mechanical aspects of the throwers themselves. This is because

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it allows the best production of strength to be used in accordance with the correct mechanical conditions. This in turn ensures that there is no loss in the speed and strength gained while maintaining them to the moment of release to ensure that the spear is thrown at the highest possible speed. This is achieved through mastering the essential elements as well as subtleties of the movement of different parts of the body that contribute to performance and correcting them during training.

The event of throwing javelin is characterized by its own nervous-muscular system whereby there is motor coordination in the numerous joints of the body that delivers as far a throw as possible. This requires appropriate timing and connection during the last step of delivering the implement. It also requires increasing the speed for all parts of the body and obtaining the best starting speed of the javelin. This appropriate timing is related to exerting the instantaneous strength for all parts of the body. The thrower is supposed to take good mechanical positions to get the best starting speed of the javelin. This speed stems from the change in the outcomes of the forces in which the throwing position inevitably have an important role to get to the point of release with perfect timing. This means that the instantaneous strength with all its manifestations is required at the highest levels possible in order to achieve this performance. Therefore, in order to increase one of the influential physical capabilities, the authors wanted to find the correct scientific method that has a beneficial effect in this regard such as the explosive power exercises for the arms according to the principle of impulse. We also wanted to determine its effect on some Biomechanical variables and the achievement of javelin for young throwers.

2. 1 Research problem

After reviewing the results of the Athletics Federation and club championship competitions, we noted that most throwers in this event obtained unsatisfactory results compared to the results of the international and Arab competitions.

The goal of the javelin is obviously to attain the best possible speed with the slightest loss of it at the moment of the throwing. This requires taking the best mechanical position of the body to obtain as maximal impulse force for both legs and the throwing arm as possible. The outcome is a high starting speed to achieve the best result. This is what attracted the attention of authors, being specialists in sport at the Specialized Athletics Center of the Ministry of Youth and Sport. After examining the technical performance of the Iraqi champions in local tournaments and the results of previous specialist studies on the javelin, we found that there is a noticeable decrease in the starting speed of the thrower's release of the spear and that it is directly related to the explosive power of the arms and legs This is inevitably due to a weakness in the performance of the explosive power of the legs and arms, especially in the throwing stage. It is also due to the lack of focus on taking the correct mechanical position. We noticed that upon the completion of throwing the javelin, the throwers regain their balance very easily unlike the other throwers who throw their bodies with the javelin after delivering the throw due to the high speed they have at the time of throwing.

1-3 Research Objectives

- Preparation of explosive power exercises for the muscles of the arms and legs of the research sample.
- Determining the effect of the proposed exercises on developing some biomechanical variables and the javelin achievement attained by the research sample.

1-4 Research hypotheses

There are statistically significant differences between the pre and post tests (in favor of the post test) of some biomechanical variables and also in the research sample's achievement in the javelin.

1-5 Research Areas

1-5-1 The human domain: (8) youth-level throwers affiliated with the Athletics Federation.

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1-5-2 Spatial domain: Stadium of the College of Physical Education for Sports Science, University of Baghdad in Jadiriyah.
1-5-3 Time domain: The time period from 1/3/2023 to 3/6/2023.

1-6 Definition of terms

1-6-1 Explosive power training: it means the ability to overcome resistance that requires the maximal speed of muscle contraction. The goal of explosive power training is to develop the work of muscle groups and make them produce the maximal ability in the shortest time during performance. There are two types of explosive power training.
1-6-2 Impulse: this is an index of the effect of force on the body in the given period of time (in transitional movements) and is equivalent to the final period of time upon the specific integration of the initial (partial) impulse force as the limits of integration are restricted between two moments: beginning and end.

2- Research methodology and fieldwork

2-1 Research method

The authors used the experimental method since it suits the research procedures.

2-2 The research sample

The selected sample consisted of (8) U-20 young throwers affiliated with the Iraqi Athletics Federation. The sample was chosen purposefully so as to fit the nature of the research in which homogeneity tests were done for the research sample.

skewness	Median	Standard deviation	Mean	Unit of measurement	Description
0.756	**80.500**	**4.13**	**80.00**	kg	**Weight**
0.446	**18.750**	**0.815**	**18.6**	year	**Age**
0.633	**5.300**	**0.578**	**5.390**	year	**Training age**

Table No. (1)

The homogeneity of the research sample shows the mean values, the standard deviation, the median, and the skewness coefficient in length, weight, and training age.

2-3 The means and tools used

Research tools and methods are essential for any researcher in order to reach the results required to achieve the research goals (Al-Shouk & Al-Kubaisi, 2004, p. 75).

Means of data collection

1- Arabic and foreign sources.
2- Test and measurement.
3- Personal interviews.
4- A cadre of co-workers.

2-3-2 Research tools and devices:

1. A metal measuring tape (75 meters in length); a 2-hour stopwatch and a whistle.
2. Electronic weighing scales (brand Sharp), and a Lenovo 510 I laptop.
3. 10 throwing spears, weight: (700grm); and 15 medical balls, weight (1 kg, 1.5 kg, 2 kg).
4. 1 Camera, type: Casio. Camera shutter speed = 240 frames per second. Web camera = 60 frames per second.
5. 2 camera holders; a scale tool (length: 1 meter); and kinetic analysis software (Kinovea 0.8.27).
6. 10 hurdles, a sector marking device
7. (Dynafoot) devices

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The Dynafoot electronic foot-scanning device is one of the modern scientific devices used in the sports biomechanics laboratories in the world. This device consists of several parts, including (Soles), (Pressure sensors technology), (Shock Sensor Technology), (Data transmission), (Power supply), (Computer Communication) and (Bluetooth 10m range).

In order to obtain the data, it is necessary to first enter some important details about the thrower to ensure the functionality of the device beforehand. These details include, name, age, weight and shoe size. This procedure is to ensure that the data is read correctly during the performance of the test. After the test, we obtain values of some of the variables under study such as the applied force, the impulse time of the thrower. Also, the Dynafoot device measures the amount of pressure applied to each part of the foot, and also gives the time length from the first foot touch to the moment of completion of the test. The time of the test is calculated. The results of the test are obtained from the last step of throwing the spear (throwing position).

2-4 Tests and measurements used in the research

2-4-1 Impulse of both legs at the moment of release:

1 Objective of the test: Measuring the impulse of the legs at the moment of release (javelin throwing position).

2 Tools used: the (Dynafoot) device

3 Method of performance: After reviewing the sources and how to use the device, the pressure sensors were placed in the thrower's throwing shoe while (Shock Sensor Technology) was appropriately fixed for each leg. The device and the computer were calibrated and the approximate time of the test was set according to the protocol of the device.

4- Scoring method: 3 attempts were given to the archer. The best results were taken as the impulse values for the thrower's throwing position.

2-4-2 The impulse of the thrower's arm, the moment of release, the force exerted by the two legs, and the impulse time.

The impulse of the target arm will be obtained by using the Kinovea analysis program (0.8.27) to calculate the time of movement of the throwing hand from the drawback moment to the moment of release (Al-Fadhli, 2010, p. 125), as shown in the equation and the force and momentum will be obtained from the Dynafoot device.

(Impulse = (throwing arm mass with the throwing tool × its ambient speed) ÷ impulse time)

2-4-2 Measuring starting velocity and angle.

The starting velocity and the starting angle were extracted by using the Kinovea 0.8.27 analysis software at the moment of release.

2-4-3 Measuring arm mass relative to body mass

The thrower's body mass in the ratio of the specified arm mass is 6.5% of the body mass and is calculated in kilograms according to the formula.

Arm mass = body mass × 6.5

2-5 Exploratory experiment.

The purpose of the exploratory experiment was to determine the Dynafoot work protocol. It was conducted on 3/1/2023 at 3:00 p.m. in the stadium of the College of Physical Education for Sports Science in Baghdad. One thrower of the sample was used for this experiment. The main goal was as follows:

- Determining the total time to install the device and synchronize it with the computer and how to obtain the results.
- Explaining the way of conducting the tests used for the sample and how to perform them consistently.
- Establishing how to overcome the problems that may be encountered by the research team.

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- Introducing the work to the supporting team and giving them an understanding of the nature of the research experiment and its measurements, especially the sequential stages for preparing the device and registering data in special forms for this purpose.
- Determining the distance and height of the camera for slow shooting, along with the approximate run-up of the thrower.

2-6 Pre-tests

After completing the exploratory experiment and eliminating any obstacles and difficulties, we conducted the pre-test for the throwers on 3/3/2023. We conducted the tests on 8 individuals, who were given three attempts each. The best result achieved in these attempts was selected for the statistical processing.

2-7 Main experiment

We implemented the prepared programme on the study sample during the special preparation period on 3/3/2023 in the stadium of the College of Physical Education for Sports Science in Baghdad.

2-7-1 Training module used in the research:

The module was developed after reviewing the specialized scientific sources and consulting the experts in the field of sports training.

The time of the main part of the training lasted (50-60 minutes) excluding the warm-up time as it is collectively conducted on the sample. The proposed module continued for a period of (12) weeks. The main principle we applied in the training sessions was administering a gradual training load. The intensity, rest and size were treated according to the principle of load diversity.

We measured the maximum intensity on the sample to determine the intensity used in the experimental approach and the maximum limit adopted for special tests. The proposed training module consisted of (36) training sessions. We used the main part of the training session, 3 sessions per week as shown in the exercises. For the first week, the first day exercises include explosive strength of the arms (pushing the medical ball forward and as in Picture No. 3).

The maximum intensity of the explosive power exercise of the arms will be obtained by calculating the impulse of the throwing arms after taking the mass of the arms and the medical ball mass and the movement analysis program (Kinovea) into account in calculating the following: i) the time of the movement of the arm, which is measured from the starting point to the moment of release and ii) the distance from the moment the medical ball was released to the beginning of the leather strap installed on the ground. The recorder will record the distance (in meters and its decimal multiples) to the landing point of the medical ball. As for flight time, it is calculated from the moment the medical ball is released until the moment it falls on the ground, i.e. the highest achieved distance. The capacity will be calculated by extracting power from the aforementioned impulse law (Al-Fadhli, 2012, p. 125). The maximal intensity is also determined for the highest achieved distance, as shown in the following equation:

Arm's explosive power = force exerted to throw a medical ball × ball distance achieved by ÷ the total time)

Capacity = (Power ×distance)/Time (Al Hashemi, 1999, p. 101).

Bar push exercise at an angle of 45 degrees The intensity is measured as the maximal weight the thrower can push for a distance of 1 meter.

The explosive power exercises for the legs included 5-hurdle jump carrying a medical ball with both hands; carrying the medical ball and doing 5 horizontal jumps without hurdles) and determining the intensity.

We calculated the ability of the first exercise by extracting strength using the aforementioned Dynafoot device. The maximum intensity was determined for the maximum horizontal distance achieved while crossing the barriers, as shown in the following equation:

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The explosive power of the two legs = the force exerted by the thrower to pass the hurdles 5 × the maximal distance achieved of the hurdles 5 ÷ the total time)
Capacity =(Power ×distance)/Time (ibid., p. 100)
The law also applies to the second exercise with the same law of ability. The strength was extracted from the device as the highest achieved distance divided by the time achieved for five jumps.

2-7-2 Post-tests

After completing the training program for the sample, we conducted the post-test for the sample's individuals on 6/6/2023. We were keen to meet the same conditions that were conducted in the pre-tests in terms of time, place, tools, and how to conduct the tests and record the results.

2-8 Statistical treatments

We used the SPSS package software to obtain the search results by using the following laws:

1- Mean - 2 - median 3 - standard deviation - 4 - skewness - 5 - T-test for correlated samples.

3- Chapter Three

3. Presentation, analysis and discussion of the results

3-1 Presentation, analysis and discussion of the results of the differences in some biomechanical variables at the time of throwing for the pre and post tests

Table (2)

This table shows statistical parameters for testing the impulse of the arms and legs; the impulse time; the force exerted by the throwing arm; the moment of throwing; the starting speed; the starting angle, and the completion of the pre and post tests.

Significance	Error level	(T) cal	Std.E.M	M.D	±S.D	x	Test	Unit of measurement	Variables
Sig.	0.013	3.293	290.24	337.87	138.6	1892.1	Pre	net	Leading leg strength
					231.8	2230.0	Post		
Sig.	0.006	3.896	100.91	139.0	110.7	1138.6	Pre	net	Propelling leg strength
					61.89	1277.6	Post		
Sig.	0.001	5.601	0.073	0.146	0.058	0.390	Pre	sec	Impulse time for leading leg
					0.030	0.243	Post		
Sig.	0.000	6.720	0.049	0.118	0.035	0.488	Pre	sec	Impulse time for propelling leg
					0.048	0370	Post		
Sig.	0.005	4.049	76.40	109.37	51.449	588.7	Pre	net	Exerted power for thrower's arm
					40.37	698.12	Post		
Sig.	0.012	3.361	1.132	1.345	0.871	23.127	pre	M/second	

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					0.748	**24.472**	**post**		**Speed of spear release**
Insig.	**0.178**	**1.497**	**1.117**	**0.591**	**1.104**	**38.158**	**pre**	**degree**	**Angle of release**
					1.035	**38.750**	**post**		
Sig.	**0.033**	**2.650**	**3.260**	**3.055**	**2.488**	**57.971**	**pre**	**meter**	**achievement**
					1.341	**61.026**	**post**		

Degree of freedom = 7

It can be seen that the significant differences that appeared in the variables were in favor of the post-test except for the starting angle. This indicates that the use of explosive power exercises according to the principle of impulse has enhanced muscle contraction (Brown *et al*., 2000). This improvement in the test results came in line with the development taking place in both the time of the applied force of the thrower's leading and pushing leg at the moment of throwing the javelin. This indicates that the impulse was greater in the post-tests of both of the thrower's legs and that the prepared explosive power exercises have achieved the goal of their application to the members of the research sample. This is what led the research sample to increase the exerted strength while increasing the effort on the central nervous system (Martins et al., 2008). The development taking place in the strength variables and its time indicates that the members of the research sample have developed their muscle strength, especially at the moment of throwing (Winter, 2009). It also indicates that this development was consistent with that development that was achieved in other biomechanical variables under study. We also attribute this development to the exercises applied by the members of the research sample in which we focused on developing the explosive power of the target arm and the two legs, within a specific time through the exercises used (Zatsiorsky, 1995), i.e. (at a moment in time). These exercises increased the internal of strength represented by the strength of the muscle contraction and the strength of the ligaments in the production of the final strength (Jančová, 2008).

The principle of the explosive power training of the arms and legs according to the principle of impulse increased the ability of the muscular feeling and the nervous system accompanying this feeling by the thrower as well as the ability to sense the movement to ultimately have a great control over the performance.

Some studies indicate that the explosive ability exercises for the muscles of the upper and lower extremities improved the smoothness of the muscle work during performance in addition to an improvement in muscle mass and range of movement (Anderson & Behm, 2005). Some studies on explosive power exercises noted that these exercises increase the strengthening of muscle contractions and improve voluntary control. This means that this type of training can facilitate the mechanisms of muscle contraction that the javelin thrower needs during the performance stages (Wathen, 1994). The advantage of using these exercises is their ability to employ a large percentage of the muscle fibers for contraction, which does not happen in the case of voluntary contraction where there is always a reserve part of the muscle fibers that did not contract in addition to the disability resulting from the muscle groups corresponding to the working muscles (Aagaard *et al*., 2002). The prepared exercises have helped in the development of movement tracks and also in an increase of strength values. This was reflected in the increase in starting speed, which in turn enhanced the development of achievement (Judge *et al*., 2016). There is a need for harmony between explosive power exercises and the requirements of the event in order to obtain the best dynamic technical performance (Alfadhli, 2010, pp. 90-91). On this basis, the authors believe that it is necessary that the thrower exerts the force in a correct and

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timely kinetic sequence with a performance from the lower part of the thrower to the upper part investing muscle work in a manner that serves an increase in the kinetic speed of the thrower. That is why we find that the thrower employs the working muscles by the kinetic sequence of which a large strength obtained and, at the end of the performance, transferred to the spear, which in turn has gained the speed required to achieve the best result. We also find that any delay in muscle work at the moment of throwing directly affects the speed of the javelin and consequently on the result.

The development of the explosive power, in which it was relied on a number of repetitions and with codified intensities, has led to an increase in the speed of movement (Duchateau & Hainaut, 2003). In addition, the use of these exercises with added weights and repeating them at intervals as well as the use of the law of ability in determining the strength of training had a positive effect on strengthening the muscles, arms and legs (Jensen & Ebben, 2003). This was coupled with improved compatibility of movement during the speed of movement to assume an ideal throwing position. This in turn resulted from the work of harmonious contractions of the working muscles through the effective exchange process between elongation and muscle contraction during the performance of exercises (Ricci, 1967, p .89). Elongation in the muscles contributes to increasing the speed of kinetic performance and the development of muscle ability in the contraction and relaxation movements that depend on the performance of the thrower's movements (Turner & Barker, 2014).

4- Conclusions and recommendations

4-1 Conclusions:

1- The proposed exercises have produced an increase in the values of the explosive power of the thrower's legs and arms as well as an increase in the effectiveness of the voluntary muscles.

2- The performance of the explosive power training for the arms and legs has achieved a high and smooth compatibility between the movements of the lower and upper extremities in a manner that serves the economy in the movement, which led to the production of the highest value of the starting speed of the tool.

3- The achievement is determined by the development taking place in strength and speed and related training sessions according to the nature of the movements performed by thrower.

4- Relying on the results of kinetic analysis contributed to the diagnosis of individual performance, which included calculations of mechanical impulse index and time, and other mechanical variables.

5- The explosive power exercises have effectively led to the development of the speed of the throwing arm at the moment of release. This facilitated the development of the final starting speed.

4-2 Recommendations

1- The study recommends that the physical training and development of the technical aspects be based on the use of exercises, tools and supporting devices within the prepared module.

2- The development of special strength is essential in competition in addition to controlling nervous adaptation, which includes a high value of the exercises and an increase in the kinetic speed of the thrower.

3- Conducting studies of other throwing events using explosive power exercises.

4- Ensuring the integration of the muscle strength of all working muscles, whether in the lower or upper extremity. This is to enhance the mechanical positions of the javelin throwers when performing the throwing.

5- Ensuring that the physical training and development of the technical aspects are based on the mechanical requirements and on the use of exercises, tools and supporting devices that achieve this and with minimal effort on the thrower.

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Appendix 1: A sample of a training session

notes	Rest between groups	groups	Rest between	repetition	intensity	exercises	unit	week

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			repetition					
	1,30m	5	5:1	10	%80 of farthest distance	Pushing medical ball using push bench as shown in Picture 3	1st session	Week 1
	1,30m	5	5:1	10	%80 of maximal time	Standing on a 10 cm-high bench and holding a javelin, then making three crisscrossed steps with spaced marks at 1m distance		
	1,30m	5	5:1	10	%80 Of the best achievement	Performing the pivot movement in the last step (throwing position), with an emphasis on placing the pivot foot on a surface tilted down at a length of 1 m and at an angle of 8 ° with the addition of weight to the driving leg by 3% and then throwing	2nd session	
	1,30m	5	5:1	10	%80 of maximal time	Jumping 5 hurdles holding a medical ball with both hands		
	1,30m	6	5:1	10	%80	Machine-base bar push exercise at an angle of 45 degrees as shown in Picture (4)	3rd session	
	1,30m	6each leg	5:1	10	%80 Of maximal time	Firm-positioned push with one leg, repeated with the other leg with a load of added weight of 5% of the trunk weight and 3% of the		

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						weight of the throwing arm for a distance of 7 meters		
	The fourth, fifth, and sixth units are repetitions of the first, second, and third units							**Week 2**