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Interrelation of the hammer swing technique with the technique of its previous rotation in highly skilled hammer throwers

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The results of studies on the relationship of the parameters of the hammer swing technique with the biomechanical indicators of the previous hammer rotation techniques are presented.

Purpose: *investigate the relationship of the hammer swing technique with the previous hammer rotation technique.*

Material & Methods: *analysis and synthesis of scientific and methodical literature, analysis of video materials, methods of mathematical statistics. 7 qualified hammer throwers, finalists of the World Cup and European Cups during the 2016–2018 seasons were investigated.*

Results: *the closest relationship was recorded between the angle of flexion in the right elbow joint and the angular velocity of the hammer (r=0,868), such studied indicators of the hammer assassination technique, such as: angular speed of the hammer, linear speed of the hammer, the center of the hammer force did not have a significant impact on the biomechanical indicators previous hammer rotation.*

Conclusion: *previous hammer rotation techniques are more dependent on the angle of flexion in the left knee, right elbow joints, the height of the hammer layer rising from the support, the size of the left foot turning outwards and the height of the heel of the left foot rising from the support during the hammer wagging.*

Keywords: *throwers, biomechanical parameters, technique, hammer swing, previous hammer rotations.*

Introduction

Hammer throwing is a complex in the coordination of movements type of athletics throwing. The high level of achievements in the international arena requires the continuous improvement of technical training of hammer throwers.

The work of L. Judge, R. Isele, G. Davila, E. Maslovsky, A. Shahdad [2; 3; 5–7] is devoted to the study of the features of the preliminary rotation of the hammer. A. Maheras, J. Silvester [8; 10] investigated the features of the rotation technique with a hammer. The definition of the linear speed of the hammer during the previous rotations involved S. Brice, K. Ness, D. Rosemond [4]; K. Murofushi [9] determined the acceleration of the hammer. V. Bakatov studied the rhythm of the hammer throw [1].

However, despite the significant amount of work devoted to the hammer throwing technique, the influence of the hammer attempt on the biomechanical indicators of previous hammer rotations is still uncertain.

Purpose of the study: investigate the relationship of the hammer swing technique with the previous hammer rotation technique.

Material and Methods of the research

The technique of seven highly skilled hammer throwers, finalists of the World Cup and European Cups during the 2016–2018 seasons was investigated. During the execution of the work, the following research methods were used: analysis and synthesis of scientific and methodical literature, analysis of video materials, methods of mathematical statistics.

Results of the research

Indicators of the hammer swing technique of highly skilled throwers are presented in Table 1.

An analysis of the hammer backswing technique showed that in the leading modern throwers the angle of the left foot is 22,5±4,9°, the height of the heel of the left foot above the support is 10,3±6,3 cm, the angle of flexion in the left knee joint is 165,3±3,2°, shoulder rotation about the vertical axis – 118,7±8,3, bending angle in the right elbow joint – 122,5±15,1°, in the left joint – 165,3±3,2°, height of the hammer formation – 1,39±0,28 m. The linear speed of the hammer movement reaches 2,99±0,88 $m \cdot s^{-1}$, the angular velocity is 1,91±0,55 $rad \cdot s^{-1}$, in the center the hammer force does not exceed 5,8±3,6 kg.

The biomechanical indicators of highly skilled throwers at the end of previous hammer hits are presented in Table 2.

The data obtained indicate that in highly skilled hammer throwers during the second rotation at the lowest point of the trajectory of the hammer layer movement, the bending angle in the right knee joint is 169,6±5,3°, in the left one – 159,3±6,9°, in the right hip joint – 167,6±3,9, in the left – 166,1±8,7°, in the right elbow – 171,4±5,7°, in the left – 172,3±5,7°. The height of the hammer layer reaches 28,8±17,1 cm.

At the highest point of the movement of the ball of the hammer,

Table 1

Biomechanical features of the hammer swing technique by highly skilled hammer throwers

Indicators	Athletes						
	Pawel Fajdek	Wojciech Nowicki	Ivan Tsikhan	Quentin Bigot	Nick Miller	Diego Del Real	Marcel Lomnicky
	POL	POL	BLR	FRA	GBR	MEX	SVK
Angle of turn of the left foot (deg.)	24,3±4,6	24,8±3,0	13,2±0,8	19,3±4,0	26,2±1,7	27,4±0,9	21,3±3,2
Height of heel of the left foot (cm)	12,5±0,7	14,1±0,5	13,9±0,5	13,3±0,4	12,2±1,2	13,1±1,4	13,8±0,5
Angle of flexion in the left knee (deg.)	158,6±2,8	146,3±0,8	139,8±8,9	138,8±2,8	156,0±5,3	162,8±0,4	145,4±3,1
Rotation of the shoulders about the vertical axis (deg.)	102,5±10,6	122,9±4,1	105,3±1,1	122,8±3,4	124,4±0,8	124,8±1,5	111,8±0,9
Angle of flexion in the right elbow joint (deg.)	128,1±7,5	120,4±13,7	123,5±6,9	131,6±5,2	89,4±3,2	128,5±6,3	127,6±4,8
Angle of flexion in the left elbow joint (deg.)	158,7±2,9	168,9±5,3	165,3±2,3	161,4±4,6	159,7±2,8	170,7±4,7	160,4±13,5
Height of ball of the hammer (m)	1,62±0,25	1,60±0,38	1,2±0,16	1,31±0,19	1,71±0,21	1,4±0,31	0,90±0,27
Hammer angular speed (rad s^{-1})	2,70±0,10	1,71±0,20	1,22±0,11	1,51±0,13	2,34±0,21	1,60±0,20	2,42±0,14
Hammer linear speed (m s^{-1})	4,10±0,14	2,51±0,30	1,91±0,10	2,23±2,01	3,40±0,14	2,63±0,40	4,00±0,10
Magnitude of the centrifugal force of the hammer (kg)	11,2±0,80	3,3±0,11	2,0±0,12	2,7±0,46	7,9±0,42	4,1±1,31	9,3±0,64

Table 2

Biomechanical indicators of hammer throwers at the end of previous hammer spins

Indicators	Athletes						
	Pawel Fajdek	Wojciech Nowicki	Ivan Tsikhan	Quentin Bigot	Nick Miller	Diego Del Rea	Marcel Lomnicky
Angle of flexion in the right knee joint (deg.)	140,9±4,2	147,3±2,1	154,5±11,0	158,6±3,5	134,1±3,6	140,9±3,0	152,0±1,8
Angle of flexion in the left knee (deg.)	142,1±6,0	150,8±3,0	139,4±3,0	164,3±1,3	152,6±3,2	147,8±6,1	143,5±1,5
Height of raising of a heel of the left leg from a support (cm)	13,0±2,8	5,0±1,4	8,0±1,4	9,1±5,7	8,5±5,0	13,2±1,4	10,5±1,0
Leg width (cm)	52,5±3,5	53,5±0,7	43,0±2,8	49,0±1,4	50,5±2,1	42,0±1,4	43,5±3,5
Angle of rotation of the right foot (deg.)	22,3±1,3	18,4±2,0	7,0±1,4	12,2±3,0	15,5±2,8	7,7±0,8	11,9±4,6
Angle of flexion in the right elbow joint (deg.)	114,5±8,0	152,3±0,4	119,6±5,5	117,9±6,6	127,2±7,4	118,9±4,7	121,3±1,1
Angle of flexion in the left elbow joint (deg.)	112,9±6,2	151,4±1,3	120,1±5,1	117,0±6,5	127,0±7,7	117,9±5,3	121,0±1,8
Torso angle (deg.)	20,4±1,6	18,1±0,8	13,1±1,3	19,6±3,0	24,4±5,6	12,3±1,2	13,4±3,0
The height of the raising of the hammer ball from the support (m)	2,07±0,05	2,08±0,02	2,02±0,05	1,92±0,04	2,07±0,08	1,95±0,02	1,98±0,06
Hammer ball linear speed (m s^{-1})	13,94±0,42	13,49±0,64	11,52±1,29	13,99±0,79	10,69±0,73	13,64±2,14	13,11±0,78
Hammer ball angular speed (rad·s^{-1})	8,72±0,27	8,30±0,40	7,58±0,84	9,34±0,53	6,81±0,47	9,00±1,42	8,48±0,51
Magnitude of the centrifugal force of the hammer (kg)	108,8±6,6	101,6±9,7	77,2±7,4	112,1±2,7	63,7±8,7	107,5±3,4	96,1±11,4

the angle of flexion in the right knee joint is 146,9±8,7°, in the left – 148,6±8,4°, the height of the heel of the left foot above the support reaches 9,6±2,9 cm, width leg placement does not exceed 47±4,8 cm, the angle of the right foot outward reversal is 13,6±5,6°, the angle of flexion in the right elbow joint is 124,5±12,8, in the left one – 123,9±12,9°, torso angle does not exceed 17,3±4,5°, the height of the ball of the hammer above the support reaches 2,01±0,06 m. The linear speed of the hammer reaches 12,91±1,29 m·s^{-1}, the angular speed of the hammer is 8,32±0,86 rad·s^{-1}, in the center the strength of the hammer layer reaches 95,3±18,2 kg. To determine the degree of influence of the biomechanical parameters of the hammer technique on the technique of previous rotations, a correlation analysis was carried out using the Pearson pair correlation method (Table 3).

The data obtained indicate a significant relationship between the angle of rotation of the left foot outward during the swing of the hammer and the angle of flexion in the right knee joint at the end of previous hammer rotations (r=–0,783). A negative inverse relationship indicates a decrease in the bending angle in the right knee joint at the end of the second preliminary rotation of the hammer with an increase in the pivot of the left foot outward during its swing.

The height of the heel of the left foot during the hammer swing only affects the flexion angle in the right knee joint (r=0,762) and the torso angle (r=–0,733) during the second preliminary rotation of the hammer, indicating an increase in the flexion angle in the right knee joint and reduce the torso angle with increasing height of the heel of the left foot above the support during the backswing of the hammer.

An analysis of the correlation relationship showed that an increase in the angle of rotation of the shoulders relative to the vertical axis affects the increase in the angle of flexion in the left knee joint (r=0,736).

A rather close relationship was observed between the magnitude of the flexion angle in the right elbow joint and the linear (r=0,786) and angular (r=0,868) speeds of the hammer ball at the end of previous conversions. Also, a close relationship was recorded between the angle of flexion in the right elbow joint and the centrifugal force of the hammer at the end of

Table 3

Interrelation of hammer backswing technique with previous hammer spins in highly skilled throwers (n=7)

Biomechanical indicators at the end of previous hammer spins	Indicators hammer swing technique									
	Angle of turn of the left foot	Height of heel of the left foot	Angle of flexion in the left knee	Rotation of the shoulders about the vertical axis	Angle of flexion in the right elbow joint	Angle of flexion in the left elbow joint	Height of ball of the hammer	Hammer angular speed	Hammer linear speed	Magnitude of the centrifugal force of the hammer
Angle of flexion in the right knee joint	–0,783	0,762	–0,886	–0,198	0,649	0,039	–0,696	–0,544	–0,482	–0,513
Angle of flexion in the left knee	0,185	–0,182	–0,230	0,736	–0,095	–0,050	0,224	–0,218	–0,307	–0,341
Height of raising of a heel of the left leg from a support	0,346	–0,269	0,666	–0,253	0,365	–0,137	–0,086	0,404	0,492	0,515
Leg width	0,347	–0,303	0,060	0,091	–0,302	–0,303	0,735	0,388	0,224	0,250
Angle of rotation of the right foot	0,444	–0,319	0,265	–0,162	–0,181	–0,436	0,609	0,694	0,578	0,599
Angle of flexion in the right elbow joint	0,262	0,272	–0,145	0,433	–0,284	0,443	0,338	–0,145	–0,213	–0,288
Angle of flexion in the left elbow joint	0,228	0,279	–0,171	0,427	–0,302	0,444	0,314	–0,167	–0,232	–0,306
Torso angle	0,341	–0,733	0,145	0,214	–0,637	–0,570	0,728	0,457	0,280	0,337
The height of the raising of the hammer ball from the support	0,228	–0,286	0,247	–0,257	–0,553	–0,148	0,614	0,427	0,320	0,367
Hammer ball linear speed	0,226	0,477	0,031	0,028	0,786	0,233	–0,075	0,011	0,053	–0,009
Hammer ball angular speed	0,073	0,442	–0,028	0,036	0,868	0,185	–0,275	–0,120	–0,047	–0,098
Magnitude of the centrifugal force of the hammer	0,178	0,433	0,051	0,007	0,834	0,206	–0,125	–0,029	0,023	–0,026

Remark. *$R>R_{cr}$, at R>(0,755).*

previous projectile hits. (r=0,834).

The correlation relationship indicates an increase in the centrifugal force of the hammer, it's linear and angular velocity with an increase in the angle of flexion in the right elbow joint during the assassination of the hammer.

A noticeable relationship was observed between the height of the hammer layer during the assassination and such parameters as the width of the legs (r=0,735) and torso angle (r=0,728) with which the thrower ends previous projectile hits. The higher the athlete raises the hammer layer during the assassination, the greater the width of the legs and the angle of the body during previous appeals.

Such indicators of the hammer swing technique, such as the angular velocity and linear velocity of the projectile, as well as the centered force of the hammer, did not have a significant effect on the biomechanical indicators of previous rotations.

Conclusions / Discussion

In most of the works devoted to the hammer throw technique, the biomechanical parameters of its individual phases are considered [5; 7; 8], however, the influence of the hammer wagging technique on the biomechanical parameters of previous hammer rotations remains uncertain. As a result of the study, the extended information of R. Isele, E. Nixdorf [6] on the biomechanical parameters of the techniques of highly skilled hammer throwers.

The results of the study indicate a large value of the angular characteristics of the throwers during the swing of the hammer for the effective performance of its previous rotations.

Our data allow us to increase the efficiency of technical training of hammer throwers. It has been established that in order to increase the speed parameters of the technique of previous hammer hits, the right arm at the elbow should be bent at an obtuse angle. To reduce the inclination during previous rotations of the projectile, reduce the height of the raising of the hammer ball and increase the height of the heel of the left foot above the support during the swing. To reduce the angle of flexion in the left knee joint at the end of previous revolutions of the hammer, it is necessary to increase the angle of flexion in the left knee joint during its swing.

Prospect of further research. It is intended to determine the influence of the hammer wag technique on the rotation with a hammer in highly skilled throwers.

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References

1. Bakatov, V. (2007), "Rhythmical structure movements optimization in hummer throwers from three turns 12–19 years", *Moloda sportyvna nauka Ukrainy*, Vol. 11, No. 3, pp. 36-41. (in Ukr.)
2. Maslovskij, E.A. & Zagrevskij, V.I. (2012), "Management of technical training of hammer throwers based on urgent information on the biomechanical characteristics of throwing", *Visnik Chernigivs'kogo nacional'nogo pedagogichnogo universitetu imeni T. G. S. Hevchenka*, Vol.

102, No. 2, pp. 73-78. (in Russ.)
3. Shahdadi, A.N., Zagrevskij, O.I. & Zagrevskij, V.I. (2013), "Comparative biomechanical analysis of hammer throwing athletes of varying qualifications", *Vestnik Tomskogo gosudarstvennogo universiteta*, No. 368, pp. 148-151. (in Russ.)
4. Brice, S., Ness, K. & Rosemond, D. (2011), "An analysis of the relationship between the linear hammer speed and the thrower applied forces during the hammer throw for male and female throwers", *Sports biomechanics*, No. 10 (3), pp. 174-184.
5. Davila, G. & Fjavier, R. (2005), "Comparative biomechanical analysis between of different performance levels", *Journal of Human Movement Studies,* No. 49 (1), pp. 31-47.
6. Isele, R. & Nixdorf, E. (2010), "Biomechanical analysis of the hammer throw at the 2009 IAAF World Championships in Athletics", *New studies in athletics*, No. 25, pp. 37-60.
7. Judge, L. (2000), "The hammer throw for men & women", *Coach and athletic director*, No. 69 (7), pp. 36-41.
8. Maheras, A. (2011), "The single support in hammer throwing techniques", *Track and Field & Cross Country*, No. 5 (2), pp. 14-20.
9. Murofushi, K., Sakurai, S. & Umegaki, K. (2007), "Hammer acceleration due to the thrower and hammer movement patterns", *Sports biomechanics*, No. 6 (3), pp. 301-314.
10. Silvester, J. (2003), *Complete book of throws*, Human Kinetics, South Australia.

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