A KINEMATIC ANALYSIS OF YURIY SYEDIKH'S WORLD RECORD HAMMER THROW

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An analysis of the kinematic values of several technique parameters of Syedikh's world record throw at the 1986 European Championships in comparison to the corresponding parameters of a number of other world class throwers.

INTRODUCTION

Yuriy Syedikh (USSR) set a world hammer throw record of 86.74m in the European Championships in Stuttgart, Germany, in 1986. He had the following series: 83.94-85.28-85.46-86.74-86.68-86.62m! Two of his throws exceeded the previous world mark, set in June 1986 in Tallinn, Estonia. The high consistency of his series and the fact that no other thrower in the last few years has approached the distance, makes the evaluation of his best throw extremely interesting for coaches and sport scientists.

Selected throws of other athletes are used to evaluate the kinetic values of Syedikh's performance. These were drawn from 75 hammer throws of national and international athletes, recorded between 1985 and 1990 at the Cologne Sports Institute.

METHOD

The world record throw of Syedikh's and all other evaluated throws were captured by two high speed cameras with a frequency of 200 frames a second. This high frequency is required for an exact analysis, allowing for hundredth of a second accuracy. The marking of body segment points was based on the model of Hanavan. The center point of the hammer head and 22 body points were marked on each frame. The calculation of the three dimensional coordinates was made from the views of both cameras. The raw data was adjusted for the establishment of the path, angle and velocity characteristics.

The evaluations begin from the moment the hammer has reached its lowest point in the lead to the first turn and end with the final stage of the delivery release of the hammer handle. This establishes the scheme for the movement pattern of a hammer throw (right handed athletes), as shown in Figure 1. The time points define the movements as follows:

10 to 12 = Turn 1 (T1)
12 to 14 = Turn 2 (T2)
14 to 16 = Turn 3 (T3)
16 to 18 = Turn 4 (T4)
16 to 19 = Delivery Phase (R)

The single turns are divided into a double support phase (ds) (both feet in contact with the ground) and a single support phase (ss) (only the rotating foot is in contact with the ground).

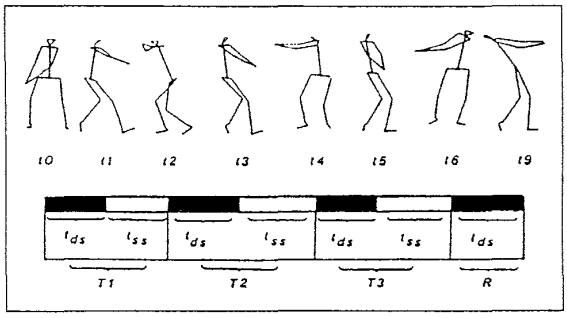


FIG.1: THE MOVEMENT PATTERN OF THE HAMMER THROW

T0—THE MINIMAL HEIGHT OF THE HAMMER HEAD BEFORE THE FIRST TURN
T1, T2, T5, T7—THE LAST GROUND CONTACT OF THE RIGHT FOOT
T2, T4, T6, T8—THE FIRST GROUND CONTACT OF THE RIGHT FOOT
T9—THE LAST CONTACT WITH THE HAMMER HANDLE OF THE LEFT HAND

DELIVERY PARAMETERS

The aim of the hammer thrower is to deliver the hammer at maximal velocity at an optimal angle. An optimal

delivery angle depends on the anthropometric measurements of the athlete and is close to 44° without velocity losses. How Syedikh solves this task is shown in Table 1.

Syedikh (URS) 86.74	
V_o (M/s)	30.7
V_oXY (m/s)	23.6
V_oZ (m/s)	19.7
α_o (°)	39.9
h_o (m)	1.66

TABLE 1: DELIVERY PARAMETERS OF SYEDIKH'S WORLD RECORD THROW OF 86.74M.

As can be seen, Syedikh's delivery angle (α) is 39.9°, about 4° short of the optimal angle. This means a theoretical distance loss of 0.5m.

The delivery height (h) of 1.66m appears to be low, but corresponds with the tendency to release the hammer at shoulder height. As Syedikh is about 1.80m tall the delivery value is in the range of his shoulder height.

We calculated his delivery velocity (V), as 30.7 m/s. The velocity of the hammer during all three turns, and in the delivery phase, is shown in Figure 2.

ROTATIONAL VELOCITY

A maximal velocity in all turns, particularly in the last turn, is required to achieve a high delivery speed. Information on this is provided in the time analysis of Syedikh's world record throw in comparison to other athletes in the same competition (Table 2).

The time analysis shows that Syedikh and Litvinov had the shortest total times of all competitors. They also achieved the lowest values in the last turn. All other evaluated athletes were significantly slower, as show in the examples of Haber and Schafer.

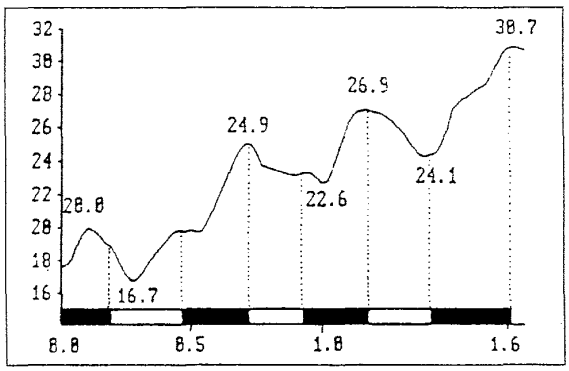


FIG. 2: THE VELOCITY GRAPH OF THE HAMMER (M/SEC) DURING SYEDIKH'S TURNS AND DELIVERY PHASES

Syedikh and other technically advanced athletes attempted to keep their single support phases shorter than the double support phases. The presented example of Schafer, and the even more distinct action of Tamm (URS) (not shown), shows the opposite trend among technically poorer athletes.

This time distribution influences the length of the acceleration path, the distance covered by the hammer in the above defined section. It is shown in Table 3.

As can be seen, Syedikh has the longest time at his disposal to accelerate the hammer as 55.8% of the total time (from point t1) is spent in double support. This is particularly significant in the 6.68m long path of the delivery acceleration that is clearly longer than in other athletes.

The reason for Syedikh's favorable distribution between double and single support phases is in his extremely

	Syedikh (URS)	Litvinov (URS)	Schafer (FRG)	Haber (GDR)
T1	0.44	0.44	0.45	0.47
tds	0.20	0.15	0.17	0.22
tss	0.24	0.29	0.28	0.25
T2	0.47	0.60	0.60	0.51
tds	0.26	0.35	0.32	0.28
tss	0.21	0.25	0.28	0.23
T3	0.43	0.44	0.51	0.50
tds	0.22	0.21	0.21	0.25
tss	0.21	0.23	0.30	0.25
T4		0.43		
tds		0.22		
tss		0.21		
R	0.27	0.24	0.24	0.24
TOTAL	1.61	2.15	1.80	1.72

TABLE 2: A TIME ANALYSIS OF SYEDIKH IN COMPARISON TO OTHER ATHLETES IN THE EUROPEAN CHAMPIONSHIPS 1986 (SEC).

		Syedikh (URS) 86.74 m	Schafer (FRG) 79.36 m	Haber (GDR) 80.76 m
T1	tds	(3.61)	(2.80)	(2.75)
	tss	3.96	4.39	4.64
T2	tds	5.15	5.87	5.72
	tss	4.45	5.59	5.02
T3	tds	5.18	4.55	5.88
	tss	4.97	6.74	5.96
R	tds	6.68	5.91	6.07
TOTAL		34.10	35.85	36.04
RELATION tds toTOTAL (t1-9)		55.8%	49.4%	53.1%

TABLE 3: THE LENGTH OF THE ACCELERATION PATH OF THE HAMMER (M) OF SYEDIKH'S WITH COMPARISON VALUES.

		Syedikh (URS) 86.74 m	Schafer (FRG) 79.36 m	Haber (GDR) 80.70 m	Weis (FRG) 82.16 m
T1	HH Max	0.79	0.91	0.88	0.93
	HH Min	0.69	0.85	0.77	0.83
	Diff.	[0.10]	[0.06]	[0.11]	[0.10]
T2	HH Max	0.84	0.94	0.93	0.96
	HH Min	0.70	0.84	0.80	0.82
	Diff.	[0.14]	[0.10]	[0.13]	[0.14]
T3	HH Max	0.88	0.95	0.95	0.97
	HH Min	0.68	0.85	0.83	0.83
	Diff.	'0.20]	[0.10]	[0.12]	[0.14]
T4	HH Max				1.01
	HH Min				0.82
	Diff.				[0.19]
R	HH Max	0.92	1.03	0.97	1.05
MEDIAN		[0.15]	[0.09]	[0.12]	[0.14]

- HH Min = = > LOWEST HIP LEVEL
- HH Max = = > HIGHEST HIP LEVEL
- Diff. = = > DIFFERENCE (HHmax - HHmin)

TABLE 4: MAXIMAL AND MINIMAL HIP LEVELS OF SYEDIKH IN COMPARISON TO OTHER THROWERS.

early foot placement that is expressed in the azimuth angles (the hammer position in its 360° travel circle).

Syedikh reaches an average azimuth value of 63° at the liftoff and 224°(!) at the landing. His average acceleration path length is therefore 200° (=55%). This means an extremely long acceleration in the double support phase. No other hammer thrower has achieved such an early placement position, particularly immmediately prior to the delivery.

LOWERING OF THE BODY

Another important aspect in the technique of the hammer throw is the dropping of the hips at the moment the hammer reaches its highest point in the single support phase. Analogically the hips are lifted again when the hammer passes the lowest point in the double support phase.

Looking at the minimal and maximal height of the hips reveals that Syedikh has in 0.68m the lowest hip position of all athletes. This applies to the absolute value, as well as the comparison with other athletes of the same height, and is not correlated to Syedikh's physique.

Syedikh also has in 0.15m the largest average and in 0.20m the largest last turn relative lowering of the hips. Only Weis (FRG) and Litvinov among the world class throwers have values anywhere near Syedikh's. Tamm and Schafer have, in less than 0.10m, particularly poor values. These values apply to throws over 80m. Athletes in the 77m region and juniors show even greater faulty hip lifting action at the moment the hammer reaches its highest point.

	Syedikh (URS) 86.74 m	Schafer (FRG) 77.84 m	Sahner (FRG) 78.34 m	Weis (FRG) 82.16 m
T1	0.33	0.41	0.38	0.37
T2	0.30	0.36	0.33	0.33
T3	0.28	0.39	0.31	0.35
T4			0.31	0.37

TABLE 5: THE DEEPEST KNEE BENDS OF SYEDIKH IN COMPARISON TO THE OTHER THROWERS.

The prerequisite for an efficient lowering of the hips is a deep knee bend of the turning leg, a parameter that does not depend on the anthropometric factors of the thrower (see also Table 5).

Syedikh has here the best values in comparison to the other throwers, constantly improving his position from turn to turn. His extreme body position, combined with the lowering of the center of gravity, give Syedikh an excellent counterweight against the pulling force of the hammer.

ANGLE CHARACTERISTICS

The hammer throw technique is strongly influenced by the movement of the trunk and the position of the hammer in relation to the shoulder axis. A particularly important technical aspect is the size of the twist between the shoulder and hip axis (Figure 3) immediately before, or at the moment of the placement of the right foot. The lowest twisting values occur between zero azimuth and the lifting of the right leg.

The tendency to create a large twist in the single support phase, thus leading to velocity losses, and to then rebuild the twist in the double support phase to accelerate the hammer, is contradictory to Syedikh's action (see Table 6).

Syedikh reaches values of only about 30° in the difference of the maximal and minimal twist in the last two turns. In contrast, the two German throwers have differences between 40 to 60°.

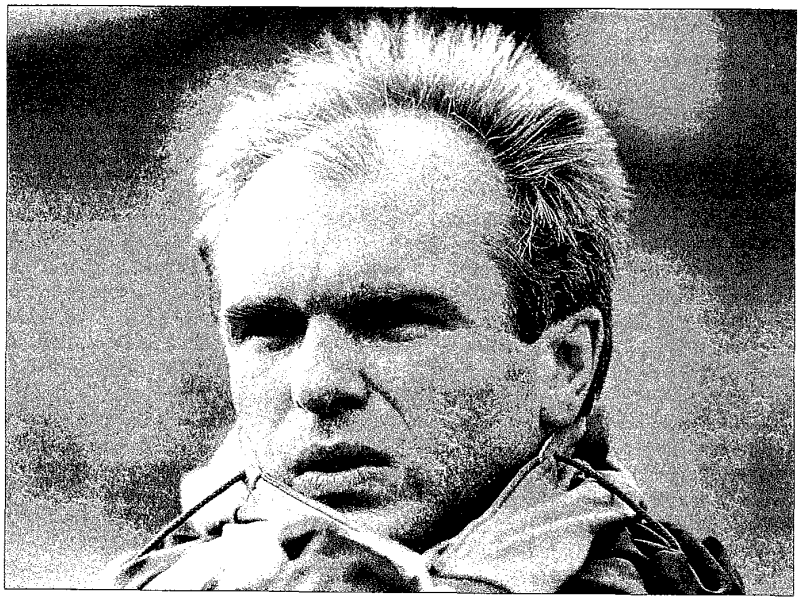
A comparison of the 1987 and 1989 throws of Weis shows a clear reduction of the twist and there is virtually no trunk rotation in the last turn.

A comparison of the angle between the shoulder axis and the hammer wire at certain points is interesting. The angle is 90° at the point when the hammer is directly in front of the body (see Figure 4). It increases up to 150° during the "trailing" phase of the hammer. The comparison shows distinct differences in the techniques. Syedikh attempts to have a fixed position, allowing the hammer to move ahead or to trail very little (between 78 and 115°).

Schafer, with maximal values up to 150°, is an extreme example, although other throwers in our study, like Minev (Bulgaria), clearly showed the trailing of the hammer with values between 90 and 130°.

TECHNIQUE AND TRAINING CONSEQUENCES

The results of the kinematic analysis of Syedikh and the comparison values of other throwers show the follow-



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Yuriy Syedikh

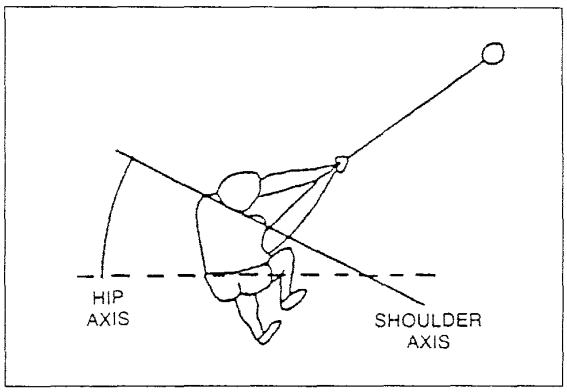

FIGURE 3: THE TWIST BETWEEN SHOULDER AND HIP AXIS.

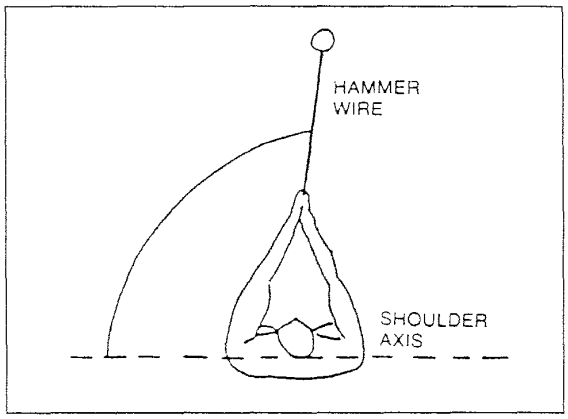

FIGURE 4: THE ANGLE BETWEEN THE HIP AXIS AND THE HAMMER WIRE

ing tendencies:

The release velocity, the release height and the release angle are mainly responsible for the distance of the throw. However, the delivery angle is negligible. Athletes, who are about 1.80 tall (Syedikh, Litvinov, Sahner) achieve their best distances from a maximal angle of 40°.

The highest possible release velocity is achieved through an optimally executed unwinding of the feet during the turn. The single support phase should be shorter here than the double support phase, particularly in the final turn. This is achieved by lifting the right foot when the azimuth is about 65° and an early placement of the foot when the azimuth is around 220 to 230°.

A maximal lowering of the body at the moment of the highest point of the hammer path is necessary to maintain high velocity during the turns. Besides, it is necessary to counteract the pull of the hammer with a low position of the knees, without giving up the vertical trunk position. A counter movement of the trunk would automatically lead to the shortening of the hammer radius.

Syedikh's technique shows that an optimal hammer velocity is achieved through a closely fixed position of the thrower and the hammer. A higher turning speed is clearly reached when the maximal twist of the trunk is between 30 to 40° and the hammer position remains a constant 90° between the shoulder axis and the hammer wire. The acceleration of the hammer takes place through creating and dismantling the distortion between the feet and the hip axis.

The development of the above mentioned technique criteria should begin early in the training of beginners. This applies in particular to the movement of the feet, the correct lowering of the body and the position of the hammer relative to the thrower. It should be developed correctly right from the beginning as relearning can later be extremely difficult.

		Syedikh (URS) 86.74 m	Schafer (FRG) 79.36 m	Weis (FRG) 76.30 m	Weis (FRG) 82.16 m
T1	Max	12	15	33	17
	Min	5	0	-2	13
	Diff.	[7]	[15]	[35]	[4]
T2	Max	45	64	62	55
	Min	15	17	3	13
	Diff.	[30]	[47]	[59]	[42]
T3	Max	39	66	55	43
	Min	10	18	14	14
	Diff.	[29]	[48]	[41]	[29]
T4	Max			49	35
	Min			8	22
	Diff.			[41]	[13]
R	Max	41	63	60	37
	Min	-13	-26	-9	-26
	Diff.	[54]	[89]	[69]	[63]

TABLE 6: THE SHOULDER AND HIP AXIS TWIST OF SYEDIKH IN COMPARISON TO OTHER THROWERS (°).