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## The effect of using plyometric training and electrical muscle stimulation on improving the physical abilities, biomechanical variables, and digital level of junior long jumpers.

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### Abstract

Muscular ability is one of the most crucial physical elements in the long jump, which can be developed using plyometric training, which works to stimulate and mobilize the largest amount of muscle fibers during performance. Electrical stimulation of the muscles works to stimulate all muscle fibers involuntarily, which works to improve muscle strength. The research aims to identify the effect of plyometric training and electrical stimulation of the muscles in improving the physical abilities, biomechanical variables, and digital level of junior long jumpers. The researchers used the experimental approach by designing one group using pre- and post-measurement on a sample of (7) junior long jumpers in the Alexandria Governorate, Arab Republic of Egypt, under the age of 18. Years of age and registered with the Egyptian Athletics Federation. Physical and biomechanical measurements and the digital level of the jump were carried out using a force measurement platform and kinetic analysis for the progression phase of the long jump. The implementation of the training program took eight weeks with 16 training units, and the results of the research showed that the use of plyometric training and electrical stimulation of the muscles led to Improving the physical capabilities of the leg muscles and improving and developing the biomechanical variables in the stage of advancement and digital level among junior long jumpers. The researchers recommend applying the results of the research to long jump competitors in the Republic of Iraq, and conducting more scientific research on the effect of electrical stimulation on the electrical activity of the muscles of track and field competitors. and this achieves one of the sustainable development goals of the United Nations in Iraq which is (Good Health)

### Keywords

plyometric training, electrical muscle stimulation, muscular ability, junior long jumpers.

### Introduction:

Muscular strength is considered an important and essential factor to ensure the development of speed, especially in the case of overcoming resistances that require a high degree of rapid contractions. The link between muscular strength and motor speed in the muscles is one of the most important features that distinguishes outstanding athletes who possess a great deal of strength and speed with the ability to move. Connecting them

in an integrated manner to create rapid force movements, such as sprinting and jumping movements in athletics. The long jump is an athletics competition that consists of four stages (approach, rise, flight, and landing). These stages participate in determining the distance of the jump. Harald Müller and Wolfgang Ritzdorf indicate that the rise stage “enables the athlete to reach the jumping board appropriately.” “At the greatest horizontal speed that can be controlled”

and the rise phase “represents the horizontal distance between the front edge of the rise board and the player’s center of mass at the moment of leaving the ground and the player generates vertical speed while minimizing the loss of horizontal speed” (11) and confirms (James Hay, John Miller, Ron Canterna ) “The flight phase is the horizontal distance traveled by the player’s center of mass in the air with good preparation for landing,” (19). (Kazuhiro) states that the landing phase is “the horizontal distance between the player’s center of mass and the landing site. The player works to increase the flight path and decrease the distance lost when the feet touch the ground. (22). (Muhammad Hassan Allawi, Muhammad Nasr al-Din Radwan) explain that “superiority in long jump motor performance is linked to a number of factors that affect performance, including physical characteristics that include muscular ability, compatibility, and physical measurements, in addition to biomechanical factors that affect the movement of the body as a projectile” (7), (Ward Smith) points out that the long jumper uses the kinetic energy and speed gained from approaching in order to rise at high speed to transfer the momentum of the acquired horizontal speed in the direction of the jump, and that direction determines the angle of ascension. (35). (Pascal et al) add that “the ability to produce maximum neuromuscular force represents the most important factors in successful performance” and for this purpose (athletes need to reach high levels of strength and increase the ability to employ it in motor performance). (32), and (Hedrick) believes that “the development of jumping ability plays an important role during the approach and ascension,” and through it the competitor can produce explosive reaction movements to the ground while ascending in the long jump. (21). Plyometric training is considered one of the most important means of developing explosive ability in jumping, and this is confirmed by the results of many scientific studies, as (Shawkat) ,( Blakey), ( Diallo) (Gehri et al). agreed that plyometric training works to develop muscular ability. Improving sports performance more effectively than other exercises. (4), (12) (13), (16), and (George et al.) confirm that “plyometric training aims to develop muscular ability and neuromuscular coordination by

improving Efficiency of neuromuscular processes and elastic components of the muscular system” (17), and (Morin et al). add that “plyometric training helps increase the ability of the muscular system to exploit the elastic energy stored in the muscles during the braking phase and to re-release it again during the propulsion phase” (30) Donald confirms that “plyometric training is done through sudden lengthening of the muscles under the influence of a load (eccentric contraction) and is immediately followed by a shortening contraction at high speed (concentric contraction), which increases the production of force and speed.” (14). Both (Ahmed Nasr El-Din) and (Gambetta) agree that muscle strength increases as the degree of excitability of the muscle fibers or the largest number of motor units within the muscle increases. (2), (15), and (Atef Rashad) states that “stimulating the muscle electrically by external means leads to the muscle producing a force greater than what it can produce voluntarily.” One of these means is electrical stimulation of the muscles, and the idea of this method depends on stimulation. Electricity directed from the outside to the muscles through involuntary contraction. (6) and (Muhammad Sobhi Hassanein) points out that “the advantage of using electrical stimulation of the muscles is its ability to stimulate all muscle fibers to contract at once, and this does not happen in voluntary contraction.” (8). From the above, we find that muscular ability is one of the most important and decisive physical elements in the long jump, which can be developed using plyometric training, which works to stimulate and mobilize the largest amount of muscle fibers during performance, and also the method of electrical muscle stimulation, which works to stimulate all muscle fibers within the muscle in a way. It is involuntary, which improves muscle strength. Therefore, researchers suggest that combining plyometric training with electrical muscle stimulation may lead to stronger and more efficient muscle contraction, which results in the production of maximum explosive muscle power during the rise phase of the long jump. By reviewing previous studies and research, we found a scarcity of research dealing with the method of electrical stimulation of muscles, despite the advantages of this method in developing muscle strength with the least effort and not putting

pressure on the joints and ligaments during performance, in addition to focusing on the muscles that are required and contribute most to sports performance. This is what prompted the researchers to conduct this study using a method of combining plyometric training and electrical stimulation of the muscles in the same training unit, as we see that plyometric training (voluntary contraction) does not involve all motor units during muscle contraction, and electrical stimulation of the muscles (involuntary contraction) works on... Stimulating all muscle fibers at once during muscle contraction, which leads to developing and improving the physical capabilities of the leg muscles, the skill performance, and the digital level of junior long jumpers. The research aims to identify the effect of plyometric training and electrical muscle stimulation on improving the physical abilities, biomechanical variables, and digital level of junior long jumpers. The research hypotheses:

Plyometric training and electrical muscle stimulation positively affect the physical abilities of junior long jumpers. Plyometric training and electrical muscle stimulation positively affect the biomechanical variables and the digital level of junior long jumpers. The research dealt with the human field of long jumpers in the Arab Republic of Egypt. As for the temporal field, the research was applied in the period from 1/10/2023 to 30/11/2023, and the spatial field in the athletics stadium at Alexandria University Stadium in the Arab Republic of Egypt.

#### **Method and procedures:**

The researchers used the experimental approach by designing one experimental group using pre- and post-measurement on a sample of (7) junior long jumpers in the Alexandria Governorate, Arab Republic of Egypt, under 18 years of age, registered with the Egyptian Athletics Federation. The following table shows the homogeneity of the research sample of junior athletics.

**Table .1** Statistical description of basic measurements and numerical level for junior long jumpers

No.	Variables	lower value	upper value	Mean	Median	Std. Deviations	Skewness	Kurtosis coefficient
1	Age (years)	16	17	16.57	17	0.535	0.374-	0.802-
2	Length (cm)	1.72	1.84	1.80	1.81	0.042	1.283-	0.236-
3	Weight (kg)	65	80	73.14	74	5.429	0.223-	0.158-
4	Body mass index (kg/m <sup>2</sup> )	20.09	24.42	22.57	22.84	1.382	0.721-	0.196-
5	Long jump distance (meters)	5	5.5	5.22	5.25	0.175	0.020	0.163-

It is clear from Table (1) the lowest and highest values, the arithmetic mean, and the standard deviation in the basic measurements and the numerical level for junior long jumpers. The values of the torsion coefficients were close to zero, and the values of the flatness coefficients were limited to between ( $\pm 3$ ), which indicates the moderation of the values and the homogeneity of the sample members before applying the research. On junior long jumpers.

Research measurements: The researchers reviewed scientific studies and research related to the research topic in order to determine the appropriate measurements that achieve the research objectives, which are as follows: -

1- Basic measurements: age (years), height (cm), weight (kg), body mass index (kg/m<sup>2</sup>)

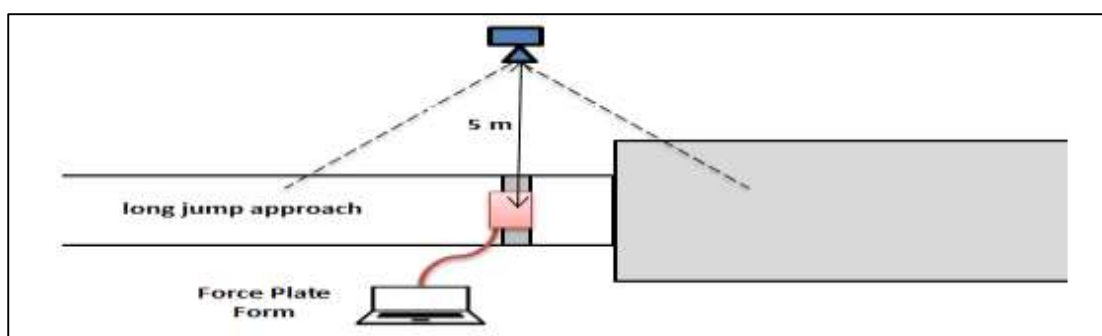
- 2- Physical abilities measurements: 30-meter sprint time (seconds), leg and back muscle strength (kg), broad jump distance (meters), vertical jump distance (cm)
- 3- Biomechanical measurements.
  - Velocities (horizontal, vertical, and resultant speed during ascension) (m/s)
  - Displacement (height of the center of gravity of the body, moment of maximum damping and thrust moment) (cm)
  - Angles (rise, flight, knee of the lift leg and thigh of the free leg at the moment of pushing) (degrees)
  - Rise time (damping, thrust, total time) (seconds)
  - Maximum impact and thrust force (Newtons). (7), (27), (29)
- 4- Digital level: Long jump distance (meters).

**Exploratory study:**

The researchers conducted the exploratory study with the aim of ensuring the validity of the devices and tools used in the research and determining the places to place the force measurement platform and the location of the photography camera for movement analysis, on a sample of (3) of the research sample of junior long jumpers.

The results resulted in adjusting the intensity of the current in the electrical stimulation device,

determining the places to place the electrodes on the muscles under investigation, and determining the place to place the force measuring platform (on the approach road in place of the riser board) as in Figure No. (1), and the place to place the camera was determined to the left of the approach road. Perpendicular to the elevation board (force measuring platform) at a distance of 5 metres, the lens height is 1.30 meters off the ground, the imaging field is 6 metres, and the drawing scale is determined with a ruler 1.22 meters long.



**Figure (1)** Locations for placing the force measuring platform and camera for junior long jumpers

**Training program:**

The training program was implemented for two months over a period of eight weeks, with 16 training units. The training unit consists of a 10-minute warm-up, 75-minute physical preparation (45 minutes for electrical muscle stimulation, 30 minutes for plyometric exercises), and 30-minute skill preparation. minutes, then cool down for 5 minutes.

**Electrical stimulation of the muscles:**

The main muscles working in jumping that are easy to stimulate electrically have been identified,

which are the Quadriceps Muscles, the Hamstrings Muscles, the Gastrocnemius Muscles, and the Tibialis anterior Muscle. The strength of the electrical stimulation was determined according to the degree of the player's tolerance for limits. Pain, after connecting the electrical stimulation device to the muscles and gradually increasing the intensity of the voltage until the athlete feels severe pain. We record the intensity coming out of the device in the competitor's form so that the training intensity and the appropriate degree of arousal can be determined for each competitor. (5), (9), (34)



**Figure (2)** DL-2 698 ELECTRO-PULATE electrical muscle stimulation device



**Plyometric exercises:**

Plyometric training aims to develop and advance the muscular ability of the legs. The researcher took into account that plyometric exercises develop the ability to push vertically (vertical jump) and diagonal push (broad jump) with horizontal body speed and advance the components of the load (intensity, volume, and rest), according to what was stated by both. From (Donald), (Hedrick), (Osama Muhammad)

(Thériault ) that “the plyometric exercises should be in the same direction as the performance” and should be performed as quickly as possible and should be gradual, starting from jumps in place, then hops, then box exercises until the deep jump, with an emphasis on being synchronized. Movement of the arms forward and upward forcefully and quickly during central contraction. (14), (20), (3) (34)

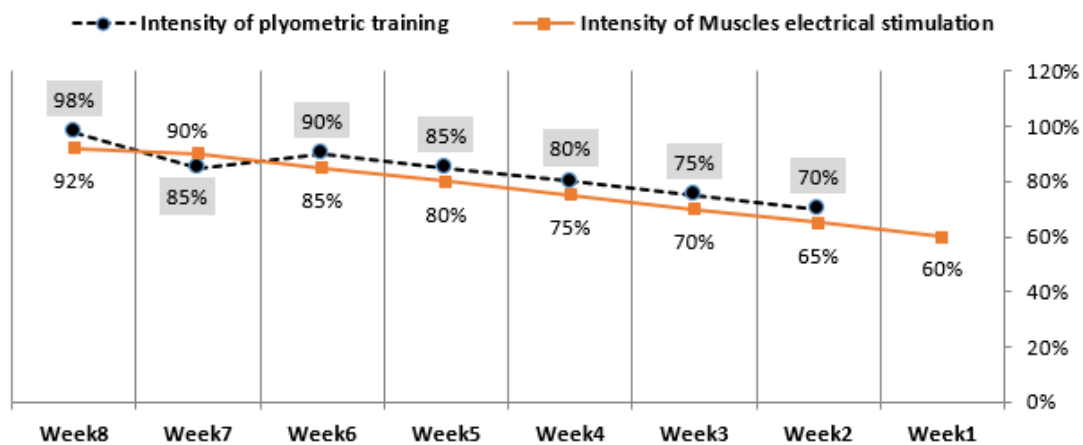


Figure (3) Intensity of plyometric training load and electrical muscle stimulation for junior long jumpers

In the skills preparation part, the researchers took into account the focus on exercises that fulfill motor tasks and develop speed in the long jump through running exercises on the track and the gradual progression in performing the jump, from

pushing with the foot to rising and descending from one to three steps, with the use of the Swedish seat, medical balls, and barriers, and then gradually in approaching. The number of steps starts from one-step up to 13 steps to reach full performance, taking into account the gradation in the intensity of the training load

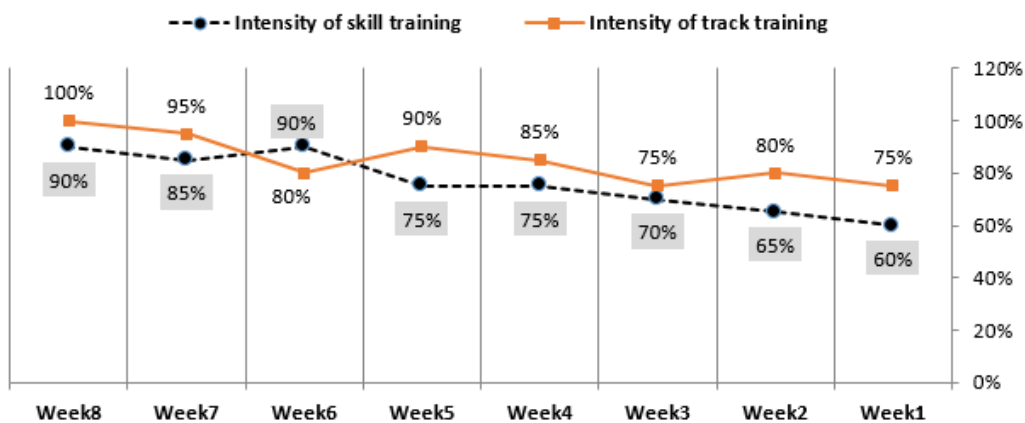


Figure (4): Intensity of training, intensity of track training, and skill training for junior long jumpers

**Statistical treatments:** The research data was processed using the IBM SPSS Statistics 20 statistical program

### **Results:**

**Table .2** Significance of the t-test and effect size for the differences between the pre- and post-measurements in the physical abilities of junior long jumpers (n = 7)

Physical abilities	Pre-test		Post-test		Difference		T value Calculated	Difference percentage %	Eta square	Type sig
	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation				
30m sprint low start (sec)	4.61	0.18	3.98	0.21	0.63-	0.27	**6.15-	13.62	0.863	High
Broad jump distance (meters)	2.44	0.15	2.79	0.21	0.34	0.11	**8.27	14.04	0.919	High
Vertical jump distance (cm)	53.86	8.19	66.00	11.68	12.14	11.42	*2.81	22.55	0.569	High
Arm muscular power for 30 seconds (count)	38.71	5.68	42.43	6.24	3.71	5.56	1.77	9.59	0.342	High
Leg muscle strength (kg)	84.57	4.58	104.43	14.01	19.86	10.61	**4.95	23.48	0.804	High
Back muscle strength (kg)	76.14	5.52	81.43	4.20	5.29	4.75	*2.94	6.94	0.591	High

\*Tabular t-statistical significance at the 0.05 level = 2.447, \*\*at the 0.01 level = 3.707

It is clear from Table (2) that there are significant differences in the calculated “T” value between the pre- and post-measurements in the physical abilities of junior long jumpers, where the percentage difference ranged between (6.94%:

23.48%) in favor of the post-measurement, and the Eta square values ranged between (0.342: 0.919) indicative of high among junior long jumpers.

**Table .3** Significance of the t-test and effect size for the differences between the pre- and post-measurements in some biomechanical (kinematic) variables for junior long jumpers (n = 7)

Physical abilities		Pre-test		Post-test		Difference		T value Calculated	Difference percentage %	Eta square	Type sig
		Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation				
Ascension time (second)	Damping time	0.037	0.006	0.039	0.008	0.002	0.010	0.50	5.02	0.040	weak
	Thrust time	0.117	0.023	0.114	0.014	0.004-	0.016	0.60-	3.17	0.056	weak
	Total time	0.154	0.026	0.152	0.020	0.002-	0.020	0.24-	1.20	0.010	weak

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Horizontal speed (m/s)	8.36	1.21	9.36	0.85	1.00	1.19	2.22	11.97	0.452	High
Vertical speed (m/s)	2.71	0.39	2.79	0.76	0.07	1.06	0.18	2.63	0.005	weak
Resulted speed (m/s)	8.86	1.06	9.79	0.82	0.93	0.96	*2.57	10.56	0.524	High
Elevation angle (degrees)	68.94	4.45	73.60	4.13	4.66	3.26	**3.78	6.76	0.705	High
Flight angle (degrees)	17.49	4.53	20.77	4.94	3.29	6.40	1.36	18.79	0.235	High
Lifting leg knee angle at the moment of push (degrees)	158.79	7.38	165.91	7.63	7.13	9.96	1.89	4.49	0.374	High
Free leg angle at the moment of pushing (degrees)	107.67	13.60	98.50	7.65	9.17-	16.54	1.47-	8.52	0.264	High
Height of the center of gravity of the body at the moment of maximum damping (meters)	1.043	0.052	1.037	0.044	1.043	0.05	0.36-	0.55	0.021	weak
Height of the body's center of gravity at the moment of thrust (meters)	1.14	0.05	1.18	0.05	0.04	0.07	1.58	3.76	0.295	High

\*Tabular t-statistical significance at the 0.05 level = 2.447, \*\*at the 0.01 level = 3.707

It is clear from Table (3) that there are significant differences in the calculated “T” value between the pre- and post-measurements in some biomechanical (kinematic) variables for junior long jumpers, where the percentage of difference

ranged between (0.55%: 18.79%) in favor of the post-measurement, and the square values ranged between The ETA ranged between (0.010 and 0.705) with a meaning that ranged between weak and high among junior long jumpers.

**Table .4** Significance of the t-test and effect size for the differences between pre- and post-measurements in some biomechanical (kinetic) variables for junior long jumpers (n = 7)

Strength measurement platform		Pre-test		Post-test		Difference		T value Calculated	Difference percentage%	Eta square	Type sig
		Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation				
Impact strength (Newton)	Net strength	4836.9	1260.8	5310.6	1432.9	473.7	1072.9	1.17	9.79	0.185	High
	On body weight	66.47	17.72	72.55	18.78	6.08	15.00	1.07	9.14	0.161	High
Thrust strength (Newton)	Net strength	2679.5	569.2	2808.4	557.98	128.9	260.32	1.31	4.81	0.222	High
	On body weight	36.77	7.98	38.61	8.12	1.84	3.70	1.31	4.99	0.224	High
Time between maximum impact force and thrust (seconds)		0.041	0.017	0.049	0.014	0.007	0.018	1.07	17.93	0.161	High
Long jump distance (meters)		5.22	0.18	5.94	0.48	0.71	0.56	*3.39	13.68	0.657	High

\*Tabular t-statistical significance at the 0.05 level = 2.447, \*\*at the 0.01 level = 3.707

It is clear from Table (4) that there are significant differences in the calculated “T” value between the pre- and post-measurements in some biomechanical variables (kinetics) for junior long

jumpers, where the percentage of difference ranged between (4.81%: 17.93%) in favor of the post-measurement, and the square values ranged from The ETA ranged between (0.161 and 0.224)

indicative of high, and the long jump distance had a difference of (13.68%) with a high impact among junior long jumpers.

### **Discussion:**

According to the results we have achieved as shown in the previous tables, it is clear to us from Table (2) that the use of plyometric training and electrical stimulation of the muscles led to the improvement of physical abilities through an improvement in speed (30 meters low start) by (13.62%) and the muscular ability of the legs (jumping). Broad and vertical) by (14.04%: 22.55%), muscular strength of the arms (inclined prone position, arms bent for 30 seconds) by (9.59%), muscular strength of the leg muscles by (23.48%), and back muscle strength by (6.94%). The effect of the program was high, which It indicates the positive effect and effectiveness of plyometric training and electrical muscle stimulation on the physical and muscular capabilities of the legs among junior long jumpers. This improvement in physical capabilities (speed, muscular ability of the legs, muscular ability of the arms, muscular strength of the muscles of the legs and back) is due to plyometric exercises and electrical stimulation of the muscles, as Jurgen Schäfer explains that “the basic physical characteristics required for success in the long jump are high running speed.” The ability to accelerate, the ability to rise using explosive force at a high horizontal speed to create a vertical rise, and good balance ability.” (21). These results are consistent with the study of (González-Badillo et al.) (Kollias) and the study of (in that “the height of the vertical jump is directly proportional to the speed of the rise,” and that “the speed of the rise performance is considered an indicator for evaluating the performance of the vertical jump,” and that “the maximum strength achieved is a main indicator of performance in the jump.”. (23), (18) and that (the broad jump from a standstill is considered one of the most important indicators in evaluating the explosive power of the jump, whether for children, adults, or athletes, evaluating the individual’s physical condition, and monitoring the educational and training process). (28). The results of (Donald’s) study indicate that “plyometric training leads to an increase in the

explosive power of the leg muscles and is an effective and effective method for improving strength and speed of movement, as it allows the nervous system to stimulate the largest number of contracting muscle fibers and improve the sequence of their contraction, which contributes to the production of greater force” (14) The results of the study (Maffiuletti et al.) confirm that (the use of plyometric training and electrical muscle stimulation leads to an increase in maximum muscle strength and an improvement in the vertical jump), and this method gives rapid results in the vertical jump and muscle strength. (26) Through these results, it becomes clear to us the importance of combining plyometric training and electrical stimulation of the muscles in developing the physical abilities of the research sample. This confirms the verification and validity of the first hypothesis, which states, “Plyometric training and electrical stimulation of the muscles positively affect the physical abilities of junior long jumpers.”. It is clear from Table (3) that the use of plyometric training and electrical stimulation of the muscles led to an improvement in some biomechanics (kinematics), as the rise time decreased by (1.20%), the damping time increased by (5.02%), the propulsion time decreased by (3.17%), and the instantaneous speed improved (Horizontal, vertical and resultant) during the ascent propulsion by (11.97%, 2.63%, 10.56%), the angle of ascent and flight increased by (6.76%, 18.79%), and the knee angle of the ascending leg at the moment of propulsion increased by (4.49%), which led to an increase in the center of gravity at the moment Thrust by (3.76%), the center of gravity of the body at the moment of maximum damping decreased by (0.55%), and the height of the thigh of the free leg increased at the moment of thrust by reducing the angle of the thigh with the torso by (8.52%), as the program had a low effect on the rise time, given that the rise time is Very small and therefore no significant differences appear, knowing that the slightest change in this time period has a significant impact on the improvement in the long jump, while the rest of the variables had a high impact, which indicates the positive impact and effectiveness of plyometric training and electrical stimulation of the muscles on some biomechanical measurements (kinematics) and the muscular



ability of the legs. In the junior long jump. It is clear from Table (4) that the use of plyometric training and electrical stimulation of the muscles led to an improvement in some biomechanics (kinetics), as the amount of net impact force on the rising plate increased by (9.79%), and the amount of force on the body weight increased to (72.55 Newtons) per kg. of body weight, with an increase equivalent to (9.14%), the amount of net propulsion force increased by (4.81%), and the amount of force on body weight increased to reach (38.61 Newtons) for each kilogram of body weight, an increase equal to (4.99%), and the time between maximum Peak strength of impact and push (17.93%), as the effect of the program was high, which indicates the positive impact and effectiveness of plyometric training and electrical muscle stimulation on some biomechanical measurements (kinetics) and the muscular ability of the legs among junior long jumpers. Through the previous improvement in anthropometric measurements, physical abilities, and biomechanical variables, this led to an improvement in the long jump distance by (13.68%) by increasing the average jump distance from 5.22 meters to 5.94 meters, as shown in Table (4). The impact of the program was high, which indicates on the positive effect and effectiveness of plyometric training and electrical muscle stimulation on the muscular ability of the legs and improving the jump distance among junior long jumpers. The improvement in the biomechanical variables (kinetic and kinematics) is due to the combination of plyometric training and electrical stimulation of the muscles led to improving the muscular ability of the leg muscles, and thus this is due to the development of jumping performance during the rise phase, as the force increased during the collision and push, the total rise time was reduced, and the damping time increased. The push time was reduced, which indicates that the content of the training program led to the push with greater speed, effectiveness, and strength, while producing an appropriate angle of rise and flight for junior long jumpers. This is consistent with what (Ahmed Abdel Baqi) (Talha Hussam El-Din) explains: "The importance of the ascent stage is that it represents the process of linking the high horizontal speed gained from the approach stage and the increase in the driving

force generated during the ascent stage, and its importance increases due to the speed of its performance because the competitor performs all his movements in a very short time, as It ranges between 0.12 - 0.19 of a second. (1) (5) (Kazuhiro Tsuboi) points out that ascending at a high speed and at an ideal angle gives the longest flight distance in a jump. Therefore, jumpers use the kinetic energy and speed gained from approaching in order to ascend at a high speed, as the ascension process transfers the momentum of the acquired horizontal speed in the direction of the jump. This direction determines the angle of elevation, which ranges between 20-30 degrees for long jumpers (22), and performing the elevation requires the transfer of kinetic energy and the re-exploitation of elastic energy in the muscle group that supplies the leg in the first stage of the pivot to help generate additional speed in the direction. Vertical during the ascension phase. (31). This improvement in skill performance is due to plyometric training and electrical stimulation, which led to an improvement in the muscular ability of the legs. This is consistent with what (Reid) states, "Developing muscular ability using plyometric training leads to improved motor performance, meaning that the strength gained from this type of training leads to performance." Improve movement in the practiced sporting activity by increasing the ability of the muscles to contract at a faster rate during the range of motion of the joint depending on how it is used in the practiced activity." (33) (Muhammad Qadri Bakri) points out that (plyometric training as a training method works to develop the explosive strength of the muscles of the legs, but the voluntary contraction that occurs during plyometric training does not involve all muscle fibers, which leads to the appearance of a loss in strength between the voluntary strength and what can be achieved. The muscle actually produces absolute force, but as for the electrical stimulation method, it works to develop the explosive force of the muscle through involuntary contraction in order to overcome an important point, which is the loss of strength or the store of strength. (10). As (Lees et al) (Hassanein and Maani). point out, "The impact stage is when the leg muscles are stimulated before touching the ground to provide strong resistance to flexion in the main joints. This stage

is harsh and enables pivoting on the fixed foot as a base to provide increased vertical velocity from the center of mass at the moment the extensor muscles begin eccentric contraction.” "At maximum knee flexion this can be viewed as a purely mechanical mechanism for producing upward velocity." (24) (9). Through these results that we have reached, which confirm the effectiveness of the combination between plyometric training and electrical stimulation of the muscles, which in turn led to improving the muscular ability of the muscles of the legs, which works to improve the biomechanical variables during the ascension phase in the long jump, as the momentum force increased during the ascent and the angle of ascension and flight increased to values approaching of elite racers, as well as an increase in the center of gravity of the body at the moment of push, with a noticeable increase in horizontal, vertical, and net speed, which reduced the rise time despite jumping with high force. This confirms the validity and verification of the second hypothesis, which states: "Plyometric training and electrical stimulation of the muscles have a positive effect on some biomechanical variables." "In the development stage for junior long jumpers." (Linthorne) confirm that (the long jump distance results from the upward force resulting from the horizontal speed at the end of the approach, and to benefit from this speed, appropriate forces must be generated when ascending in order to launch the body at the maximum speed and at an appropriate angle during the ascent), in addition to generating a high vertical speed. While minimizing loss of horizontal velocity to ensure rapid forward transition, for elite athletes the optimal lifting technique is to lower body mass in the take-off step, place the foot before the center of mass, and rise at an angle of about 21 degrees with a vertical speed (about 3.1 m/s for women and 3.4 m/s for men), while maintaining a horizontal speed of approach (about 8.0 m/s for women and 8.8 m/s for men). (25). The researchers believe that this significant improvement in the long jump distance is a result of the positive effect of the combination between plyometric training and electrical stimulation of the muscles, which led to better stimulation and mobilization of muscle fibers through the combination of voluntary and

involuntary muscle contraction, and this led to improving the ability of the muscles to produce maximum muscle power. This was evident in the significant improvement in the digital level of junior long jumpers, which indicates the validity of the second hypothesis, which states: "Plyometric training and electrical muscle stimulation positively affect the biomechanical variables and digital level of junior long jumpers."

### **Conclusions:**

- Plyometric training and electrical muscle stimulation led to improving the physical abilities (speed, strength, and muscular ability of the legs, torso, and arms) among junior long jumpers.
- Plyometric training and electrical muscle stimulation led to the improvement and development of biomechanical variables in the progression phase of junior long jumpers.
- Plyometric training and electrical muscle stimulation led to improving the digital level of junior long jumpers.

### **Recommendations:**

- According to the results, the researchers recommend applying the results of the current research to long jump competitors in the Arab Republic of Egypt and the Republic of Iraq, and conducting more scientific research on the effect of electrical stimulation on the electrical activity of the muscles of track and field competitors.

### **References:**

- 1- Ahmed Abdel Baqi Ali (2008) An analytical study of the additional thrusts in the triple jump competition (first division level), unpublished master's thesis, Faculty of Physical Education for Boys, Alexandria University.
- 2- Ahmed Nasr El-Din Sayed (2003) Sports Physiology (Theories and Applications), Dar Al-Fikr Al-Arabi, first edition, Cairo.
- 3- Osama Muhammad Ibrahim Abu Tabal (1999) The effect of codifying plyometric exercises using power analysis on some dynamic variables of performance in the triple jump competition, unpublished doctoral thesis, Faculty of Physical Education for Boys, Alexandria University.

- 4- Shawkat Abdel Monsef Ali (2014) A comparative study of the effect of both mixed training and combined training (combined and alternating) on explosive ability and the digital level of the triple jump competition, unpublished master's thesis, Faculty of Physical Education for Boys, Alexandria University.
- 5- Talha Hussam El-Din and others (1997) The Scientific Encyclopedia of Sports Training (Strength, Ability, Force Endurance, Flexibility), Al-Kitab Publishing Center, first edition.
- 6- Atef Rashad Khalil (1995) The effect of deep jump training on some physical abilities of volleyball players, unpublished master's thesis, Faculty of Physical Education for Boys, Helwan University.
- 7- Muhammad Hassan Allawi, Muhammad Nasr al-Din Radwan (2001) Motor Performance Tests, Dar Al-Fikr Al-Arabi, Cairo.
- 8- Muhammad Sobhi Hassanein (2004) Measurement and Evaluation in Physical Education and Sports, Part One, Dar Al-Fikr Al-Arabi, Cairo.
- 9- Muhammad Sobhi Hassanein, Ahmed Kasri Maani (1998), Encyclopedia of Applied Sports Training, first edition, Al-Kitab Center for Publishing, Cairo.
- 10- Muhammad Qadri Bakri (1993) Muscle Training and Electrical Stimulation, Athletics Magazine, Regional Development Center, Cairo.
- 11- Harald Müller, Wolfgang Ritzdorf (2009) Perform a jump throw, International Federation of Athletics Federations, the official guide of the International Federation of Athletics Education.
- 12- Blakey J. B, Southard D. (1987) The combined effect of weight training and plyometrics on dynamic leg strength and leg power. *Journal of Applied Sports Science Research*. 1, 14-16
- 13- Diallo O, Dore E, Duche P, Van Praagh E (2001) Effects of plyometric training followed by a reduced training programme on physical performance in prepubescent soccer players, *J Sports Med Phys Fitness*, 41(3):342-8.
- 14- Donald, A., Chu (1998) Jumping into plyometrics , *Human Kinetics*
- 15- Gambetta V., (1987) Principles of Plyometric training, Track and technique, Fall, No. 97
- 16- Gehri D.J., Ricard M.D., Kleiner D.M., Kirkendall D.T. (1998) A comparison of plyometric training technique for improving vertical jump ability and energy production. *Journal of Strength and Conditioning Research* 12(2), 85-89
- 17- George Davies, Bryan L. Riemann, Robert Manske (2015) Current concepts of plyometric exercise, *International Journal of Sports Physical Therapy*. Vol. 10(6): 760–786
- 18- González-Badillo, J. J., Jiménez-Reyes, P., & Ramírez-Lechuga, J. (2017). Determinant Factors of the Squat Jump in Sprinting and Jumping Athletes. *Journal of Human Kinetics*, 58, 15.
- 19- Hay J.G., John A. Miller, Ron W. Canterna (1986) The Techniques of Elite male long jumpers, *Journal of Biomechanics* Volume 19, Issue 10, Pages 855–866.
- 20- Hedrick, A., & Anderson, J. C. (1996). The vertical jump: A review of the literature and a team case study. *Strength & Conditioning Journal*, 18(1), 7-12.
- 21- Jürgen Schiffer (2011) the Horizontal Jumps, *New Studies in Athletics*, 26:3/4; 724.
- 22- Kazuhiro Tsuboi (2010) a mathematical solution of the optimum takeoff angle in long jump, *Procedia Engineering*, Volume 2, Issue 2, Pages 3205-3210
- 23- Kollias, I., Hatzitaki, V., Papaiakevou, G., & Giatsis, G. (2001). Using principal components analysis to identify individual differences in vertical jump performance. *Research Quarterly for Exercise and Sport*, 72(1), 63.
- 24- Lees A., Fowler N. and Derby D. (1993) A biomechanical analysis of the last stride, touch-down and take-off characteristics of the women's long jump, *Journal of Sports Sciences*, 11, 303-314
- 25- Linthorne, N. P., Baker, C., Douglas, M. M., Hill, G. A., & Webster, R. G. (2011). Take-off forces and impulses in the long jump. In *ISBS-Conference Proceedings Archive* (Vol. 1, No. 1).
- 26- Maffiuletti, N. A., Dugnani, S., Folz, M. A. T. T. E. O., Di Pierno, E. R. M. A. N. O., & Mauro, F. (2002). Effect of combined

- electrostimulation and plyometric training on vertical jump height. *Medicine & Science in Sports & Exercise*, 34(10), 1638-1644.
- 27- Makaruk, H., Starzak, M., & López, J.L. (2015) The role of a check-mark in step length adjustment in long jump. *J. Hum. Sport Exerc*, 10(3), pp.756-763.
- 28- Marijana Hraski, Željko Hraski, Snježana Mraković, Vatroslav Horvat (2015) Relation between Anthropometric Characteristics and Kinematic Parameters which Influence Standing Long Jump Efficiency in Boys and Adolescents, *Coll. Antropol.* 39, Suppl. 1: 47–55
- 29- Masaki W., Nicholas P L., (2005) Optimum take-off angle in the standing long jump, *Human Movement Science*, Volume 24, Issue 1, Pages 81-96
- 30- Morin JB1, Jeannin T, Chevallier B, Belli A. (2006) Spring-mass model characteristics during sprint running: correlation with performance and fatigue-induced changes, *Int J Sports Med.* 27(2):158-65
- 31- Panoutsakopoulos, V., & Kollias, I. (2007). Biomechanical analysis of sub-elite performers in the women's long jump. *New Studies in Athletics*, 22(4), 19-28.
- 32- Pascal B., Florian U., Benedikt M., Alexander J.A., Timothy H., Robin R., Harald T., Laurent B. (2019). Combining higher-load and lower-load resistance training exercises: A systematic review and meta-analysis of findings from complex training studies, *Journal of Science and Medicine in Sport*, Volume 22, Issue 7, Pages 838-851
- 33- Reid, P. (1989). Plyometrics and high jump. *New studies in athletics*, 4(1), 67-74.
- 34- Thériault, R., Boulay, M. R., Thériault, G., & Simoneau, J. A. (1996). Electrical stimulation-induced changes in performance and fiber type proportion of human knee extensor muscles. *European journal of applied physiology and occupational physiology*, 74, 311-317.
- 35- Ward-Smith AJ. (1984). Calculation of long jump performance by numerical integration of the equation of motion. *J Biomech Eng*; 106: 244–8.

### تأثير استخدام التدريب البليومتري والتنبيه الكهربى للعضلات على تحسين القدرات البدنية والمتغيرات البيوميكانيكية والمستوى الرقمي لناشئي الوثب الطويل

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القدرة العضلية من أهم العناصر البدنية الحاسمة في الوثب الطويل والتي يمكن تنميتها باستخدام التدريب البليومتري الذي يعمل على استثارة وتعبئة أكبر قدر من الألياف العضلية أثناء الأداء، ويعمل التنبيه الكهربى للعضلات على استثارة جميع الألياف العضلية بشكل لا إرادى مما يعمل على تحسين القوة العضلية، ويهدف البحث إلى التعرف على تأثير التدريب البليومتري والتنبيه الكهربى للعضلات فى تحسين القدرات البدنية والمتغيرات البيوميكانيكية والمستوى الرقمي لناشئي الوثب الطويل ، وقد استخدم الباحثون المنهج التجريبي بتصميم مجموعة واحدة باستخدام القياس القبلى والبعدي على عينة عددها (7) من ناشئي الوثب الطويل بمحافظة الإسكندرية بجمهورية مصر العربية تحت 18 سنة والمسجلين بالاتحاد المصرى لألعاب القوى، وتم إجراء القياسات البدنية والبيوميكانيكية والمستوى الرقمي للوثب باستخدام منصة قياس القوة والتحليل الحركى لمرحلة الارتقاء فى الوثب الطويل ، واستغرق تطبيق البرنامج التدريبي ثمانية أسابيع بواقع 16 وحدة تدريبية، وجاءت نتائج البحث بأن استخدام التدريب البليومتري والتنبيه الكهربى للعضلات أدى الى تحسين القدرات البدنية لعضلات الرجلين وتحسين وتطوير المتغيرات البيوميكانيكية فى مرحلة الارتقاء والمستوى الرقمي لدى ناشئي الوثب الطويل ، ويوصى الباحثون بتطبيق نتائج البحث على متسابقي الوثب الطويل بجمهورية العراق، وإجراء المزيد من الأبحاث العلمية على تأثير التنبيه الكهربى على النشاط الكهربى للعضلات لمتسابقي ألعاب القوى. وهذا ما يحقق احد اهداف التنمية المستدامة للامم المتحدة فى العراق (الصحة الجيدة)

البحث  
مستخلص

التدريب البليومتري، التنبيه الكهربى للعضلات، القدرة العضلية، ناشئي الوثب الطويل

الكلمات المفتاحية