A comparative study of the effect of anatomical changes of both the throwing and free arm of javelin throwers

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Abstract:-

This research aims to conduct a comparative study of anatomical changes between the throwing arm and the free arm of javelin throwers, by analyzing differences in heights, circumference, bone density and muscle strength using advanced measurement tools such as **X-ray** and Dual-Energy X-ray Absorptiometry (**DXA**).. The researcher adopted the descriptive approach for its suitability to the nature of the study, where a basic sample was selected from (6) contestants from Mansoura Club registered with the Egyptian Athletics Federation, in addition to an exploratory sample consisting of (2) contestants from the same community. The study measured the total length of the arm, the length of the upper arm, forearm and palm, in addition to the circumference of the upper arm and forearm, bone density, as well as measuring a set of muscle strength indicators such as grip, stretching, distancing, internal and external rotation, and grip strength.

The results showed statistically significant differences in favor of the aiming arm in several variables, most notably the circumference of the upper arm and forearm, bone density and muscle strength, which indicates that specialized sports training leads to clear anatomical and functional adaptations in the active upper limb. The results also confirmed that the length of the humerus, forearm and palm did not show significant differences, which can be explained by the effect of genetic factors on bone lengths more than the effect of training. The study showed that adaptations in the arm aimed at increasing muscle and bone mass, which are key factors in improving skill performance and achieving athletic achievement in javelin throwing effectiveness. The researcher recommends the need to integrate anatomical measurements within training programs and periodic evaluation, and employ their results in directing physical preparation plans and sports selection, taking into account the achievement of muscular and anatomical balance between the arms to avoid injuries and improve the level of performance.

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الملخص العربي

دراسة مقارنة لتأثير التغيرات التشريحية لكل من الذراع الرامية والحرة لمتسابقي رمي الرمح.

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يهدف هذا البحث إلى إجراء دراسة مقارنة للتغيرات التشريحية بين الذراع الرامية والذراع الحرة لدى متسابقي رمي الرمح، وذلك من خلال تحليل الفروق في الأطوال والمحيطات وكثافة العظام والقوة العضلية باستخدام أدوات قياس متقدمة كالأشعة السينية **(X-Ray)** وجهاز Dual-Energy X-ray Absorptiometry **(DXA)**. وقد اعتمد الباحث المنهج الوصفي لملاءمته لطبيعة الدراسة، حيث تم اختيار عينة أساسية من (٦) متسابقين من نادي المنصورة المسجلين بالاتحاد المصري لألعاب القوى، بالإضافة إلى عينة استطلاعية مكونة من (٢) متسابقين من نفس المجتمع. وتناولت الدراسة قياس الطول الكلي للذراع، وطول العضد والساعد والكف، بالإضافة إلى محيط العضد والساعد، وكثافة العظام، فضلاً عن قياس مجموعة من مؤشرات القوة العضلية مثل القبض والبسط والتبعيد والدوران الداخلي والخارجي وقوة القبضة.

أظهرت النتائج وجود فروق دالة إحصائيًا لصالح الذراع الرامية في عدة متغيرات، أبرزها محيط العضد والساعد وكثافة العظام وقوة العضلات، مما يدل على أن التدريب الرياضي المتخصص يؤدي إلى تكيفات تشريحية ووظيفية واضحة في الطرف العلوي النشط. كما أكدت النتائج أن طول العضد والساعد والكف لم يظهر فروقًا دالة، وهو ما يمكن تفسيره بتأثير العوامل الوراثية على الأطوال العظمية بشكل أكبر من تأثير التدريب. وقد بينت الدراسة أن التكيفات في الذراع الرامية تتجلى في زيادة الكتلة العضلية والعظمية، وهي تعد من العوامل الأساسية في تحسين الأداء المهاري وتحقيق الإنجاز الرياضي في فعالية رمي الرمح. ويوصي الباحث بضرورة دمج القياسات التشريحية ضمن برامج التدريب والتقويم الدوري، وتوظيف نتائجها في توجيه خطط الإعداد البدني والانتقاء الرياضي، مع مراعاة تحقيق التوازن العضلي والتشريحي بين الذراعين لتفادي الإصابات والارتقاء بمستوى الأداء.

A comparative study of the effect of anatomical changes of both the throwing and free arm of javelin throwers

Introduction and research problem:

Physical abilities and anatomical characteristics are among the key determinants of athletic excellence, as their development plays a vital role in enabling athletes to reach elite performance levels, and that the development of these abilities and anatomical qualities of the player is closely related to the process of reaching the highest digital level.

Osama Ahmed Hussein, et al. (2016) **state** that sports anatomy is one of the basic sciences directly related to physical education, as it is used to understand and interpret the anatomical foundations on which movement and athletic performance are based. The content of anatomy in the faculties of physical education differs from its counterpart in medical colleges, as it is taught within a framework that suits the nature of the motor and sports specialization, and focuses on the applied aspects that contribute to improving performance and understanding the mechanics of movements. The anatomy curriculum in the sports field includes topics such as: The body's motor abilities, the role of anatomical formation in supporting physical education sciences, and the analysis of motor errors and methods of correcting them. Therefore, knowledge of applied anatomy is essential for coaches, as it plays a role in designing effective training programs, preventing injuries and achieving the highest levels of sports. (7:3)

Walid Youssef Al-Hammouri and Sadiq Khaled Al-Hayek (2006) **point out the** importance of the skeletal system represents the main axis in the human body and is responsible for all organs of the body and gives it a moderate straight shape, and protects the vital organs of the body inside it, where it protects the heart and lungs through the rib cage, and protects the brain and its organs through the skull, and the presence of the skeleton in the form of small detailed bones helped the body to carry out its various and varied movements, and the bones work as stores of calcium, phosphorus and magnesium salts, which are important salts for blood physiology, The bones are important for the muscles because they are taken from these bones as a center for their integration and origin, and the bones contain a substance whose color tends to yellow known as bone marrow, a substance that retains red blood cells, white blood cells and platelets, which are important substances to give the body its needs. (19:8)

Iqbal Rasmi Muhammad, Muhammad Muhammad Sweidan (2006) **states** that bones consist of organic materials and are one-third of the weight of the bone and inorganic materials and are two-thirds of the weight of the bone, and organic materials consist of bone cells, bone tissue and blood vessels, and inorganic materials include many salts, the most important of which are calcium and

phosphorus, and the components of the bone are exposed to changes at each stage of different stages of life, especially organic matter, where it decreases with age or as a result of some diseases, so it becomes fragile or easy to break, and if Less inorganic substances The bone is warped and soft, as occurs in rickets in children and osteomalacia in pregnant women who are malnourished. (3:25)

Iqbal Rasmi Mohammed (2008) **agrees** with what was stated in **the magazine Assessment of bone (2002)** that the anatomical characteristics represent one of the most important variables that directly affect the level of sports performance, there is a clear relationship between the structural aspect, which is expressed (anatomical structure and physical structure) and the functional aspect, which is expressed by sports performance, and that anatomical characteristics It directly affects performance, as there are differences in anatomical structure among the great sports heroes that affect their results. (2:17), (20:3)

Haitham Abdel Hamid Daoud et al. (2021) **point out** that physical measurements are essential individual characteristics that play an influential role in achieving higher sports levels, since each sports activity has specific physical and anatomical characteristics that suit its motor and technical requirements. Body composition, including height, weight, and limb ratios, is one of the decisive factors that determine the player's ability to reach optimal athletic achievement, as the compatibility between body structure and activity type contributes to raising the efficiency of performance, and is a prerequisite for excellence in high-level competitions. (18:34)

Abu Ela Ahmed Abdel Fattah (2003) **believes** that there is a relationship between the physical and anatomical composition of the player in terms of height, weight, length of limbs, bones and surroundings and the possibility of reaching high levels, as each sports activity has certain physical characteristics that must be observed when choosing players for different activities, and the association of anatomical qualities with many motor abilities is a strong basis for excellence in various sports activities. Anatomical is one of the most important factors that determine sports skill and is based on reaching high athletic levels. (5:44)

Fatima Mahmoud Abu Abdoun (2003) **explains** that anatomical qualities are one of the most important factors on which coaches and workers in various sports and athletics competitions in particular depend, because of their great role in achieving achievements and upgrading the desired technical levels, as the integrated physical construction appropriate to the type of sports activity, gives the opportunity to reach a high level

of performance, and the superiority of some races in sports activities is due to their distinction in some physical and anatomical characteristics. required by high performance. (14:193)

Ehab Kamel Al-Afifi **(2002) also adds** that each sports activity has anatomical characteristics commensurate with the quality of the activity practiced and varies from one activity to another, and that the integrated physical structure appropriate to the type of sports activity, gives the opportunity to reach a high level of performance, and that the superiority of some races in sports activities is due to their distinction in some physical and anatomical characteristics. (4:303)

Gabriel, Managra, et al., (2023), and Jelicic M., Sekuic D., (2002) agreed that each sports activity has special physical requirements to reach the competitive level, and when choosing a player, he must meet the requirements for the type of activity, whether physical or physical. (22:71) (23:141)

Farraj Abdel Hamid Tawfiq (2004), Abdel Halim Mohamed Abdel Halim, et al. (2002) and Kamal Jamil Al-Rabdami (2002) mention that the javelin throwing competition is one of the difficult competitions that depend on the player's physical abilities and physical qualities and are affected by many mechanical and physical variables such as (speed, strength, and others), and this competition is characterized by fast performance, as the total movements in which it is performed are synchronous and integrated during the approaching stages, which are called the last five steps, especially in the step The latter, which is known as (the final throwing stage), and all these stages need the trainer to be highly accurate in choosing exercises for the quality of performance, as the main goal of throwing competitions is to keep the tool away by throwing or by pushing as far as possible without any violation of the rules and conditions of the competition. (15: 96) (11: 172) (16:315)

Farraj Abdel Hamid Tawfiq (2004) **and Sidqi Ahmed Salam (2014) indicate** that the javelin throwing competition is one of the throwing competitions in field and track competitions, and is characterized by all the advantages of other throwing competitions, and the distance of the shooter in the javelin depends on the speed of leaving the hand to the spear, flexibility and accuracy of compatibility in the performance of the movement between the movements of the legs, the throwing arm and the torso, and the increasing speed, straightness and length of the javelin route, air resistance and spear angle. (15: 95) (10:232)

The researcher believes that javelin throwing competitions are no less important than other competitions, whether in athletics or other sports, where international championships are held for them and this competition requires special specifications for performance based on scientific foundations in order to achieve high levels, the coach, whatever his technical ability,

can not be considered a champion unless he has the anatomical qualities appropriate for this type of sports activity, Reaching advanced levels of mathematical skills is not easy to achieve if there is no appropriate and balanced anatomical specification for that skill.

Saif Harith Ibrahim, Mohammed Abdul Shaheed Hassan (2019) **explains that** javelin throwers rely mainly on the strength of the upper limb in the process of performing throws, as the exercises prepared for them contributed to increasing the efficiency of the functional devices, which in turn helped to raise the efficiency of the players and the strength of their arm, especially the throwing arm, which works to pull the spear and stabilize it at the maximum point, which requires bearing the force, because fatigue will lead to poor achievement, weak pulling force and poor efficiency as well. (9:147)

Sidqi Ahmed Salam (2014) points out that there are several main factors that help increase the distance of throwing the javelin, most notably: the speed of leaving the javelin from the hand, the gradual increase in speed while avoiding periods of deceleration during the approaching and disposal stages, in addition to the length and straightness of the javelin line, the angle of throwing, and air resistance. Achieving motor harmony between parts of the body during performance also contributes significantly to reaching the maximum possible distance. (10:232)

The javelin throw event is a sporting event that requires a combination of physical, technical and anatomical factors to achieve optimal performance. In particular, the upper limb, especially the throwing arm, is a key axis in the execution of the throwing skill, as this arm bears a recurring load of loads and pressures during training and competition, which leads to anatomical and muscular changes resulting from adaptation to the nature of performance. Although specialized training leads to a clear adaptation of the physical components associated with the limb, most previous studies have focused on skill aspects or common injuries, without delving into the anatomical differences between the aiming arm and the free arm resulting from regular exercise in javelin throwing effectiveness. Few of these studies have used modern measurement tools such as X-rays or DXA technology to accurately measure bone density and limb circumference.

Through the researcher's observation of the athletes specialized in javelin throwing, there were clear signs of variation in the characteristics of the arms in terms of height, circumference, bone density and muscle strength, which raised an important scientific question about the extent to which specialized sports training affects the anatomical structure of both arms, and the extent to which there are differences that can be measured and analyzed. Therefore, the problem of this research stems from the need for a

comparative scientific study of the anatomical and functional changes that occur in the throwing arm and free arm of javelin throwers, with the aim of determining The nature of these changes and their employment in the development of training programs and directing the sports selection processes with accurate scientific foundations.

Research Objective:

This study aims to conduct a comparative analysis of the anatomical differences between the throwing and non-throwing arms of javelin throwers.

Research Questions:

1. What are the anatomical changes of both the throwing arm and the free arm of the javelin throwers?
2. What are the key muscular strength indicators that differentiate the throwing arm from the non-throwing arm among javelin throwers?
3. Are there statistically significant differences between the anatomical changes of both the aiming and free arm of javelin throwers?

Search terms:

Anatomical changes:

Anatomical changes are the process of changing the structure or shape of the body, and the anatomical change may occur due to environmental factors such as climatic conditions or changes in the level of nutrition and water, it can also be the result of genetic evolution, disease or age, and the anatomical change includes a change in the size or shape of tissues, muscles, bones and organs. (29:48)

Anatomical Position:

It is an erect position of stature, in which the face is forward and looking forward and its upper limbs are extended on the sides of the body and the palms of the hand forward and the toes are pointed forward, and the purpose of the anatomical position is to study the anatomy of the human body uniformly, despite the different languages and places on the surface of the earth. (26:4)

Related studies:

1. Study of **Saif Harith Ibrahim and Muhammad Abdul Shaheed Hassan (2019) (9):** entitled **"Special exercises and their impact on bearing the strength of the arms and the accuracy of aiming for bow and arrow players"** and aimed to identify the effect of strength endurance exercises in developing the strength of the arms and the extent to which they reflect on the accuracy of motor performance in sports skills, specifically the skill of shooting. The researchers used the experimental

approach due to its suitability to the nature of the study, and a sample of (6) players aged between (18-22) years was selected, who underwent a training program based on strength endurance exercises. The results showed that there were statistically significant differences in favor of the telemetry in the aiming accuracy test, which indicates the effectiveness of the training program in improving the qualitative strength of the arms, and thus positively affecting the accuracy of performance. The researchers recommended the need to focus on the use of strength endurance exercises within the training plans to develop the efficiency of the arms and achieve Higher levels of accuracy in skill and athletic performance.

2. Study of **Ali Alwan Khoman (2014) (13):** entitled **"Anthropological measurements of the upper limbs and their relationship to the kinematic characteristics and achievement of the effectiveness of javelin throwing for disabled women"** and aimed to identify some anthropometric measurements of the upper limbs, and the kinematic characteristics associated with the effectiveness of javelin throwing among females with disabilities, and the extent of their impact on the level of achievement. The researcher used the descriptive approach, and the study was conducted on a number of players, where ten analytical attempts were carried out for each case, through which data of measurements and mechanical variables were collected. The results found that motor problems associated with performance can be detected through anthropometric measurements, and the study also demonstrated the importance of kinematic chain in the upper limbs associated with the joints responsible for effective performance. The results indicated that the decisive stage in performance requires observance of legal conditions, which helps in conserving kinetic energy and reducing errors.

3. Study of **Julia Marie Maki (2013) (25):** entitled **"Biomechanics of Javelin Throwing: Analysis of the Effect of Anatomical Variation on Throwing Performance, with Indications on the Fossil Record"** and aimed to identify the motor patterns used during the performance of the javelin throw, with the aim of examining the morphological correlations associated with the force and accuracy of the throw in living humans. The sample included (41) experienced archers who used to throw balls and objects similar to the javelin, where they underwent a number of accurate measurements Using advanced techniques for motion analysis. The results showed that the shoulder joint is exposed to low angular

speeds and relatively little torque, and the elbow joint moves less during the javelin throw than during the ball throw, indicating a lower role of the arm in producing force during the throw. The study confirmed that there is no direct correlation between the effectiveness of the javelin throw and any anatomical or morphological variable of the arm, and therefore the researcher recommends that future studies should focus on the role of the trunk and legs in supporting movement and improving overall performance.

4. Study of **Mohammed Al-Raqqad (2009) (8):** entitled **"The relationship of some physical characteristics and anthropometric measurements to the level of achievement with the effectiveness of javelin throwing"** and aimed to identify the relationship of some physical characteristics and anthropometric measurements to the level of achievement in the javelin throwing event. The sample was selected from all members of the study population, and their number reached (30) players participating in the King Hussein Sports Championship for athletics, in order to ensure the comprehensiveness of representation and diversity of physical level. A set of anthropometric measurements were carried out that It included different lengths and perimeters, and the researcher used descriptive statistics, torsion coefficient and correlation coefficient to analyze the data. It was concluded that there is a statistically significant correlation between the jump test from stability and level of achievement in the effectiveness of the javelin throw, in addition to a significant relationship between the various anthropometric measurements and the level of performance, which indicates the importance of these variables in interpreting and predicting sports achievement in this discipline.

5. Study of **Waleed Yousef Al-Hammouri and Sadiq Khaled Al-Hayek (2006) (19):** entitled **"Predicting the contribution of physical and physical qualities to the digital achievement of shot put and discus"** and aimed to identify the ratios of the contribution of physical and physical qualities in the digital achievement of shot put and discus. The research was conducted on a sample of (64) students from the Faculty of Physical Education at the University of Jordan, and the descriptive approach was used, and measurements of lengths, circumferences, explosive power, constant force, speed and flexibility were made, in addition to the digital level of shot put and disc ejection. The results showed prediction of total length, humeral circumference of contraction, leg thickness, waist circumference, and jump physical qualities of stability, grip strength,

flexibility in the numerical achievement of the discus throw function. The results showed that the physical characteristics and physical characteristics that contribute to predicting the shot put distance are length, humeral circumference, forearm length contraction, and jumping physical characteristics of stability and grip strength.

6. Study of **Abd al-Salam al-Fayrouzi al-Turrouzi (2006) (12):** entitled **"The relationship of some anthropometric and physical characteristics of the foot among the long jumpers"** and aimed to analyze the relationship between the anthropometric qualities and the physical abilities of the foot among the long jumpers, by applying it to a sample of (10) students from the field of athletics. The researcher relied on the descriptive approach for its suitability to the nature of the research problem, where the data was collected through accurate measurements, and analyzed using the arithmetic mean and deviation Normative, correlation coefficients, along with linear regression equation to explain the relationships between variables. The results of the study showed a statistically significant correlation between anthropometric and physical characteristics and performance results in the long jump competition, and an accurate predictive equation was reached to estimate the distance based on these variables. The researcher recommended the importance of conducting more field studies that focus on the relationship between physical composition and sports achievement, especially in jumping and jumping events.

7. Study of **Salazer et al., (2006) (28): "Anthropological characteristics and structural maturity of male swimmers in Venezuela"** and aimed to identify morphological features and study the structural growth of male Venezuelan swimmers during different stages of development. The study was conducted on a sample of (114) swimmers aged (7-18) years, and it used the experimental method, which included the application of the International Anthropometric Measurements Manual (ISAK).) to measure physical dimensions, in addition to analyzing structural growth using five indicators including bone mass, muscle, fat, protein, and water. The results showed that regular swimming contributes to achieving a clear harmony between structural growth and physical growth, which reflects positively on morphological variables and motor ability. The study also indicated that the development of these indicators is closely related to the type of physical activity, which reinforces the importance of exercise in the early stages to support the structural and career development of young athletes.

The extent of benefit from the associated studies:

Through the presentation and analysis of these studies and their results, some points were extracted that could be benefited from:

- Identify the research problem and formulate the goal and questions in a scientific manner.
- Determine the procedural steps to implement the research (methodology, sample, tools, exploratory study).
- Using X-Ray.
- Determine the most appropriate anatomical position for upper limb imaging.
- Selecting the most important anatomical measurements that can be used in this research, in line with its objectives and basic variables.
- Processing data statistically, tabulating and presenting them, discussing the results , formulating the most important ones, and coming up with the most important recommendations.

Search Procedure:

Research Methodology:

The researcher **used** the descriptive approach due to its suitability to the research objective and questioning.

Research Community :

A community consists of (8) javelin throwers at Mansoura Club, who number (8) racers from the upper levels of the age group of (18-21) years and registered with the Egyptian Athletics Federation for the 2022/2023 sports season.

Research sample:

The basic research sample was selected in a deliberate way, and their number reached (6) contestants from the upper levels of the age group of (18-21) years at Mansoura Club and registered in the Egyptian Athletics Federation for the sports season 2022/2023, and another exploratory sample was selected from the same research community and outside the basic sample, and its strength reached (2) contestants.

Conditions for selecting the research sample:

- Not to be practicing any other activity.
- To be a practitioner of the javelin throwing competition for a period of not less than (6) years.
- To be free from any deviations or sports injuries.

Homogeneity of the research sample:

The **researcher conducted** homogeneity of the research sample as shown in **Table (1)**.

Table (1)

The arithmetic mean, median, standard deviation and torsion coefficient of the research population (n=6)

M	Variables	Unit of measurement	Arithmetic mean	Broker	Standard deviation	Torsion coefficient
1	**lifetime**	Year	18.965	19.00	1.036	0.415
2	**Length**	Poison	180.85	181.00	5.626	0.963
3	**Weight**	Kg	79.526	79.00	8.925	-0.215

Table (1) shows the arithmetic mean, median, standard deviation, and torsion coefficient of the research population, where the results of the torsion coefficient indicate that all values fall between (+3), and this is an indicator of the homogeneity of the members of the research sample.

Tools and devices used in research:

- Rustameter to measure height and weight
- Digital X-ray Imaging System **(X-RAY).**
- Dual-Energy X-ray Absorptiometry (DXA) **bone density device**
- A computer equipped with a special program for measuring the rays to measure the lengths of the bones of the arm.
- A dynamometer to measure the muscular strength of the arm.
- Tape measure for measuring the lengths of connections.

Measurements used:

- Measure the total height and weight of the body.
- Limb length: (arm length, upper arm length, forearm length, palm length)
- Circumference: (humeral circumference, forearm circumference)
- Bone densitometry.

Muscle strength tests of the arm (grip - stretch - distance - rotation in - rotation outward - grip strength): using a dynamometer to measure the muscular strength of the arm

Exploratory Study:

The exploratory study was conducted on the number of javelin throw contestants during the period from 4/2/2023 AD to 5/2/2023 AD **with the aim of:**

- The Digital X-ray Imaging System **(X-RAY) can** be used to measure arm bone lengths and the Dual-Energy X-ray

Absorptiometry **(DXA)** device to analyze bone densitometry.

- The most appropriate anatomical position of the bones of the arm so that it can be imaged with an x-ray machine.

Exploratory Study Procedures:

The study was conducted on (2) javelin throwers from the same research community and outside the basic sample, and a radiologist at Nile Hospital was used.

Results of the exploratory study:

- The validity of the use of the x-ray device and the obtained anatomical measurements under research have been ascertained.
- Determine the most appropriate anatomical position for the bones of the arm so that it can be imagitated with **X-ray** machine.
- How the specialist uses the Dual-Energy X-ray Absorptiometry (**DXA**) device to measure bone density.

Basic research experience:

The basic study of the research was conducted during the period from 10/2/2023 AD to 18/2/2023 AD, through the following steps:

- Special devices and tools have been prepared in conducting anthropometric measurements under research.
- The radiology machine was booked at Nile Hospital in order to facilitate imaging procedures for the research sample, and to make an appointment with the specialist doctor, as well as the Dual-Energy X-ray Absorptiometry (**DXA**) device to measure bone density.
- The measurements and development were carried out in the presence of the specialist doctor and took the measurements under research on the basic research sample so that **the researcher ensures** the validity of the extracted data.

Statistical processing:

The researcher used statistical coefficients:

- Arithmetic mean.
- Broker.
- Standard deviation.
- Torsion coefficient.
- Mann and Netney's test to signify differences.

Presentation and discussion of results:

To answer the first question : what are the anatomical changes of both the throwing and free arm of javelin throwers?,

The arithmetic mean, standard deviation and torsion coefficient were extracted, and the results were reached as shown in the following tables:

Table (2)

Anatomical changes of the arm of javelin throwers

(arithmetic mean, median, standard deviation and torsion coefficient) (n=6)

M	Variables	Unit of measurement	Arithmetic mean	Broker	Standard deviation	Torsion coefficient
1	**Arm length**	Poison	82.661	83.000	4.725	-0.215
2	**Huercopal length**	Poison	36.769	36.000	2.615	0.882
3	**Forearm length**	Poison	27.924	28.000	2.356	-0.097
4	**Palm length**	Poison	17.968	18.000	1.129	-0.085
5	**Huercopic circumference**	Poison	34.529	34.000	2.689	0.590
6	**Forearm circumference**	Poison	22.849	22.500	1.963	0.533
7	**Bone density**	mg/cm2	37.965	38.000	3.695	-0.028

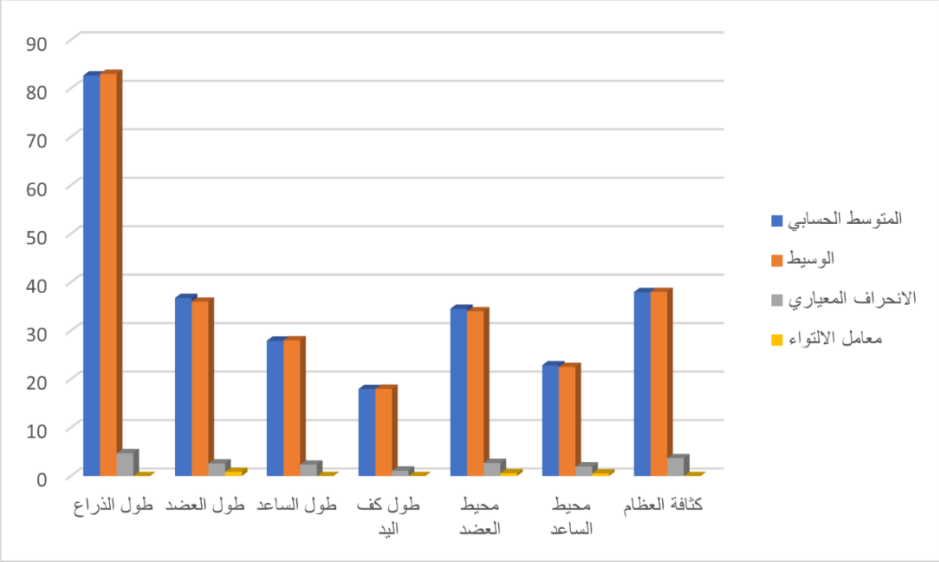

Figure (1) Anatomical changes of the arm of javelin throwers

Table (2) shows the anatomical changes of the arm of the javelin throwers, where the arm length came with an arithmetic mean of (82.661), standard deviation (4.725), humeral length (36.769) and standard deviation (2.615), forearm length (27.924) and standard deviation (2.356), palm length (17.968) and standard deviation (1.129), and circumference of (1.129), and the circumference of the forearm (27.924) and standard deviation (2.356), palm length (17.968) and standard deviation (1.129), and the circumference of Hubrachial (34.529) and standard deviation (2.689), forearm circumference (22.849),

standard deviation (1.963), bone density (37.965) and standard deviation (3.695).

These results reflect the adaptation of the throwing arm to the performance requirements of the javelin throw, as it is subjected to high mechanical stress during training and competitions. This is consistent with what **Michael G. Bamben et al. Michael G. Bemben et al. (2000),** that physical exercise, especially resistance exercises, helps stimulate blood circulation within the bone tissue, which leads to increased deposition of mineral elements in the bones and raise their density. (21:182)

This is also consistent with what was mentioned **by Mufti Ibrahim Hammad (2000),** where he pointed out that regular physical exercise leads to an increase in bone width and density by depositing larger amounts of mineral salts on them, which directly contributes to strengthening bones and increasing their hardness. He also stressed that bones are clearly affected by the repeated stress and pressure processes placed on them during physical activity, which makes exercise one of the effective factors in improving the health and structure of the skeleton. (17:35)

The **researcher believes** that the anatomical measurements of the arm of the javelin throwers reflect the special anatomical adaptation that occurs as a result of the continuous and regular practice of javelin throwing. The observed increase in the circumference of the upper arm and forearm as well as the increase in bone density of the arm indicate the nature of the biological response of muscles and bones to repetitive training loads. The researcher believes that these changes are a key factor in improving performance, as they provide the anatomical basis for generating the force needed to propel the spear farther.

Table (3)

Anatomical changes of the free arm of javelin throwers

(arithmetic mean, median, standard deviation, and torsion coefficient) (n=6)

M	Variables	Unit of measurement	Arithmetic mean	Broker	Standard deviation	Torsion coefficient
1	**Arm length**	Poison	81.766	82.000	4.260	-0.165
2	**Huercopal length**	Poison	36.079	36.000	2.456	0.096
3	**Forearm length**	Poison	27.788	27.500	2.521	0.343
4	**Palm length**	Poison	17.899	18.000	1.641	-0.185
5	**Huercopic circumference**	Poison	33.290	33.000	2.446	0.356
6	**Forearm circumference**	Poison	21.680	21.500	1.997	0.270
7	**Bone density**	mg/cm2	34.587	34.000	3.875	0.454

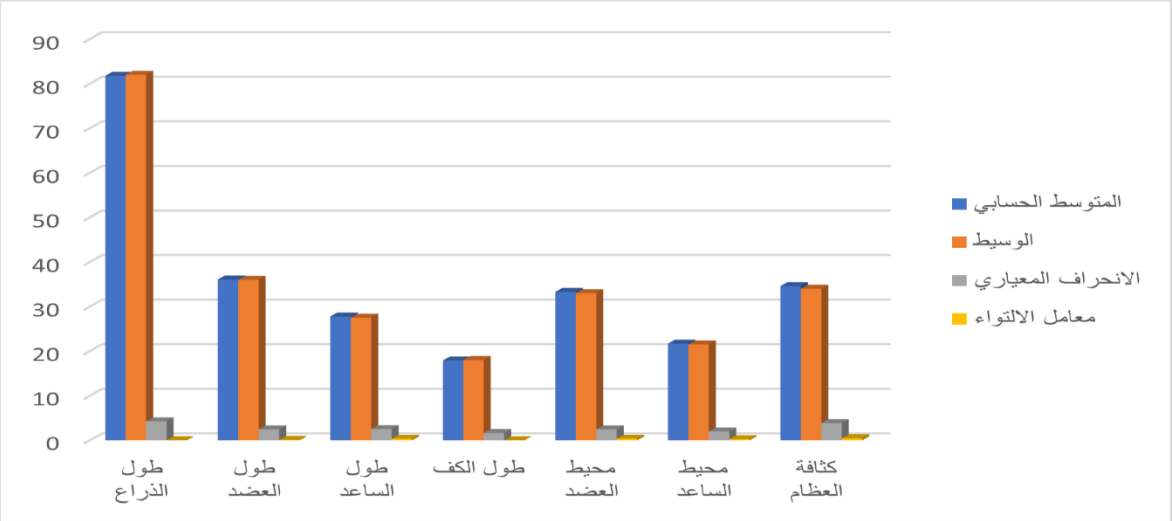

Figure (2) Anatomical changes of the free arm of javelin throwers

Table (3) shows the anatomical changes of the free arm of the javelin throwers, where the arm length came with an arithmetic mean of (81.766), standard deviation (4.260), humeral length (36.079), standard deviation (2.456), forearm length (27.788), standard deviation (2.521), palm length (17.899) and standard deviation (1.641).), humeral circumference (33.290) and standard deviation (2.446), forearm circumference (21.680) and standard deviation (1.997), bone density (34.587) and standard deviation (3.875).

It can be seen that the anatomical measurements of the free arm differ from the aiming arm in terms of some dimensions and muscle composition, and this confirms what **Osama Ahmed Hussein and others (2016) pointed out** that anatomical changes occur in response to the processes of stress and muscle tension resulting from repeated exercise. (7) Adoption of the Convention on the Rights: 55)

These results are consistent with the study of **Ali Alwan Khoman (2014),** who explained the importance of anthropometric measurements in the early detection of motor problems associated with the performance of javelin throwing skill, especially those related to motor balance and muscular coordination during the implementation of the various stages of movement, which contributes to improving the quality of performance and preventing injuries. (13:67)

The **researcher believes** that the anatomical changes of the free arm of javelin throwers show relatively lower values compared to the throwing arm, and this reflects the selective nature of the anatomical adaptation in response to the specific requirements of each limb of the body during the performance. **The researcher believes** that this contrast between the arms is not just an accidental consequence, but rather an accurate reflection of the biological adaptation mechanisms that occur in the athlete's body in response to the different functional requirements of each arm during the

performance of the javelin throw. The **researcher** emphasizes It is important to take this variation into account when designing training programs to avoid major imbalances that may negatively affect the overall health of the athlete in the long term.

To answer the second question: what are the muscular strength variables of both the throwing and free arm of javelin throwers?

The arithmetic mean, standard deviation and torsion coefficient were extracted, and the results were reached as shown in the following tables:

Table (4)

Variables of muscular strength of the throwing arm of javelin throwers (arithmetic mean, median, standard deviation, and torsion coefficient) (n=6)

M	Variables	Unit of measurement	Arithmetic mean	Broker	Standard deviation	Torsion coefficient
1	**Arrested**	Kg	35.625	35.000	2.560	0.411
2	**Numerator**	Kg	26.448	26.500	2.012	-0.052
3	**Distance**	Kg	21.388	21.000	1.662	0.250
4	**Spinning in**	Kg	25.449	25.500	2.221	-0.048
5	**Turning out**	Kg	22.598	22.000	1.415	-0.353
6	**Grip strength**	Kg	32.474	32.500	1.114	-0.070

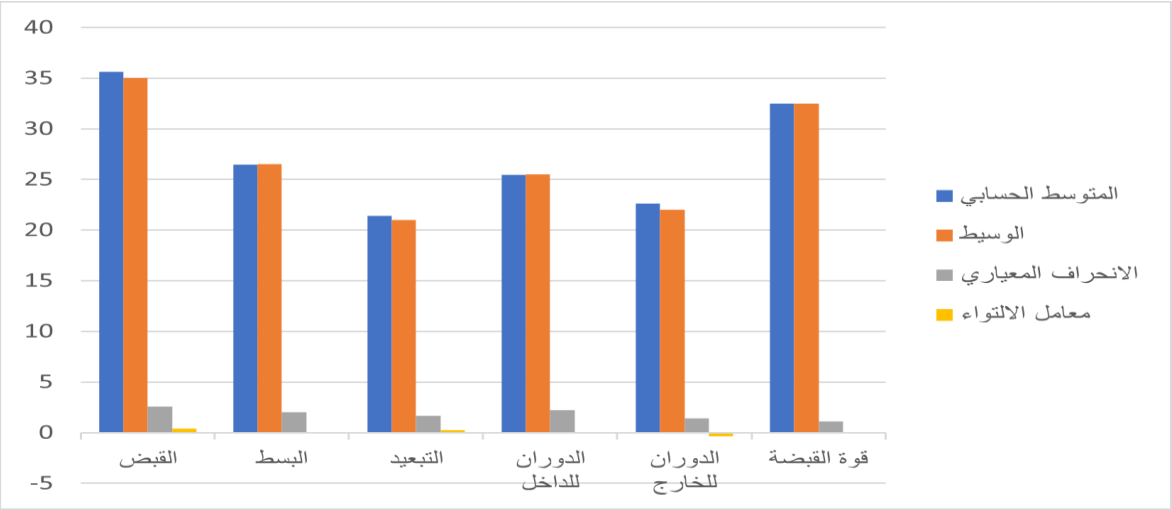

Figure (3) Variables of the muscular strength of the arm aimed at javelin throwers

Table (4) shows the variables of the muscular strength of the arm of the javelin throwers, where the strength of the shoulder flexor muscles came with an arithmetic mean of (36.625) and a standard deviation of (2.560), and the extensor force of the shoulder muscles (26.448) and standard deviation (2.012), and the strength of the distal muscles (21.388) and standard deviation (1.662), and the muscle force of

rotation inward (25.449).) and standard deviation (2.221), muscle strength outward rotation (22.598) and standard deviation (1.114).

These indicators of muscular strength are essential requirements for the performance of javelin throwing skill efficiently and effectively, as they contribute to the generation of the required force and the proper direction of the spear during the throw. These results support the findings of **the study "Saif Harith Ibrahim and Mohammed Abdul Shaheed Hassan (2019),** which emphasized the importance of strength endurance exercises in developing the strength of the arms, and their direct impact on improving the accuracy of skill performance and athletic achievement. (9:117)

These results are also consistent with what **Farraj Abdel Hamid Tawfiq (2004) and Sidqi Ahmed Salam (2014)** pointed out, where they confirmed that the success of the performance in the javelin throw competition depends largely on the speed of separation of the spear from the hand, in addition to the flexibility of the joints and the accuracy of neuromuscular coordination, especially in the temporal coordination between the movement of the legs, the throwing arm and the torso, which is one of the key factors to achieve the optimal throw and reach a long distance with high accuracy. (15:95) (10:232)

The researcher **believes** that the variables of the muscular strength of the arm aimed at the javelin throwers reflect the importance of developing various muscular abilities, especially the grip force, grip strength and rotational force inward, as these variables recorded the highest values. **The researcher believes** that these results confirm the importance of focusing on these specific motor patterns during training due to their crucial role in the quality of javelin throwing. As the **researcher** sees The relative balance between the force of rotation in and out is a positive indicator of joint health and contributes to reducing the chances of injury that may result from the muscular imbalance around the joint.

Table (5)

Variables of the muscular strength of the free arm of javelin throwers (arithmetic mean, median, standard deviation, and torsion coefficient) (n=6)

M	Variables	Unit of measurement	Arithmetic mean	Broker	Standard deviation	Torsion coefficient
1	**Arrested**	Kg	31.551	32.000	2.611	-0.292
2	**Numerator**	Kg	25.015	25.000	2.111	0.014
3	**Distance**	Kg	18.241	18.500	2.251	-0.183
4	**Spinning in**	Kg	22.255	22.500	2.200	-0.230
5	**Turning out**	Kg	20.254	20.500	2.984	-0.247
6	**Grip strength**	Kg	30.474	30.500	1.114	-0.070

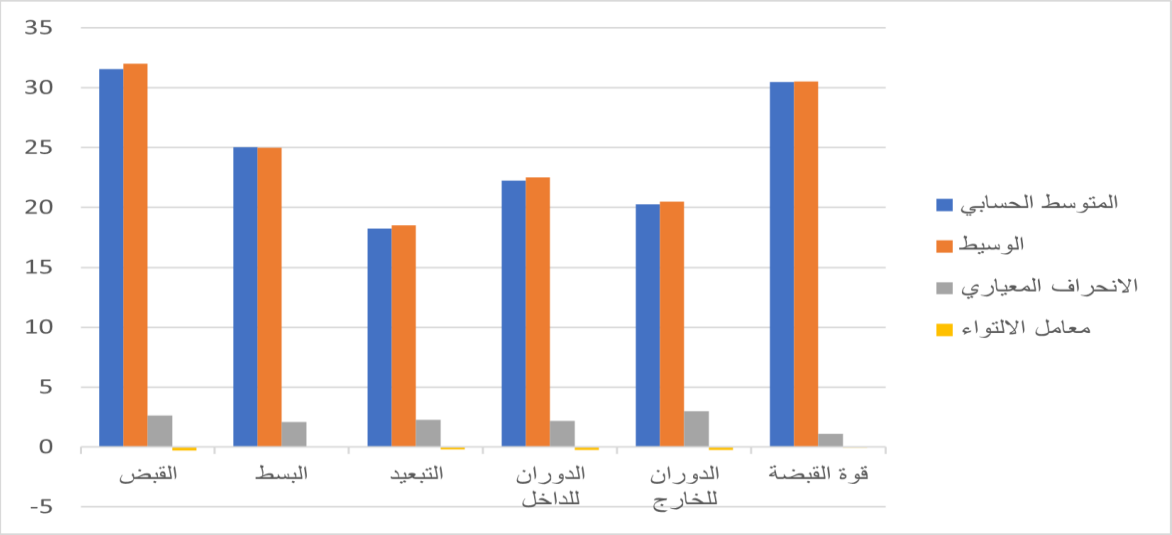

Figure (4) Variables of the muscular strength of the free arm of javelin throwers

Table (5) shows the variables of the muscular strength of the arm of the javelin throwers, where the strength of the shoulder flexor muscles came with an arithmetic mean of (31.551) and a standard deviation of (2.611), and the extensor force of the shoulder muscles (24.015) and standard deviation (2.111), and the strength of the distal muscles (18.241) and standard deviation (2.251), and the muscle force of rotation inward (22.255) and standard deviation (2.200), muscle strength outward rotation (20.254) and standard deviation (2.984).

It is noted that the muscular strength of the free arm is relatively less compared to the throwing arm in all variables, which is consistent with what was pointed out by **"Osama Mustafa Riad (2000)" that the athlete's** practice of activity for long periods clearly affects the physical shape of the player, and gives him special morphological specifications related to the structure of the body and the nature of performance in the practiced sports activity, especially in the most used party during training and competition. (6:102)

These results are consistent with the study **of "Walid Yousef Al-Hammouri and Sadiq Khaled Al-Hayek (2006)",** which confirmed that anatomical and anthropometric measurements are factors that determine the shape and composition of the body, and that the fitness of the individual in sports activities depends mainly on the suitability of the physical structure to perform the required work. (19:44)

The researcher **believes** that the variables of the muscular strength of the free arm of javelin throwers show a consistent pattern in the distribution of muscular strength with the throwing arm, albeit with lower values, which indicates an overall effect of training on both arms with greater specialization of the throwing arm. **The researcher believes** that maintaining appropriate levels of muscular strength of the free arm is of great importance in achieving the motor balance of the body as

a whole while performing the javelin throwing skill, as the free arm contributes to achieving balance and stability. During the various throwing stages. The researcher also stresses the need to pay attention to developing the capabilities of the free arm in a balanced manner with the arm aimed at avoiding functional and anatomical imbalances in the long term.

To answer the third question: Are there statistically significant differences between the anatomical changes of both the throwing arm and the free arm of the javelin throwers?

The significance of the differences between the aiming and free arm in anatomical changes was extracted using the Mann and Tney test to indicate the differences, and the results were reached as shown in the following tables:

Table (6)

The significance of the differences between the throwing arm and the free arm in the anatomical changes of javelin throwers (n=6)

M	Variables	Unit of measurement	Throwing arm		Free Arm		The value of Man and Netney	Z value
			Average ranks	**Total ranks**	**Average ranks**	**Total ranks**		
1	**Arm length**	poison	8.83	53.00	4.17	25.00	4.00	2.33*
2	**Huercopal length**	poison	8.00	48.00	5.00	30.00	9.00	1.51
3	**Forearm length**	poison	8.25	49.50	4.75	28.50	7.50	1.75
4	**Palm length**	poison	6.17	37.00	6.83	41.00	16.00	0.33
5	**Huercopic circumference**	poison	8.33	50.00	4.67	28.00	5.00	1.97*
6	**Forearm circumference**	poison	9.50	57.00	3.50	21.00	0.00	2.89*
7	**Bone density**	mg/cm2	9.50	57.00	3.50	21.00	0.00	2.89*

***Tabular "Z" value at a significant level of 0.05 = 1.962**

***Mann Whitney peak at 0.05 = 7.00**

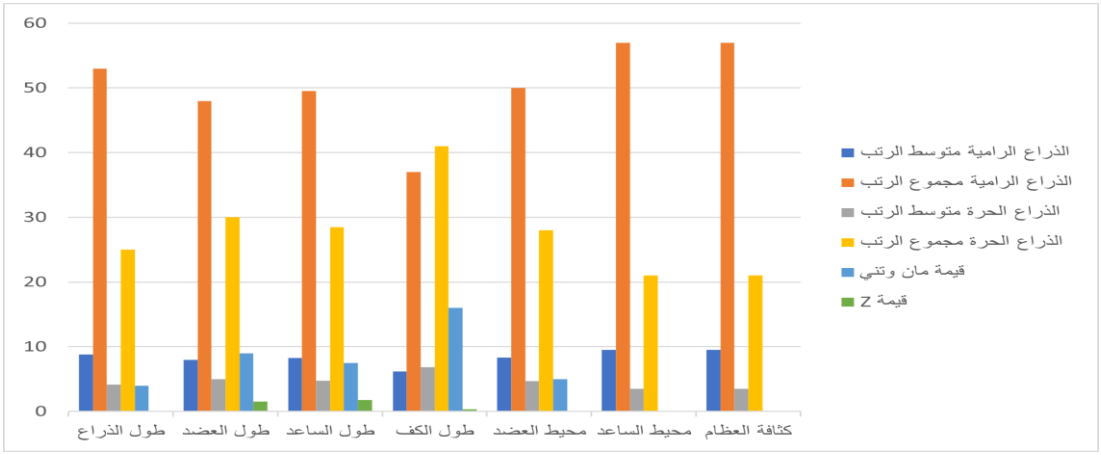

Figure (5) Significance of the differences between the throwing arm and the free arm in the anatomical changes of javelin throwers

Table (6) shows that there are statistically significant differences between the anatomical changes of both the throwing and free arm of the javelin throwers (arm length - humeral circumference - forearm circumference - bone density) in favor of the throwing arm, as the calculated "Z" value is greater than its tabular value at a significant level of 0.05, and there are no differences in anatomical changes (humeral length - forearm length).– Palm length) where the calculated "Z" value is less than its tabular value at a significant level of 0.05.

These findings are consistent with what **Najeh et al.(2025)",** in their study on the effect of repeated single-throws, where it showed that athletes who play sports that require the use of one arm intensively, such as baseball, show clear morphological and anatomical changes in the arm used compared to the other arm, especially in the shoulder muscles and scapula. (27)

These results are also consistent with the study of **Abu Ela Ahmed Abdel Fattah and Mohamed Sobhi Hassanein (2003),** which showed that regular and directed sports training leads to significant physiological and anatomical changes in the active and frequently used parts of the body, more clearly than those that are not used regularly in motor activity, which reflects the effect of training specialization in shaping the physical and functional structure of the athlete. (5:87)

These findings are in line with what **was confirmed by Al-Beik, Ali Fahmy, and Imad El-Din Abbas (2009),** who indicated that anatomical and functional adaptations appear more pronouncedly, specifically in musculoskeletal and bone groups that bear the brunt of physical exertion during specialized and continuous athletic performance, as a result of the adaptive responses that regular training induces in the long term. (1:103)

The absence of significant differences in the length of the upper arm, forearm and palm between the arms is due to the fact that these longitudinal dimensions are anatomical characteristics that are not easily affected by physical training, unlike muscle contours and bone density that show a clear response to regular exercise. **Karasik & Broeckel (2018) have suggested** that these lengths are related to the basic structure of the body, making them less susceptible to change. The study of **Wain et al. (2023)** shows that the structural proportions of the body are subject to formative considerations that are difficult to modify through training only. (24), (30)

The **researcher explains** that the results provide strong scientific evidence of the nature of selective anatomical adaptations that occur as a result of regular practice of javelin throwing. The statistically significant differences in the variables of arm length, humeral circumference, forearm circumference, and bone density in favor of the arm clearly reflect the effect of repeated and specialized training loads on these variables, as muscles

and bones respond to repetitive mechanical stress by increasing their density and size.

The researcher also **points out** that the absence of significant differences in the lengths of the humerus, forearm and palm confirms that bone lengths are affected by training to a lesser degree than the circumference and bone density, as a result of their association with genetic factors. He believes that these results are of practical importance for coaches and athletes, as there is a need to focus on strengthening the arm muscles aimed at improving bone density through specialized training programs, while maintaining muscular and bone balance between the arms to prevent injuries in the long term.

Table (7)

The significance of the differences between the throwing arm and the free arm in the muscular strength variables of javelin throwers (n=6)

M	Variables	Unit of measurement	Throwing arm		Free Arm		The value of Man and Netney	Z value
			Average ranks	**Total ranks**	**Average ranks**	**Total ranks**		
1	**Arrested**	kg	9.50	57.00	3.50	21.00	0.00	2.68*
2	**Numerator**	kg	8.25	49.50	4.75	28.50	7.50	1.79
3	**Distance**	kg	8.83	53.00	4.17	25.00	4.00	2.33*
4	**Spinning in**	kg	9.50	57.00	3.50	21.00	0.00	2.87*
5	**Turning out**	kg	9.50	57.00	3.50	21.00	0.00	2.89*
6	**Grip strength**	kg	9.50	57.00	3.50	21.00	0.00	2.87*

***Tabular "Z" value at 0.05 significance = 1.962 *Mann Whitney peak at 0.05 = 7.00**

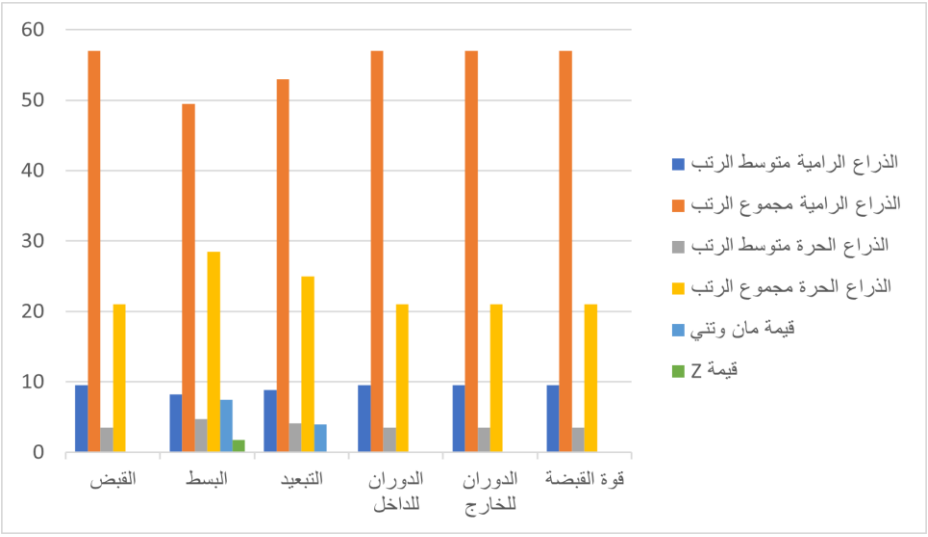

Figure 1: Significance of the differences between the throwing arm and the free arm in the muscular strength variables of javelin throwers

Table (7) shows that there are statistically significant differences between the muscular strength variables of both the throwing arm and the free arm of the javelin throwers in favor of the throwing arm, as the calculated "Z" value is greater than its tabular value at a significant level of 0.05, and there are no differences in muscular strength (extensor) as the calculated value of "Z" is less than its tabular value at a significant level.

These results are consistent with the study **of "Saif Harith Ibrahim and Mohammed Abdul Shaheed Hassan (2019),** which found that the development of arm strength has a direct and effective impact on developing the accuracy of the performance of the javelin throwing skill, as the results of the study showed that the use of strength endurance exercises contributed significantly to improving the motor and skill efficiency of athletes specialized in this event. (9:115)

Farraj Abdel Hamid Tawfiq (2004) **points out** that the movements of capture, distancing and turning inward are one of the most important basic movements involved in the implementation of the skill of throwing the javelin with high efficiency, and therefore the difference appears clearly and significantly in the level of strength of these movements between the arms, as a result of functional specialization and intensive training that the throwing arm is exposed to without the other. (15:98)

As for the absence of significant differences in the strength of the extension between the arms, it can be explained in the light of **what was stated by "Al-Beik, Ali Fahmy, and Imad Al-Din Abbas (2009)",** that the movement of extending the arm is not one of the basic movements or affecting mainly in directing and releasing the spear, but rather plays a secondary and auxiliary role compared to other more effective movements, such as capture, rotation and distance, in determining the accuracy and strength of the throw. (1:103)

The **researcher believes** that the results provide a clear picture of the nature of the functional adaptations that occur in the muscles responsible for the performance of the javelin throw. The statistically significant differences in most variables of muscle strength in favor of the arm reflect the effect of functional specialization of the muscle groups involved in performance, especially in the capture, distance and rotation movements that play a pivotal role in the speed and accuracy of javelin steering.

The researcher also points out that these results emphasize the importance of focusing on the development of muscle groups mainly involved in skill performance, especially the shoulder, humeral and forearm muscles responsible for the movements of arrest and rotation, with the need to pay attention to the muscular balance between the working muscles and the corresponding muscles.

The **researcher explains** that the absence of significant differences in the strength of the stretch between the arms

indicates the need to reconsider the training programs used to develop this muscle group, or it may be a positive indicator that reflects an appropriate muscle balance between the arms in this particular movement, which may contribute to the prevention of injuries associated with muscular imbalance. The **researcher** emphasizes On the importance of conducting further studies to determine the optimal ratios of muscle strength between the arms of the javelin throwers to ensure the highest level of performance while avoiding the risk of injuries.

Through these results, the **researcher sees** that anatomical measurements are one of the most important factors affecting physical performance and achieving the digital level because of their effects related to the physical, skill and mechanical aspects, so it is one of the most important foundations that play a major role in building sports training processes, as well as selecting juniors and directing them to various activities, and that each sports activity has its multiple requirements that must be available to their practitioners and that achieving results is largely related to what he possesses. The individual has characteristics that fit the nature of those requirements.

Conclusions:

Based on the results of this research, and through its findings using statistical treatments, it was possible to reach:

1. There are statistically significant differences in favor of the throwing arm in some anatomical changes in the circumference of the humerus, forearm and bone density, which indicates the effect of continuous sports training on the bone and muscle composition of this limb.
2. The throwing arm showed significantly higher values in muscular strength variables such as grip, dismissal, internal and external rotation and grip strength, reflecting the functional adaptation resulting from motor specialization in javelin throwing.
3. Higher bone density in the arm refers to the adaptive response of bones to repetitive mechanical stress, which reflects the importance of this type of training in strengthening the skeleton and reducing the risk of injuries.
4. The obvious differences between the arms indicate a pattern of anatomical and functional adaptation, which occurs as a result of allocating training loads to one party without the other during performance, which requires taking into account balance in training.
5. The free arm, despite its involvement in maintaining balance during performance, showed lower values in almost all the variables studied, underscoring its secondary role compared to the throwing arm in javelin throwing.

6. Overall, the findings underscore the potential of anatomical metrics as a foundational tool in optimizing training protocols and talent identification strategies in javelin throwing.

Recommendations:

1. The need to adopt anatomical measurements of the arms (throwing and free) as one of the main components in the design of training programs for javelin throwers, in a way that contributes to improving motor efficiency and achieving the best achievements.
2. Employ X-Ray and DXA techniques periodically to monitor structural changes in the arms, especially at the beginning and end of the training season, to support accurate training decisions.
3. The need to include specialized exercises to strengthen the core muscles of the throwing arm, such as the muscles of grasping, distraction and rotation, with a focus on achieving muscle balance between different muscle groups, in order to reduce the risk of chronic injuries resulting from repetitive stress during training and competition.
4. Pay attention to the free arm in training in a balanced manner to ensure that no dysfunction or anatomical imbalance may affect the stability of the athlete's overall performance during the throwing skill.
5. The results of anatomical measurements should be used as an aid in sports selection processes, to ensure that physical characteristics are compatible with the requirements of javelin throwing effectiveness in terms of strength, height and bone density.
6. Expanding similar studies involving other limbs and torso, with the aim of building an integrated database on anatomical changes resulting from javelin throwing, and developing more accurate training methodologies.

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