Biomechanical analysis of bilateral deficit phenomenon for upper limbs in Weight training

*Dr/ Hani Abdol Aziz Saleh

Introduction:

Garykamen, Gordon E, Rbertson, Graham E, Caldwell, Joseph Hamill, and Saunders N, Whittlesey (2004) see it as the duty of sport-related science to come up with the latest methods that can be used. To analyze and study sports movement, in order to determine the best form of performance can be performed in order to develop and improve the level of sports performance. (4: 1)

Ehab Abdel-Basir and Adel Abdel-Basir (2005) report that each part of the chain is equipped with a driving force, which is the strength of the muscles that can be fixed at the same time, thus changing the parts of the chain, thus changing the degree of freedom of movement. (2: 110 - 109)

Hani Abdulaziz (2019) also emphasizes that dynamic motor performance requires many special skills and each skill includes a set of performance and that the most effective way to improve and develop performance is kinetic analysis, where it requires determining the correct mechanical performance of the skill. (7:34)

The phenomenon of bilateral disability is one of the mathematical phenomena that have been studied from the perspectives of science related to sports for the purpose of interpretation. :

Reaction Time Deficit.

Mahmoud Qasim Ali (2009), citing Ohtsuki (1981), suggests that the deficiencies in the reaction time of the lower body can be explained by the fact that binary motion forces the activation of both hemispheres of the brain, whereas unilateral motion essentially requires a single hemisphere. The stimulus does not affect, he concludes, that bilateral delays in the reaction time of the upper body can be due to the fixation of the inner lobe of the brain that analyzes information and decision-making and that during the performance of bilateral action (BL) the central nervous system becomes interested not only in the reactionary task In hand but also in conjunction and coordinate movement of the parties This dispersion of the overall performance. (14: 7), (19: 8)

Aerobic performance deficits

* Assistant Professor in Sports Training and Movement Science Department, Faculty of Physical Education for (Men – Girls) in Port-Said, Port-Said University

☸Associate professor at Faculty of education – Physical Education & Movement Science Department, Al Qassem University, K.S.A

Glacier Ohtsuki (1981) points out that there is a decrease in the maximum volume of oxygen consumption when performing bilateral versus individual training, where the maximum volume of oxygen consumption during cycling with men was 23% greater than the maximum volume of oxygen consumption during cycling with one man. It is assumed that the maximum oxygen consumption is linked to muscular work, doubling the muscle size will lead to a doubling of the maximum volume of oxygen consumption, but this hypothesis has not been achieved, which indicates the existence of bilateral deficit. (19: 4)

Muscle Power Deficit

Glacier Ohtsuki (1981), in their choice of t-leg force during Bilateral BL, and UL (Unilateral), indicates that the force during tethering of the legs together (BL) is approximately 75% of the average total force produced during an intramuscular accident. In UL, the decrease in BL deficit reached 13: 25% and the reason for this deficit was explained by the incomplete motor unit (MU) activity in the muscle when both parties worked together. (19: 8)

Research importance and problem:

Through the researcher readings in the phenomenon of bilateral disability, and where addressed from more than a scientific point of view, the researcher has concluded to three possible causes of the phenomenon of secondary disability are either due to deficit or lack of reaction time, or deficit oxygen performance, or because of muscle power deficit. (14: 8)

However, to the knowledge of the researcher did not address the researchers to the mechanical causes of the phenomenon of bilateral disability and the contribution of biomechanics to the interpretation of this phenomenon.

The researcher believes that the performance angles may have an effect in the interpretation of the phenomenon of bilateral disability, so the researcher tried to explain the phenomenon of bilateral disability through biomechanical analysis, which may explain the existence of this phenomenon in athletes, which serves both theoretical and practical in training in various individual and collective sports.

Research Goals:

This study aims to explain and study the phenomenon of bilateral disability of the upper end during weight training from the standpoint of biomechanics through:

- Biomechanical analysis of the phenomenon of the second deficit.

- Determine the percentage of disability of the upper limb during weight training.

Research Hypothesis:

1- what is the mechanism of bilateral disability of the upper limb during weight training?

2- what is the ratio of bilateral disability of the upper end during weight training?

Research Terms:

1- Bilateral Deficit:

"It is the loss of power resulting from the performance of the two parties together (BL) than the sum of the forces produced at the performance of the unilateral parties." (14: 9)

Bilateral performance (BL):

"It is the work of both ends of the lower or upper part together when performing muscle strength exercises." (14: 9)

Unilateral performance (UL):

"It is the work of each end of the lower or upper part alone when performing muscle strength exercises." (14: 9)

Research Procedures:

1- Research Methodology

The researcher used the descriptive method using the survey method to suit the nature of the study.

2- Research Simple:

The main study sample was chosen by deliberate method from the players participating in Maximum Gym Club in Port Said. The sample included (4) players.

Table (1)

The Description of research sample (n=5)

			Measurement Unit	Mean	standard deviation	torsion coefficient
Growth rates	1	Tall	Cm	181.25	1.25	0.25
	2	Wight	Kg	72.75	0.95	0.855
	3	Age	Year	27.5	0.577	0.000
	4	training	month	18	0.81	0.000
Arms Force test	5	(Standing in front of the muscular strength device) Bend your arms high back toward the body	Kg	50.00	1.00	0.000
	6	(Standing in front of the muscular strength device) Bend one arm upward toward the body	Kg	27.00	1.00	0.000

From Table (1) it is clear that the values of the torsion coefficient for each of these variables (understudy) have been limited to (± 3), which indicates the moderation of the iterative curve of the study sample in these variables.

3- Data collection tools:

- Biomechanics Data collection tools:
Capture, 3D Video by Gopro hero4 black Camera (240fbs)

Figure (1) Gopro hero4 black

- Calibration cube 2*2*1

Table (2)
Dimensions of the calibration cube

	Camera 1	**Camera 2**
Camera distant from cube	6.73m	6.73m
Camera height	1.35m	1.35m
Distant between cameras	4.15m	
Camera`s angle	90°	90°

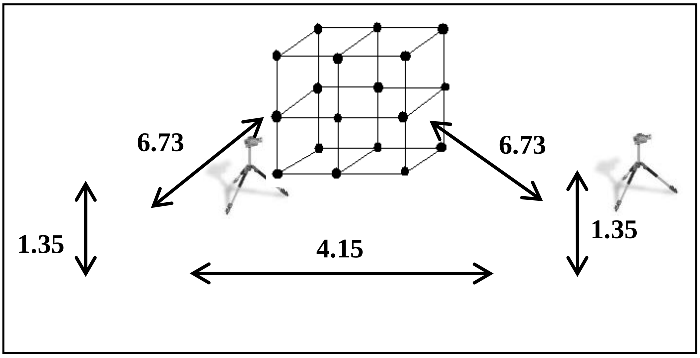
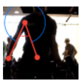
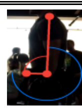
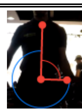
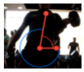
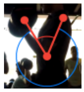


Figure (2) Dimensions of the calibration cube

- Biomechanics analysis by "Kinonea" software:
Biokinematics analysis system using real-time video camera and computer by Kinovea biomechanical analysis program, according to the proposed analysis model as shown in Figure (3)

Figure (3) analyzing the model

	Average body angles to measure bilateral disability (bilateral muscular work) of the study sample			Mean body angles scores for measuring bilateral disability (individual muscular work) of the study sample			
	Angle of Elbow	Trunk tilt angle forward and backward	Trunk tilt angle of both sides	Angle of Free arm	Angle of Elbow	Trunk tilt angle forward and backward	Trunk tilt angle of both sides
Phase one							

Phase two							
Phase three							

- Anthropometric Data collection tools

The methods and tools for data collection that are appropriate to the nature of the study were identified by looking at the scientific references, researches and previous studies.

- Restameter to measure the total length of the body.
- Medical balance device to measure the mass of the player.

4- Pilot Study:

The researcher conducted a pilot study to identify the conditions and problems that may face the researcher during the basic study and was implemented on Tuesday 23/7/2019, at Maximum Gym Club in Port Said. The survey was conducted on (1) players from one club. The survey aimed to identify:

- Dimensions for cameras.
- Visibility through cameras to facilitate later analysis.

And the pilot study achieved its objectives.

5- Basic study:

The basic study was carried out on Thursday 25/7/2019 at Maximum Gym Club in Port Said.

6- Statistical Treatments

The researcher used the program (Statistical Package for Social Science) (SPSS 20) (Statistical Package for Social Science) in the processing of data statistically using the appropriate statistical coefficients of the study.

7- Results:

1- Present the results:

This chapter includes the presentation and discussion of the results by studying the differences in the results of biomechanical analysis, in the light of the data and results of the measurements under study on the sample and based on the results of statistical analysis that are consistent with the nature of the current study. In the light of the study hypotheses, the researcher will present his findings as follows:

- Presentation of the data of the biomechanical variables under study:

- Degrees of body angles of angles under study and backward to measure bilateral disability (bilateral muscular work - individual muscular work) of the study sample:

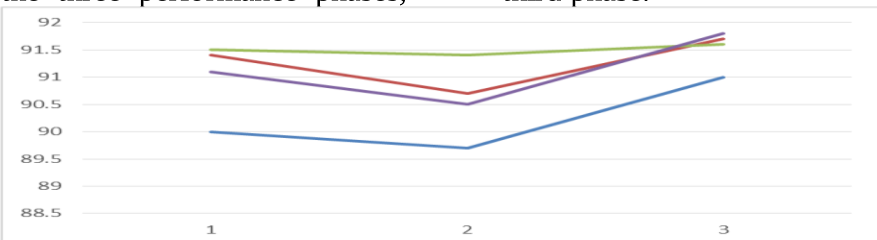
Table (3)

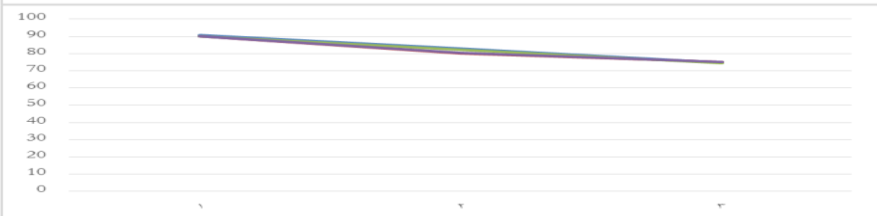
Body angles scores the body angle under study to measure bilateral deficits (bilateral muscle work - individual muscle work) of the study sample

Variables	Performance	Player 1	Player 2	Player 3	Player 3

	Phases	Angle of Free arm	Angle of Elbow	Trunk tilt angle forward and backward	Trunk tilt angle of both sides	Angle of Free arm	Angle of Elbow	Trunk tilt angle forward and backward	Trunk tilt angle of both sides	Angle of Free arm	Angle of Elbow	Trunk tilt angle forward and backward	Trunk tilt angle of both sides	Angle of Free arm	Angle of Elbow	Trunk tilt angle forward and backward	Trunk tilt angle of both sides
Bilateral muscular work	Phase one		١٥٦.٣	٩٢.٩	٩٠.٠		١٥٤.٩	٩١.٢	٩١.١		١٥٥.٠	٩٢.٠	٩٠.٠		١٥٤.٨	٩٠.٢	٩١.١
	Phase two		٨٨.٦	٩١.٠	٩٠.٨		٨٩.٤	٩١.٥	٩٠.٤		٨٨.٠	٩١.٢	٩٠.٤		٨٨.٩	٩١.٠	٩٠.٥
	Phase three		٥٢.٩	٩٠.٤	٩١.٠		٥٢.٤	٩٣.٠	٩١.٧		٥١.٠	٩٠.٢	٩١.٢		٤٨.١	٩٣.٨	٩١.٨
Individual muscular work	Phase one	٤٥.٠	١٤٨.٩	٩٠.٦	٩٠.٩	٤٦.٣	١٤٨.٦	٩٠.٨	٩٠.٠	٤٤.٨	١٤٩.٠	٩٠.٠	٩٠.١	٤٤.٢	١٤٨.٥	٩٠.٠	٩٠.٢
	Phase two	٤٦.٧	٩٤.٢	٩٠.٩	٨٢.٨	٤٦.٩	٩٣.٨	٩٠.٦	٨٠.١	٤٥.٦	٩٥.٢	٩٠.٣	٨٢.٤	٤٦.٧	٩٢.٥	٩٠.٠	٨٠.٣
	Phase three	٦٦.٩	٥٤.٠	٩١.٨	١٧٤.٩	٦٧.٠	٥٢.٩	٩١.٤	٧٥.٣	٦٨.٨	٥٤.٦	٩٢.٠	٧٤.٥	٦٦.٨	٥٣.٥	٩١.٤	٧٥.١

It is clear from Table (3) the angles of the body under study, where it is clear that the degrees of tilt angle of the sides of the work of the individual and bilateral muscle ranged between (91.8 - 74.5) during the three phases of performance, and the degrees of tilt angle of the front and back of the work of the individual muscle and bilateral ranged between (93.8 During the three performance phases, elbow angle degrees for individual and bilateral muscular work ranged from 165.3- 148.6 during the first phase, 95.2- 88.0 during the second phase, and 54.6- 48.1 during the third phase. The degrees of free arm angle for individual muscular work ranged between (44.2- 46.3) during the first phase, and (45.6) - 46.9) during the second phase, (68.8 - 66.8) during the third phase.





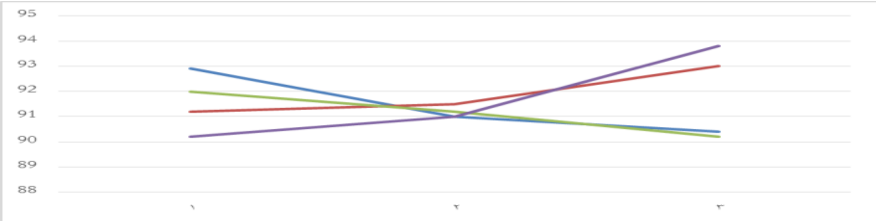


Figure (6) Trunk tilt angle forward and backward (Bilateral muscular action)

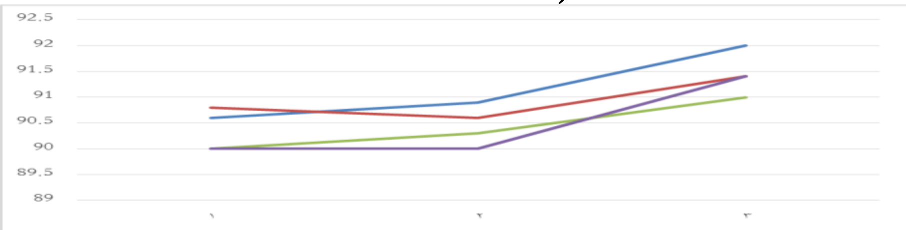


Figure (7) Trunk tilt angle forward and backward (Individual muscular action)

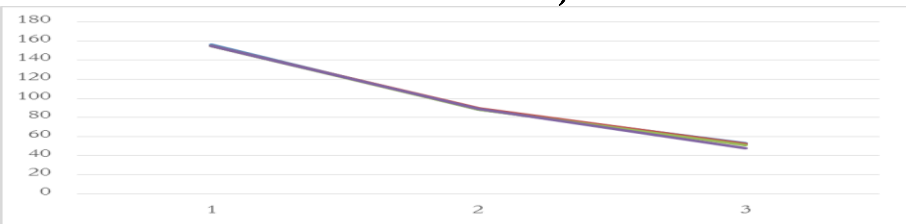


Figure (8) Angle of Elbow (Bilateral muscular action)

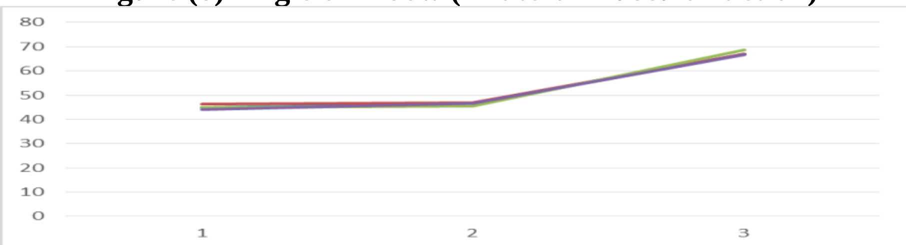


Figure (9) Angle of Elbow (Individual muscular action)

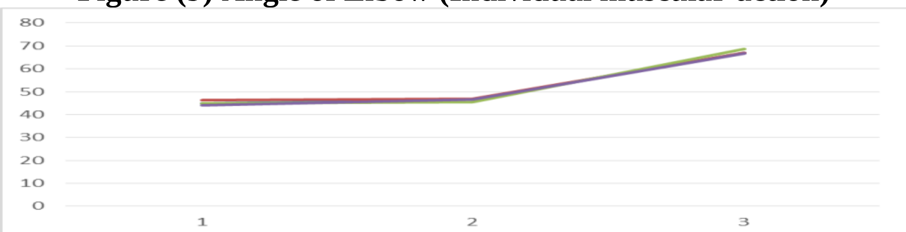


Figure (10) Angle of Free arm (Individual muscular action)

Average degrees of body angles:

Table (4)

Average degrees of body angles

	Average angles of the body (individual muscle action)				Average body angles (bilateral muscle action)		
	Angle of Free arm	Angle of Elbow	Trunk tilt angle forward and backward	Trunk tilt angle of both sides	Angle of Elbow	Trunk tilt angle forward and backward	Trunk tilt angle of both sides
Phase one	٤٥.٠٧	١٤٨.٠٧	٩٠.٣٥	٩٠.٣	١٥٥.٢٥	٩١.٥٧	٩٠.٥٥
Phase two	٤٦.٤٧	٩٣.٩٢	٩٠.٤٥	٨١.٤	٨٨.٧٢	٩١.١٧	٩٠.٥٢
Phase three	٦٧.٣٧	٥٣.٧٥	٩١.٦٥	٧٤.٩٥	٥١.١	٩١.٨٥	٩١.٤٢

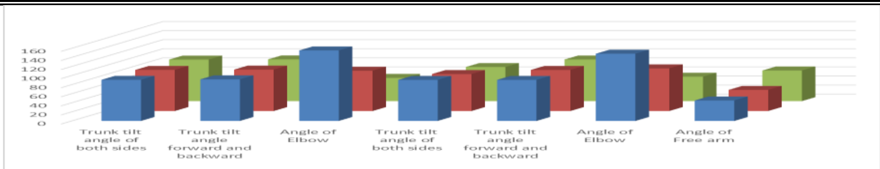


Figure (11). Average degrees of body angles

3- Significance of differences between the two measurements of angles under study to measure bilateral disability (bilateral muscular work - individual muscular work)

Table (5)

Wilcoxon Indication of differences between the two measurements of the angle of inclination of the trunk forward and backward (bilateral muscle work - individual muscle work)

	Phases	Mean Rank -	Sum of rank +	Mean Rank -	Sum of rank +	z	Significance
1	Phase one	0.00	2.50	0.00	10.0	-0.826	0.068
2	Phase two	1.00	3.00	1.00	9.00	-1.461	0.144
3	Phase three	1.75	3.25	3.50	6.50	0.552	0.581

Table (6)

Wilcoxon Indication of differences between the two measurements of the angle of Trunk tilt angle of both sides (bilateral muscle work - individual muscle work)

	Phases	Mean Rank -	Sum of rank +	Mean Rank -	Sum of rank +	z	Significance
1	Phase one	1.50	2.93	1.50	8.50	-1.300	0.194
2	Phase two	0.00	2.50	0.00	10.0	-2.121	0.043*
3	Phase three	0.00	2.50	0.00	10.0	-2.121	0.043*

* Means the presence of statistically significant differences at the level of significance (0.05)

Table (7)

Wilcoxon Indication of differences between the two measurements of Angle of Elbow (bilateral muscle work - individual muscle work)

	Phases	Mean Rank -	Sum of rank +	Mean Rank -	Sum of rank +	z	Significance
1	Phase one	0.00	0.50	0.00	10.0	-1.841	0.6
2	Phase two	2.50	0.00	10.0	0.00	-1.841	0.66
3	Phase three	2.50	0.00	0.0	0.00	-1.826	0.68

- Percentage of bilateral disability (bilateral muscular work - individual muscular work) of the study sample:

The amount of bilateral deficit is calculated by the following equation:

$$BLD\ (\%) = \left(100 \times \frac{bilateral\ performance}{right\ unilateral + left\ unilateral}\right) - 100$$

Table (8)

Percentage of bilateral disability (bilateral muscular work - individual muscular work) of the study sample

		Maximum strength of bilateral muscular action	Maximum strength of individual muscular work	The difference between the maximum strength	Bilateral Percentage
1	Player 1	50	54	4	
2	Player 2	50	54	4	
3	Player 3	50	54	4	
4	Player 4	50	54	4	
	Mean	50	54	4	8%

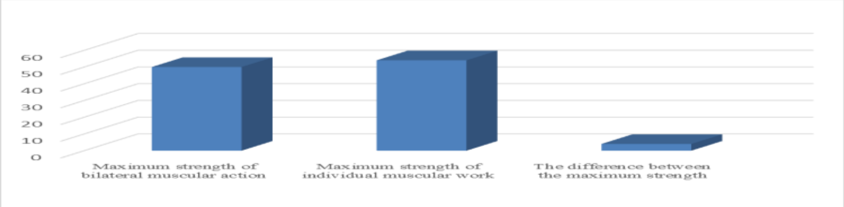


Figure (12). Percentage of bilateral

Discussion of the results:

Discussion of the results of the first Question:

"What is the mechanism of bilateral disability in the upper limb during weight training?"

It is clear from Table (5) that there are no statistically significant differences between the angles of the tilt of the trunk forward and backward between bilateral muscle work and individual muscle work.

Table (4) shows that the average inclination angle of the trunk forward and backward during bilateral muscle work in the first phase 91.75° and in the second phase 91.17° and in the third phase 91.85°, while the average angle of inclination of the trunk forward and backward during the individual muscle work in the first phase 90.35° in the second phase 90.45° and in the third phase 91.65°

The researcher attributes this to the player's tightening of the muscles of the back, abdomen, shoulder and chest belt, which reduces the tendency of the trunk forward or back in an attempt to overcome the resistance encountered during lifting the weight, whether with arms or one arm, which leads to not tilt the trunk forward or back in all From individual and bilateral muscular work, consistent with Otoski (1981) (19), Vanderfort et al. (1984) (23).

As shown in Table (7), there are no statistically significant differences between the angles of the elbow during the individual muscular work and the individual muscular work, as Table (4) shows that the average angle of inclination of the elbow during the bilateral muscular work in the first phase 155.25° and in the second phase In phase III 51.1°, the average inclination angle of the elbow during individual muscular work in phase I was 148.07°, in phase II 93.92° and in phase III 53.75°.

The researcher attributes this to the fact that the player seeks the maximum contractility of the muscular biceps Muscle Biceps Muscle, which is consistent with both Mohammed Al-Angari, Mohammed Deif (2016) (1), and Hani Abdul Aziz (2019 AD) (7) that the elbow joint has only two degrees of freedom DOF namely Tide and flexion is also considered to be a joint and characterized by the movement of large movement with reduced amount of loss of force during the movement of the joint.

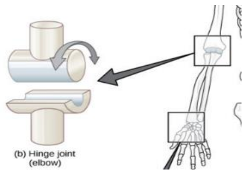


Figure (13) Elbow joint

The test used to measure the bilateral disability of the upper limb during weight training requires the player to reach the maximum muscle contractility of the joint, and was excluded attempts that did not reach the elbow joint to the maximum extent.

Consistent with Vander Fort et al. (1987) (24), Carnell Andrew et al. (2012) (3), and Jacob Scarabout et al. (2016) (10) in that it is a condition of measuring bilateral disability and the joint's arrival of its maximum contraction.

The researcher attributes this to the fact that the length of the arc that moves the gravity is almost equal in both bilateral muscle work and individual muscle work as shown in Table (9).

Table (9)
Percentage of bilateral disability (bilateral muscular work - individual muscular work)

	Body Length	Upper Arm Length	Angle Degree		Radian		Bow length	
			Bilateral	Individual	Bilateral	Individual	Bilateral	Individual
Player 1	180	28.26	106.7	95	1.862	1.658	52.63	46.86
Player 2	181	28.41	104	94.4	1.815	1.647	51.58	46.82
Player 3	182	28.57	102.4	95.7	1.670	1.670	51.07	47.73
Player 4	182	28.57	103.4	94.9	1.656	1.656	51.57	47.33
Mean	181.25	28.4	104.12	95	1.658	1.658	51.71	47.18

As shown in Table 9, the average length of the arc in bilateral muscular work was 51.71 cm and in individual muscular work was 47.18 cm, which caused no differences in the angle of the elbow joint during the measurement of bilateral deficits under study, consistent with Howard et al. (1991) (9), Gordon et al. (2004) (4) that angular muscular work is highly correlated with the length of the arc that the body travels where it is the work piece of performance.

As shown in Table (6), there are no statistically significant differences between the tilt angles of the torso forward and backward between individual muscle work and individual muscle work during the first stage of performance.

Table (4) shows that the average inclination angle of the torso for both sides during bilateral muscular work in the first stage is 90.55°, while the average inclination angle of the sides during the individual muscular work in the first stage is 90.30°.

The researcher attributes this to the fact that the starting position in both individual muscle work and bilateral muscle work is similar, there is no difference or mechanical differences in the starting position during this stage, which is proved by the results of Table (4).

As shown in Table (4) there is a relative stability in the angle of inclination of the trunk of the sides during bilateral muscular work, where in the first stage 90.55° and in the second stage 90.52° and in the third stage 91.42°.

The researcher attributed this to the fact that the distribution of weight evenly on both ends of the body led to the balance of the body during the performance and stability of the body shape, which is consistent with Abdulrahman Al-Angari and Mohammed Deif (2016) (1), and Matukoski et al. (2011) (15) to be equivalent to external forces acting On the body lead to the balance of the body and gain motor stability.

As shown in Table (6) there are statistically significant differences between the angle of the torso tilt for both sides to measure bilateral disability during individual muscle work in the second and third stages of performance, where Table (4) shows that the average angle of tilt of the sides during the individual muscle work in the second stage 93.9°, and in the second stage 53.75°.

The researcher attributes the different angles due to the inclination of the trunk towards the working arm, as an automatic reaction to engage the chest and shoulder muscles in the muscular work in order to overcome the resistance of gravity.

This is consistent with Henry Smith et al. (1961) (8) and Hackenen et al. (1995) (6) that the muscles involved in weight lifting are directly related to the motor nerves responsible for them, and that the muscle reaction is a way to overcome Resistance to muscle.

This is also consistent with Usha Kuru Ganti (2011) (21) and Hani Abdulaziz (2019) (7) in that the muscle contraction starts from the arrival of the neuronal signal through the motor unit, which is directly related to the brain and thus the neurological reactions resulting from the brain.

This gives preference to individual muscular work, which is consistent with Moorhouse et al. (2000), (17) and Ouda et al. (1994) (18). The attention of the player and the dispersion of nerve signals during bilateral muscular work.

As shown in Table (4), the angle of the free arm during the individual muscular work gradually increases in the stages of performance, reaching the average angle of inclination of the free arm during the individual muscular work in the first stage 45.07°, the second stage 46.47°, and in the second stage 76.37°. It is also evident that there is no free arm during bilateral muscle work, because both arms are involved in overcoming gravity.

The researcher believes that this is a major factor in the existence of the phenomenon of bilateral disability, since the free arm is considered in this case as a mechanical tool that works to help the player's body to overcome the resistance it faces on the other arm.

It is clear from Table (9) that the length of the bow that the lever arm crossed was about 47.18 m in individual muscular work, whereas in bilateral muscular work was 51.71 cm. Reduce the arc that cuts the weight and thus the ability of the muscle to exert greater strength during individual muscle performance.

The length of the arc and the multiplication of the force exerted in order to calculate the work done shows that the work done during the individual muscle work is less than in the work of the bilateral muscle work, which in turn gives preference to the work of the individual muscle work.

Discussion of the results of the second Question:

"What is the ratio of the upper limb bilateral disability during weight training?"

As shown in Table (8), the ratio of bilateral disability to (8%) of the total muscle strength exerted, as the average maximum strength of the upper limb during bilateral muscle work (50 kg), while the maximum strength of the upper limb of individual muscle work (27 kg) (54 kg) for the arms.

Bilateral deficits were between 6% and 18% in many studies, consistent with the results of each Kwakami study (1998) (12), Jacob Shelbeck (2001) (11), Kudogian et al (2003) (13), Zigdwing (2007) (25), and Jacoby et al. (2016) (10).

Conclusions and recommendations:

Conclusions:

Based on the results of the research and in the light of the objective and hypotheses of the research, the researchers reached the following conclusions:

- Determine the percentage of bilateral disability of the muscular work of the upper limb by about (8%).
- the angle of inclination of the trunk of both sides is a major factor in the phenomenon of bilateral disability.
- The angle of the free arm is a major factor in the phenomenon of bilateral disability.
- Both the free arm and the torso inclination of both sides are factors that give preference to individual muscular work.
- the greater the length of the bow that the arm cuts during muscle work, which leads to the emergence of bilateral disability.

recommendations

Based on the Conclusions of the research and the conclusions reached, the researchers recommend the following:

- Study of the phenomenon of bilateral disability of the lower limb.
- Observe the tilt angle of the torso during training to overcome the phenomenon of bilateral disability.
- Observe the angle of free arm inclination during training to overcome the phenomenon of bilateral disability.
- Work to increase the length of the arch and increase the angle of muscle work during training the upper limb to overcome the phenomenon of bilateral disability.
- Use the equation

$$BLD\,(\%) = \left(100 \times \frac{bilateral\ performance}{right\ unilateral + left\ unilateral}\right) - 100$$

" to calculate the phenomenon of bilateral disability.

References:

1- Abdul Rahman Al Anqary, Mohamed deef:

(2016): Sports biomechanics physical activities, saud Uni. Publisher, Saudi Arabia.
2- Adel & Ehab Abdel Baser. (2005): Biomechanical analysis theory and application in spoerts, Al Motahedah Publication, Port Said.
3- Cornwell, Andrew & Khodiguian, Nazareth & Yoo, Eun. (2012): Relevance of hand dominance to the bilateral deficit phenomenon. European journal of applied physiology. 112. 10.1007/ s00421-012-2403-z.
4- D,Gordon E,Rbertson, Gary kamen, Graham E, Caldwell, Joseph Hamil, Saunders- N, Whittlesey: (2004): Research Methods in Biomechanics, Human Kinetics publisher ; Champaign.
5- Essam helmy, Gaber bureqaa: (1997): Sports Training, Dar Al Fekr Al Araby, Egypt.
8- Ha¨kkinen K, Pastinen UM, Karsikas R, Linnamo V (1995) Neuromuscular performance in voluntary bilateral and unilateral contraction and during electrical stimulation in men at different ages. Eur J Appl Physiol 70:518–527
9- Hani Abdul Aziz Saleh: (2019): Principles of Kinesiology, Al-Mutanabbi Publishing and Distribution House, Dammam, Saudi Arabia.
10- Henry FM, Smith LE (1961): Simultaneous vs. separate bilateral muscular contractions in relation to neural overflow theory and neuromata specificity. Res Q Exerc Sport 32:42–46
11- Howard J, Enoka R: (1991) Maximum bilateral contractions are modified by neurally mediated interlimb effects. J Appl Physiol 70:306–316.
12- Jakob Škarabot, Neil Cronin, Vojko Strojnik & Janne Avela: (2016): Bilateral deficit in maximal force production, Arbeits physiologie
13- Jakobi JM, Chilibeck PD (2001): Bilateral and unilateral contractions: possible differences in maximal voluntary force. Can J Appl Physiol 26:12–33
14- Kawakami Y, Sale DG, MacDougall JD, Moroz JS (1998): Bilateral deficit in plantar flexion: relation to knee joint position, muscle activation, and reflex excitability. Eur J Appl Physiol 77:212–216
15- Khodiguian N, Cornwell A, Lares E, DiCaprio PA, Hawkins SA (2003) Expression of the bilateral deficit during reflexively evoked contractions. J Appl Physiol 94:171–178
16- Mahmoud Qasim: (2009), "the impact of various resistance exercises to alleviate bilateral disability and some physical, motor and skill capabilities of volleyball players," Unpublished Master Thesis, College of Basic Education - University of Mustansiriya, Baghdad.
17- Matkowski B, Martin A, Lepers R (2011): Comparison of maximal unilateral versus bilateral voluntary contraction

force. Eur J ApplPhysiol 111(8):1571–1578

18- Mohamed Moneer: (2003), Effect of some of the methods of "lengthening - shortening" on the muscle capacity of the two men for volleyball players ", Master Thesis, unpublished, Faculty of Physical Education, Banha Branch, Zagazig University

19- Morehouse SA, Szeligo F, DiTommaso E (2000) Characteristics of the bimanual deficit using grip strength. Laterality 5(2):167–185

20- Oda S, Moritani T (1994) Maximal isometric force and neural activity during bilateral and unilateral elbow flexion in humans. Eur J Appl Physiol 69:240–243

21- Ohtsuki T (1981): Decrease in grip strength induced by simultaneous bilateral exertion with reference to finger strength. Ergonomics 24:37–48

22- Rejc E, Lazzer S, Antonutto G, Isola M, di Prampero PE (2010) Bilateral deficit and EMG activity during explosive lower limb contractions against different overloads. Eur J Appl Physiol 108(1):157–165

23-Usha Kuruganti, Tiernan Murphy, Trevor Pardy: (2011): Bilateral deficit phenomenon and the role of antagonist muscle activity during maximal isometric knee extensions in young, athletic men, European Journal of Applied Physiology, Volume 111,

24- Van Diee¨n JH, Ogita F, De Haan A (2003): Reduced Neural drive in bilateral exertions: a performance limiting factor? Med Sci Sports Exerc 35(1):111–118

1- Vandervoort AA, Sale DG, Moroz JR (1984) Comparison of motor unit activation during unilateral and bilateral leg extension. J Appl Physiol 56:46–51.

25- Vandervoort AA, Sale DG, Moroz JR (1987): Strength-velocity relationship and fatigability of unilateral versus bilateral arm extension. Eur J Appl Physiol 56:201–205

26- Zijdewind I (2007) Reduced cortical activity during maximal bilateral contractions of the index finger. Neuroimage 35(1):16–27