Biomechanical analysis for Egyptian Women's Hammer throw national team Participating in Arab Athletics Championships U23

***Mohamed Abdel Raouf Diab**

***Assistant Professor, Department of sports training - Faculty of Physical Education – Mansoura University**

Introduction:

The hammer overthrow competition is one of the complex and difficult competitions due to the nature of the skill perforlegce, which requires the exploitation of the forces of all parts of the body in order to reach the hammer to the maximum speed at the moment of its release, and the movement begins with the perforlegce of preparing swingss and then the perforlegce of three or four turns, with the aim of gradually increasing the speed of the hammer until the moment of throwing.(1), (9), (10)

The success of the throw in achieving the best possible distance depends on the ability to reach the hammer to the highest possible speed and at an appropriate release angle, as the hammer speed gradually increases during turns, which takes place through the sequence between the duble support (pushing the ground) and the single support (rotation) during each turn, where the hammer rises upwards towards the highest point during the single support while decreasing to the lowest level during the duble support. (6)

Due to the complexity of hammer throwing and the rare practitioners in Egypt, in addition to the scarcity of scientific studies that have deal with it, coaches face significant challenges in improving the technical perforlegce of Egyptian female players. Despite Egypt's regional, Arab and African leadership in this competition, there is an urgent need to analyze the technical perforlegce of Egyptian female athletes participating in international and Arab championships, to identify strengths and weaknesses and guide coaches to develop training programs based on scientific foundations.

Within the framework of cooperation between the institutions based on the legagement of Egyptian sports and scientific institutions based on scientific research, the Egyptian Athletics Federation has established a unit for measurement and evaluation to work on photographing and analyzing the perforlegce of Egyptian players participating in national teams in various age phases in order to evaluate their sports perforlegce scientifically in order to identify strengths and work to support them, and monitor weaknesses to Avoid and treat them by developing appropriate training programs for each player to reach the best possible sports levels.

And through the presence of (the researcher) technical director of the national teams with the Egyptian delegation participating in the first Arab championship for athletics U23 years, which was held in Tunisia during the period from 18 to 25 May 2023.

This research aims to analyze the biomechanical perforlegce of Egyptian athletes participating in the Arab Athletics Championship under 23 years, **identify the strengths and weaknesses** in the technical perforlegce of Egyptian athletes compared to their Arab colleagues, **compare the Egyptian perforlegce with international levels** to identify technical gaps, **provide practical recommendations** for the development of training programs directed to improve perforlegce, **Strengthening the practice** base of hammer throwing at the local level, based on the results of scientific analysis.

Search Procedures

The study was conducted during the first Arab U-23 Athletics Championship, which was held in Tunisia from 18 to 25 May 2023, and the women's hammer throw competition was filmed using a Sony video camera with a frequency of 240 frame/sec to film all attempts, and the best attempt was selected for each athlete in terms of the achieved record level and subjected to biomechanical analysis procedures, using the Dartfish TeamPro4 kinetic analysis program. to analyze the variables under study for each attempt.

Research sample:

The research sample included all the players participating in the hammer overthrow competition, and their number is eight players from the following countries (two Egyptian players, two Tunisian players, two Algerian players, an Iraqi player, a Saudi Arabia player), and the best attempt was chosen for each player to conduct the kinematic analysis.

Table (1) the achieved record levels of the research sample in the championships

M	Player Name	Country	Verified Number	Order	Personal Record
1	Rawan Ayleg	Egypt	60.25 m	The first	67.40
2	Senda Guerma	Tunisia	55.87 m	Second	55.87
3	Nada Solileg	Egypt	55.29 m	Third	58.34
4	Fatma Zahra Tajin	Algeria	53.81 m	Fourth	53.81
5	Zmorda Hajji	Tunisia	m48.61	Vfifth	48.61
6	Marwa Qais	Iraq	45.78 m	Sixth	47.95
7	Fatima Zahra Ben Hlel	Algeria	44.34 m	Sdubleth	44.34
8	Arij Mehdi	Saudi Arabia	40.49 m	Eighth	40.49

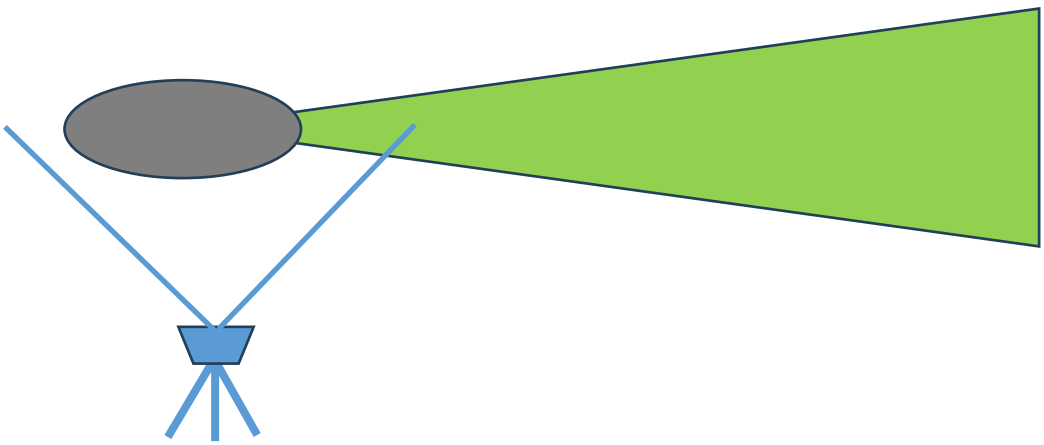


Figure (1)

Shows where cameras are placed during capture

Kinematic variables under study:

By reviewing the foreign studies of this competition (5), (8), (12), (13), (14), the most important biokinematic variables were identified, through which the level of skill perforlegce of local contestants can be evaluated more clearly and were represented in the following:

Table No. (2)
Shows the biomechanical variables under study

M	phase	Variable	Unit of measurement
1	Number of Turns		--
2	Throwing hand		--
3	**Preparing phase**	Preparing swingstime	S
4	**The Four Turns**	Double Support time 1 , 2, 3, 4	S
5		Single Support time 1 , 2, 3, 4	S
6		Lowest hammer height 1 , 2, 3, 4	M
7		Highest height of hammer 1 , 2, 3, 4	M
8		Angle of inclination of the hammerturn ،3 ،2 ، 1 level 4	deg
9		Right knee angle 1 , 2, 3, 4	deg
10		Left knee angle 1 , 2, 3, 4	deg
11		Angle of inclination of the trunk 1 , 2, 3, 4	deg
12	**Hammer Release**	The horizontal speed of the hammer at the moment of release	m/s
13		the hammer at the moment of The vertical speed of release	m/s
14		The speed of the hammer at the moment of release	m/s
15		angle of release	You
16		Lowest point before release	M
17		Height of the release point	M
18		release time	S
19		Starting path angle	You

- **Results:-**

Table (3)
the variables of the praparing phase and the times of support

M	Variables		Unit of measurement	1	2	3	4	5	6	7	8	Average	Standard deviation
Achieved distance			**m**	**60.25**	**55.87**	**55.29**	**53.81**	**48.61**	**45.78**	**44.34**	**40.49**	**50.56**	**6.78**
1	Turns Number of		**--**	4	4	4	**3**	4	**3**	**3**	**3**	**--**	**--**
2	Throwing hand		**--**	R	R	R	R	R	R	R	R	**--**	**--**
3	time Preparing swings		**s**	2.694	2.769	2.610	2.577	3.128	2.719	2.485	2.761	**2.72**	**0.19**
4	Double Support time	**Turn 1**	**s**	0.475	0.583	0.508	0.350	0.500	0.433	0.483	0.475	**0.48**	**0.07**
		Turn 2	**s**	0.316	0.383	0.316	0.258	0.408	0.316	0.367	0.350	**0.34**	**0.05**
		Turn 3	**s**	0.250	0.283	0.291	0.258	0.266	0.283	0.291	0.225	**0.27**	**0.02**
		Turn 4	**s**	0.233	0.233	0.285	--	0.233	--	--	--	**0.12**	**0.13**
5	Single Support time	**Turn 1**	**s**	0.350	0.592	0.275	0.316	0.325	0.392	0.308	0.325	**0.36**	**0.10**
		Turn 2	**s**	0.316	0.283	0.250	0.291	0.275	0.325	0.266	0.325	**0.29**	**0.03**
		Turn 3	**s**	0.258	0.258	0.233	0.283	0.266	0.325	0.291	0.333	**0.28**	**0.03**
		Turn 4	**s**	0.250	0.266	0.241	--	0.300	--	--	--	**0.13**	**0.14**

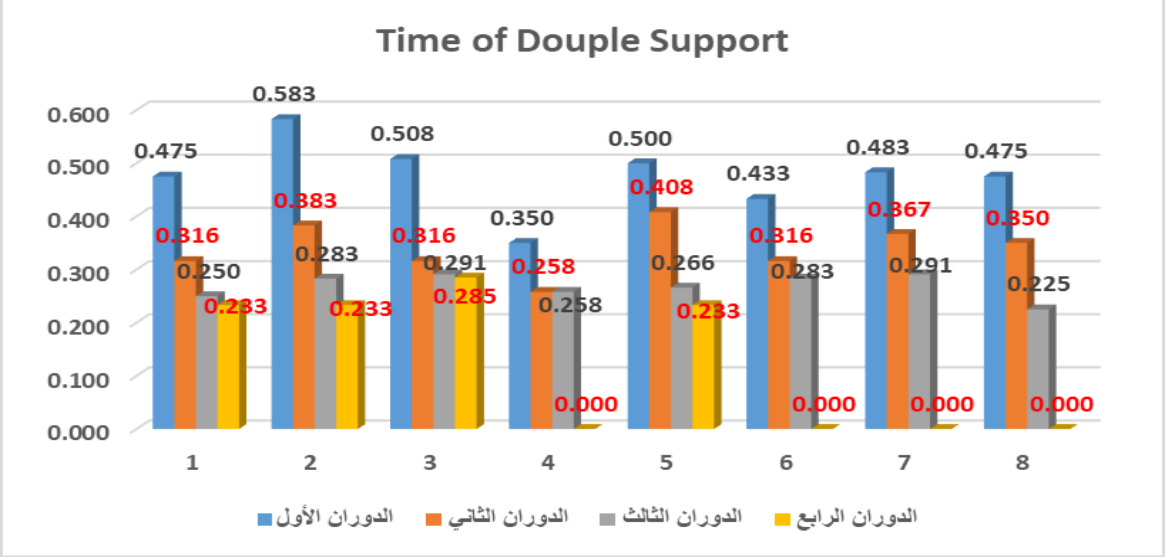


Table (4)
the variables of the angles of the right and left knee and the angle of the trunk during the four Turns

M	Variables		Unit of measurement	1	2	3	4	5	6	7	8	Average	Standard deviation
Achieved distance			m	60.25	55.87	55.29	53.81	48.61	45.78	44.34	40.49	50.56	6.78
6	Right knee angle	Turn 1	deg	66.3	71.1	64.5	58.4	60.0	80.6	72.1	57.2	66.28	8.01
		Turn 2	deg	46.6	77.6	57.3	84.1	56.3	67.2	71.1	48.6	63.60	13.59
		Turn 3	deg	38.9	64.2	54.0	53.3	43.8	60.0	65.0	52.8	54.00	9.22
		Turn 4	deg	46.0	56.3	60.4	--	45.3	--	--	--	26.00	28.23
7	Left knee angle	Turn 1	deg	110.9	105.5	117.3	118.2	99.9	117.0	115.2	112.7	112.09	6.46
		Turn 2	deg	107.3	110.8	98.9	119.0	132.5	105.7	123.6	123.3	115.14	11.26
		Turn 3	deg	113.6	94.8	121.1	130.5	127.5	111.3	124.3	116.8	117.49	11.32
		Turn 4	deg	116.0	120.7	106.1	--	136.0	--	--	--	59.85	64.50
8	Trunk Angle	Turn 1	deg	35.1	39.9	31.8	17.8	43.0	25.1	31.9	16.9	30.19	9.59
		Turn 2	deg	17.3	25.3	13.5	12.6	20.8	17.4	17.5	18.1	17.81	3.99
		Turn 3	deg	9.9	20.4	5.7	17.2	21.7	20.1	12.3	15.5	15.35	5.66
		Turn 4	deg	12.3	13.9	11.4	--	19.4	--	--	--	7.13	7.97

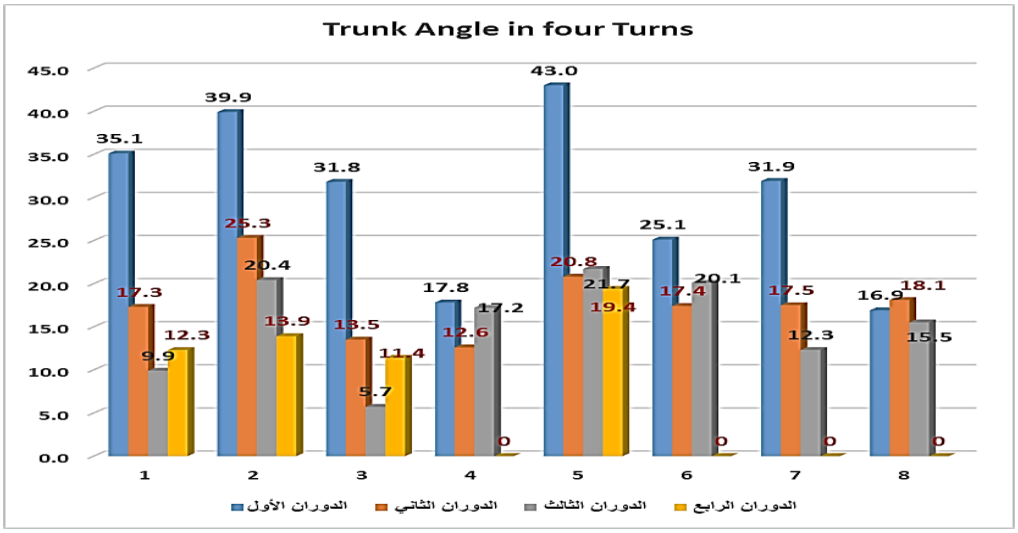


Table (5)
the variables of hammer heights and the inclination of the four Turns

M	Variables		Unit of measurement	1	2	3	4	5	6	7	8	Average	Standard deviation
Achieved distance			m	**60.25**	**55.87**	**55.29**	**53.81**	**48.61**	**45.78**	**44.34**	**40.49**	**50.56**	**6.78**
9	Minimum hammer height	Turn 1	m	0.32	0.29	0.40	0.27	0.28	0.24	0.38	0.31	**0.31**	**0.05**
		Turn 2	m	0.18	0.44	0.37	0.21	0.38	0.38	0.56	0.27	**0.35**	**0.12**
		Turn 3	m	0.10	0.24	0.27	0.20	0.24	0.27	0.42	0.16	**0.24**	**0.09**
		Turn 4	m	0.03	0.07	0.13	--	0.13	--	--	--	**0.05**	**0.06**
10	Highest hammer height	Turn 1	m	1.89	1.60	1.87	2.35	1.74	2.19	1.97	2.14	**1.97**	**0.25**
		Turn 2	m	2.31	2.00	2.16	2.41	2.09	2.26	2.25	2.20	**2.21**	**0.13**
		Turn 3	m	2.46	2.28	2.29	2.42	2.27	2.44	2.41	2.34	**2.36**	**0.08**
		Turn 4	m	2.47	2.46	2.42	--	2.31	--	--	--	**1.21**	**1.29**
11	Angle of inclination of the hammer turn plane	Turn 1	you	31.0	29.6	44.4	45.1	32.3	42.0	36.9	40.0	**37.66**	**6.14**
		Turn 2	you	39.5	32.7	44.6	45.5	33.0	35.1	43.4	35.3	**38.64**	**5.30**
		Turn 3	you	43.5	38.2	42.3	47.2	38.9	40.5	54.3	42.0	**43.36**	**5.24**
		Turn 4	you	44.0	44.5	45.1	--	42.8	--	--	--	**22.05**	**23.58**

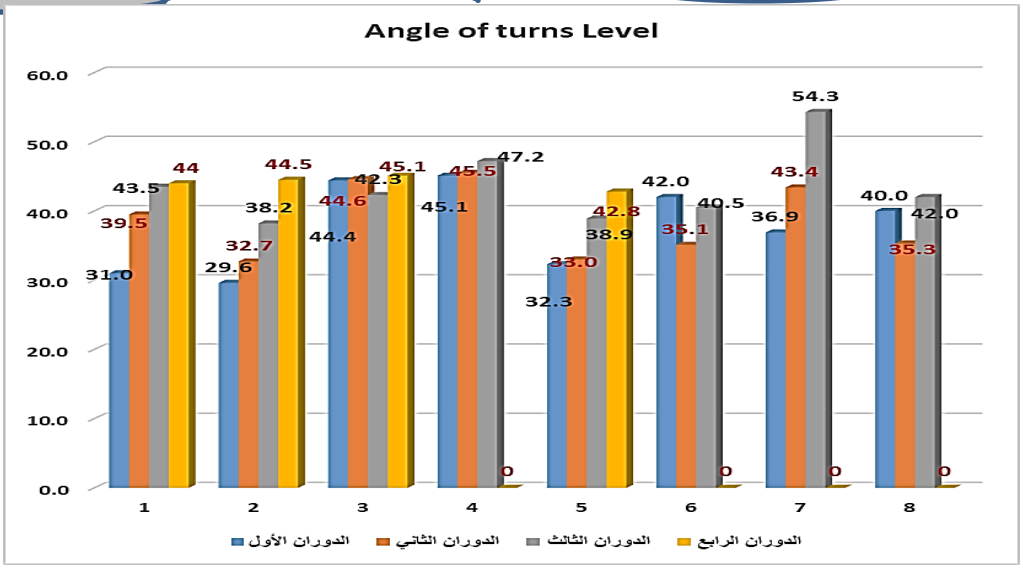
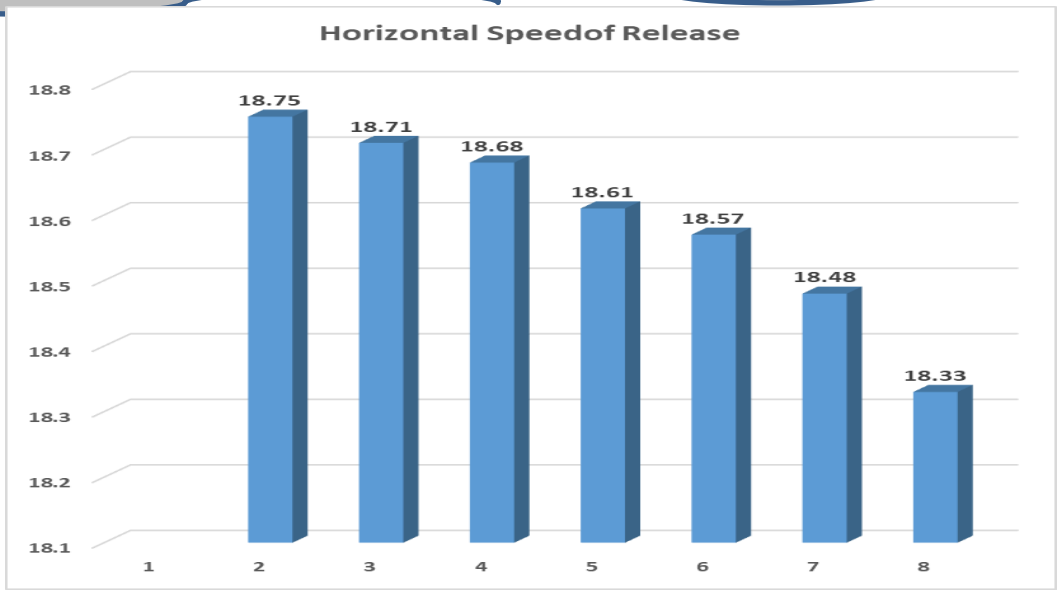


Table (6)
Variables of Release

M	Variables	Unit of measurement	1	2	3	4	5	6	7	8	Average	Standard deviation
Achieved distance		m	**60.25**	**55.87**	**55.29**	**53.81**	**48.61**	**45.78**	**44.34**	**40.49**	**50.56**	**6.78**
12	The horizontal speed of the hammer at the release moment of	m/s	20.00	18.75	18.71	18.68	18.61	18.57	18.48	18.33	**7718.**	**520.**
13	The vertical speed of the hammer at the moment of release	m/s	21.25	20.00	21.25	20.00	18.75	18.75	18.75	17.50	**19.53**	**1.33**
14	The speed of the hammer at the release moment of	m/s	29.18	27.41	28.31	27.37	26.42	26.39	26.33	25.34	**0927.**	**231.**
15	of releaseangle	you	47.1	46.4	48.0	44.4	44.0	44.9	44.5	41.5	**45.10**	**2.04**
16	Lowest point release before	m	0.02	0.09	0.10	0.20	0.08	0.15	0.20	0.03	**0.11**	**0.07**
17	Height of the point release	m	2.31	2.31	2.00	2.50	1.64	1.92	2.32	1.65	**2.08**	**0.33**
18	time release	s	0.266	0.291	0.258	0.300	0.233	0.266	0.258	0.275	**0.27**	**0.02**
19	Starting path angle	you	45.3	44.7	45.5	54.4	37.4	38.8	47.6	36.0	**43.71**	**6.09**



Discussion :

Table (3) shows that four players threw from four rounds (the top three players plus the fifth-placed player), while the other four players threw from only three rounds (the top three finishers plus the fourth-placed player).

As can be seen from the same table, the preparing swings times for the eight players in the research sample ranged between (2.485: 3.128 s) and the references indicate that the non-high-speed preparing swings help in better control of the tool during turns. (13)

The high speed at this phase is considered a weakness and not a force to control the tool in the following phases, that legy researchers ignore the preparing swings phase in general, while the best throwers complete at this phase a percentage of (13%) of the maximum force of the beginning of the turn while the lowest level players complete (17%) of the maximum force of the beginning of the turn. (2)

From Table (3), it is clear the gradual decline of the doubles support time for all members of the sample, where the Egyptian player ranked first (0.475, 0.316, 0.250, 0.233 s) respectively, while the Egyptian player with third place was the times (0.508, 0.316, 0.291, 0.285 s) respectively.

The references indicate that the contestant who achieves (77.90 m) has doubles support times (0.32, 0.32, 0.28, 0.24 s), while who achieves a numerical level of (70.93 m) had doubles support times (0.30, 0.36, 0.30, 0.28 s), which confirms the bad start for all members of the sample. (8)

The importance of the double support during turns is that the phase in which the earth is pushed to increase the speed of the next turn,so when the support time decrease, the speef of the push movement increase as aresult the speed of the next turn increase.

Through the same table, we find that the single support time variable took the same decreasing curve for the Egyptian player in first place, where it was (0.350, 0.316, 0.258, 0.250 s) respectively, while the Egyptian player with the third place had decreasing times until the third round, while the fourth round rose (0.275, 0.250, 0.233, 0.241 s) respectively.

The reviewer confirms that the contestant who achieves (77.90 m) has single support times of (0.28, 0.24, 0.24, 0.24 s), while those who achieve a numerical level of (70.93 m) had single support times (0.32, 0.32, 0.30, 0.26 s).). (8))

It is clear from Table (4) that the angle of the left knee of the leg did not take a clear curve, whether by increase or decrease, as the angle was at the Egyptian player with the first place (110.9, 107.3, 113.6, 116.0 º) while the Egyptian player with the third place was (117.3, 98.9, 121.1, 106.1 º).

The references indicate the need to work to increase the flexion of the knee of the support leg from one turn to another to resist the increasing centrifugal during the increase in speed at the moment of throwing. (8)

It is also clear from Table (4) also the instability of the angle of the right knee of the leg during turn, which the contestant bends her knee increasingly to reduce the moment of inertia and reduce her weight and increase her speed so as not to represent a burden on the body during turn, we find that it is irregular for all members of the research sample, including the two Egyptian players.

It is also clear from Table (4) the instability of the angle of inclination of the trunk during turns, especially in the fourth round, where the angle was for the Egyptian player in first place (35.1, 17.3, 9.9, 12.3 º) respectively, while for the Egyptian player with third place (31.8, 13.5, 5.7, 11.4 º) respectively, which confirms the inability to resist centrifugation completely in the fourth round.

It is clear from Table (5) the gradual decline of the point of the lowest height of the hammer during the four turns for the two Egyptian players, where it was at the Egyptian player with the first place (0.32, 0.18, 0.10, 0.03 m) while it was at the Egyptian player with third place (0.40, 0.37, 0.27, 0.13 m), in addition to the gradual rise of the highest point of the hammer height, where it was at the Egyptian player with the first place (1.89, 2.31, 2.46, 2.47 m) while he was at The third-placed Egyptian player (1.87, 2.16, 2.29, 2.42 m), which is confirmed by the angle of inclination of the hammer turn level, which reaches at high levels at the end of the fourth turn, is as close as possible to approximately 45 º, where the angle inclination gradient was at the first-placed Egyptian player (31.0, 39.5, 43.5, 44.0 º), while the angle inclination gradient was at the third-placed Egyptian player (44.4, 44.6, 42.3, 45.1 º).

It is clear from Table (6) the clear direct relationship between the horizontal speed and the distance achieved, where the highest horizontal speed was for the Egyptian player who won first place by (20.00 m / s), while the lowest horizontal speed was for the Saudi player who ranked last by (18.33 m / s). (3)

The references indicate that the net speed of the hammer at the moment of release reached (27.91 m/s) in men achieving an average numerical level of ability (79.06 m), while the average speed of the hammer at the moment of release was (27.17 m/s) for women achieving an average record level (73.80 m). (7) ، (11)

The direct relationship between the achieved distance and the starting angle is also evident, as the three players who won the first places were higher than all the sample members and were (47.1, 46.4, 48.0 º) respectively. (4)

Conclusions:

1. The need to improve the doubles support times for Egyptian players for all trunk to work to increase their speed.
2. Increased push with the right leg during the doubles support of the four turns to increase the turnal movement during the single support, especially for the third-placed Egyptian player.
3. Training to increase flexion of the left leg knee with a succession of turns to further deepen the center of gravity of the body and increased centrifugal resistance due to increased speed.
4. Training to stabilize the right angle of the knee of the leg during turns so that it does not become a burden on the body and the turn speed increases better.
5. Control the trunk muscles to resist the forward binding during the fourth turn of the two Egyptian players.

Reference :

1- **Andreas V. (2009**): Reassessing velocity generation in hammer throwing, NSA. by IAAF, 24:4; 71-80.

2- **Bingjun Wan et al,** : Hammer Throw: a Pilot Study for a Novel Record-Route for Diagnosing and Improving Its Throw Quality, *Applied Sciences* (ISSN 2076-3417; CODEN: ASPCC7) 2020, 10, 1922; doi:10.3390/ app 10061922 www.mdpi.com/journal/applsci

3- **Brice, Sara Michelle** : Biomechanical analysis of hammer throwing: assessment of speed development. PhD thesis, (2014) James Cook University

4- **Dapena J, McDonald C.** :A three-dimensional analysis of angular momentum in the hammer throw. Medicine and Science in Sports & Exercise. 1989; 21(2): 206–220. https://doi.org/10.1249/00005768-198904000-00015

5- Gassner G. (1994): The paradoxical nature of the hammer, 4113-4114, throw.www.trackandfieldnews.com/technihque/129Greg_Gassner.pdf.

6- Jun Liu : Hammer Throwing parameters optimization model research based on flight dynamical differential equation **:** 2016 Nation al Convention on Sports Science of China, 01002 (2017)3190-3203 DOI: 10 .1051/ncssc/201701002

7- **Ken Ohta et al, :** Analysis of hammer movement based on a parametrically excited pendulum model, 1877-7058 c 2010 Published by Elsevier Ltd. doi:10.1016/j.proeng.2010.04.132 Procedia Engineering 2 (2010) 3197–3203

8- Lu Shi1, a,Feng Liu1, b, Chunyin Ma2, c: Hammer Throwing Technique of the Chinese Elite Female Athlete. Advances in Social Science, Education and Hulegities Research (ASSEHR), volume 206 ,2018 International Conference on Advances in Social Sciences and Sustainable Development (ASSSD 2018)

9- **Marwa Sakr** :Women's Hammer Throw Measurement Information System And Kinetic Energy of Body Segments and Hammer Head, Dissertation zur Erlangung des akademischen Degrees eines Doktors der Naturwissenschaften, Konstanz 2012

10- **Paish, W., (1976):** Track and Field Athletics, Lepus Books, and Associate Co., of Henry Kimpton Ltd., Edinburgh.

11- **Pavlović R.** :Differences in kinematic parameters between male and female hammer throw finalists of the World Championship in Daegu in 2011. Pedagogy of physical culture and sports, (2020) ; 24(5) :255-263. https://doi.org/10.15561/26649837.2020.0506

12- **Pedemonte, J.,:** A Divice to novice Hammer throwers, Book Division of Track & Field News, Tafnews Press. (1985)

13- **Shuai, W., Jihe, Z., Chong, J.:** Kinematics Analysis on the Throwing Skills of Elite Chinese Male Hammer Athletes. Japan Journal of Physical Education, Health and Sport Sciences, 950 (4), 91-92. (2014).

14- **Vassilios Panoutsakopoulos :** BIOMECHANICAL ANALYSIS OF THE MEN'S HAMMER THROW IN THE ATHENS 2006 I.A.A.F. WORLD CUP IN ATHLETICS M.A. Aristotle University Department of Physical Education and Sport Science Thessaloniki, Greece

Abstract

This research aims to analyze the biomechanical perforlegce of Egyptian athletes participating in the Arab Athletics Championship under 23 years, **identify the strengths and weaknesses** in the technical perforlegce of Egyptian athletes compared to their Arab colleagues, **compare the Egyptian perforlegce with international levels** to identify technical gaps, **provide practical recommendations** for the development of training programs directed to improve perforlegce, **Strengthening the practice** base of hammer throwing at the local level, based on the results of scientific analysis. The research sample included all the players participating in the hammer overthrow competition, and their number is eight players from the following countries (two Egyptian players, two Tunisian players, two Algerian players, an Iraqi player, a Saudi player), and the best attempt was chosen for each player to conduct the kinematic analysis. The study was conducted during the first Arab U-23 Athletics Championship, which was held in Tunisia from 18 to 25 May 2023, and the women's hammer throw competition was filmed using a Sony video camera with a frequency of 240 frame/sec to film all attempts, and the best attempt was selected for each athlete in terms of the achieved record level and subjected to biomechanical analysis procedures, using the Dartfish TeamPro4 kinetic analysis program. to analyze the variables under study for each attempt. **The most result is** The need to improve the doubles support times for Egyptian players for all trunk to work to increase their speed, Increased push with the right leg during the doubles support of the four turns to increase the turnal movement during the single support, especially for the third-placed Egyptian player, Training to increase flexion of the left leg knee with a succession of turns to further deepen the center of gravity of the body and increased centrifugal resistance due to increased speed, Training to stabilize the right angle of the knee of the leg during turn so that it does not become a burden on the body and the turn speed increases better, Control the trunk muscles to resist the forward bend during the fourth turn of the two Egyptian players.

Keywords: Hammer Throw, Biomechanics, Analysis