KINEMATIC ANALYSIS OF GLIDE AND SPIN SHOT PUT TECHNIQUE
(TIMMERMANN versus BARNES at the Olympic Games in Seoul 1988)

ŠTĚPÁNEK, J.
Laboratory of Czechoslovak Athletic Federation
Prague
Czechoslovakia

The best and the most dramatical competition in all history of shot put was held at the Seoul Olympics. The gold was won by Ulf TIMMERMANN with a throw of 22.47 metres, an Olympic record. Randy BARNES was only 8 centimetres behind for silver.

The top two medallists used different throwing techniques:

1. Ulf TIMMERMANN (GDR 62 194/120) 22.47 utilizing the glide
2. Randy BARNES (USA 66 195/121) 22.39 utilizing the spin

These two best throws were chosen and subsequently analysed. The main purpose of the presentation is to describe some acquired data and to indicate possible interpretation for the evaluation of both techniques.

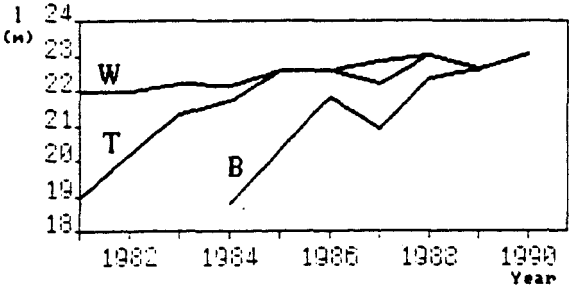


Figure 1:

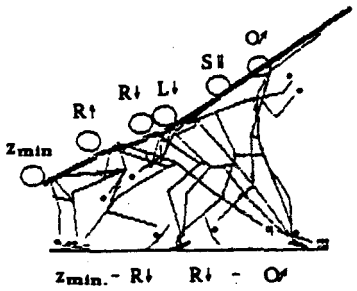
The diagram presents the development of performances during the last 10 years. It includes new world record - 23.12 m - which Randy BARNES set up in May, this year. Long-term data indicate that the best shot putters achieve peak performances after more than 10 years of training, at an average age over 27. Prognoses to the future you can make by yourself. I believe that Randy BARNES is able to make another progress.

METHODS

At the Seoul Olympics, the throws were recorded by two Photosonics high speed cameras with synchronous film shooting at 196 frames per second. A Vanguard Digi-Pad 5A digitizer was used to measure the locations of 22 anthropometric points. Computer programs were then used to calculate the three-dimensional (3D) coordinates of the investigated points, the centre of gravity location and the other geometric and kinematic values.

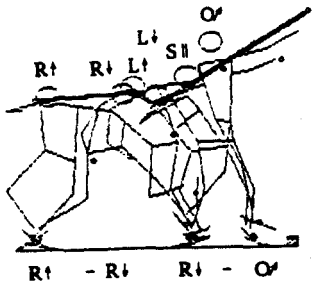
For better chance to compare it and for better orientation in the text, pictures and analyses we stick to the traditional division of the whole motoric manoeuvre into separate phases by means of so called key event.

The first part of the put - from the beginning stationary position to the moment when the shot passes through the lowest point of its path ($z_{min.}$) - does not have much influence on the remaining movements and the resulting performance. For this reason we are not going to deal with that part in our analysis.



Ulf TIMMERMANN 22,47 m

Figure 2:



Randy BARNES 22,39 m

Figure 3:

Symbol	Key Events	Phase
z_{min}	at the lowest point of the shot path	
R	and when right foot support is left	Start
R	moment of glide beginning	
L	moment of turn beginning	Glide turn
R	moment of glide (turn) end	Transition
L	moment of foot landing in the double-support position	Shoulder rotation
S	moment when shoulders axis reaches position parallel to the put direction	Push-off
O	moment when the shot leaves the fingers	
$z_{min.}$ - R↓ R↑ - R↓	preparation for delivery of the shot	Preparation
R↓ - O↗	effective acceleration of the shot	Delivery

RESULTS

In evaluating our findings we have proceeded from data with very marked influence to that whith no direct influence on the final performance. In this case we select only 3 in our opinion the main parts of the whole analysis:

- moment of shot release,
- delivery phase,
- acceleration of some selected body segments.

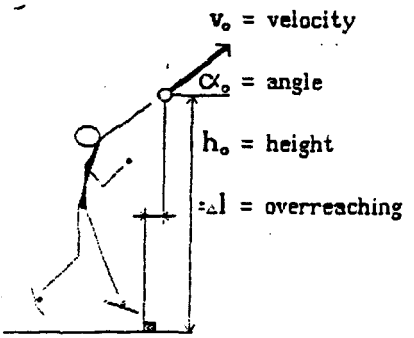


Figure 4:

Moment of shot release - 0

The shot velocity at the moment of release (v_0) is the most important factor of the performance. At that moment other parameters can be reduced to release angle (α_0), release height (h_0) and the amount of overreaching or incomplete reaching of the shot ($\pm\Delta l$).

	Performance l[m]	Lenght $\pm\Delta l$[m]	Velocity v_0[m/s]	Angle α_0[°]	Height h_0[m]
1.TIMMERMANN	22.47	0.20	14.20	36.3	2.27
2.BARNES	22.39	0.21	14.25	34.9	2.24
influence of perf. diff.B-T in [m]	-0.08	+0.01	+0.13	-0.19	-0.03

Comparison of kinematic parameters of the shot at the moment of release showed that BARNES was slightly better in the release velocity, but he lost the gold medal especially through the smaller release angle. Release height and overreaching did not affect results of the competition so significantly.

Delivery phase R - 0

Generally, the whole action of the shot put can be divided into two main parts. The decisive point is the moment the shot starts to increase its velocity markedly. In our case the delivery phase begins with the touch down of the right foot, and culminates at the moment the implement leaves the athlete's fingers.

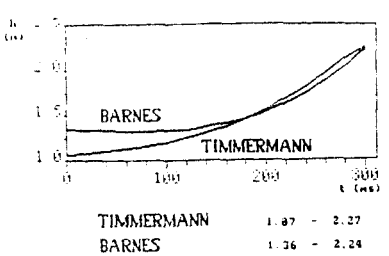


Figure 5:

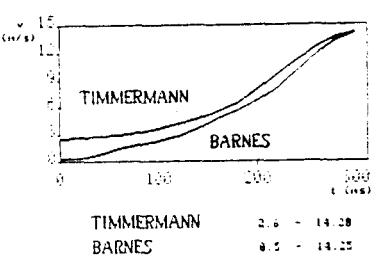


Figure 6:

At the delivery phase TIMMERMANN lifts the shot from 1.07 m at 2.27m height and in the same time - 300 ms - he increases the shot velocity from 2.6 to the final 14.20 m/s along a length of 1.99 m of the effective acceleration path of the shot.

On the other hand, BARNES lifted the shot from 1.36 at 2.24m height in a slightly shorter time - 290 ms. But he is able to accelerate the shot from a half to 14.25 m/s utilizing only 1.75 m length of the effective trajectory.

At the final push-off phase there are not so significant differences.

A few supplementary data :	TIMMERMANN	BARNES	Differ.
* width of delivery stance	111 cm	71 cm	40 cm
* duration of the shoulder axis rotation phase	0.03 s	0.08 s	0.05 s
* shot path at L.- S.. phase	17 cm	32 cm	15 cm
* shot path at R.- L. phase	49 cm	18 cm	31 cm
* direction of the shot path R.- L. phase	↑	↓	-
* max. angle of the shoulder axis and the hip axis	43°	54°	11°
* glide (turn) length	93 cm	122 cm	29 cm

These characteristic differences are given by different mechanical principles of both techniques.

From the comparison of the graphic representation of the spatial reconstruction of the shot path we can observe quite distinctive differences in the preparation phase and, on the other hand, an unexpected similarity in the final phase of the put.

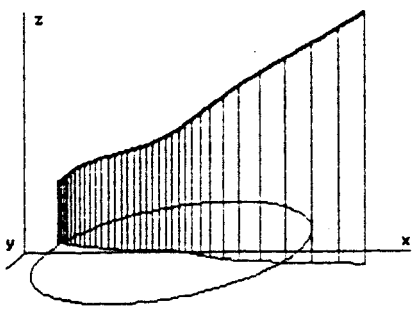


Figure 7:

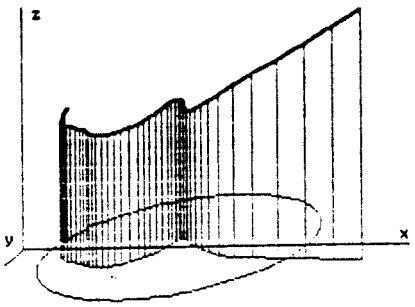


Figure 8:

From the point of view of the projection into the perpendicular plane, the glide technique shot path by its form approaches the straight line.

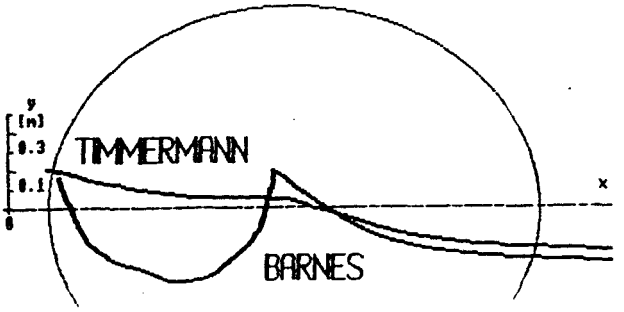


Figure 9:

Regarding the third dimension, we found out a horizontal deviation of the shot path from the straight direction:
- at the preparation phase: TIMMERMANN - 22 cm BARNES - 38 cm
- at the delivery phase: - 21 cm - 28 cm

and horizontal deviation of the shot path from the centre of gravity direction:
- at the preparation phase: TIMMERMANN < 2cm BARNES - 28 cm
- at the delivery phase: 24 cm - 43 cm

Acceleration of some body segments

The main difference in the mechanical principles of the glide and rotation technique of shot putting consist in different concepts of the link-up between the preparation and the phase of the delivery. As well as the acceleration of some body segments is different; but it could help with transfer of momentum to the implement.

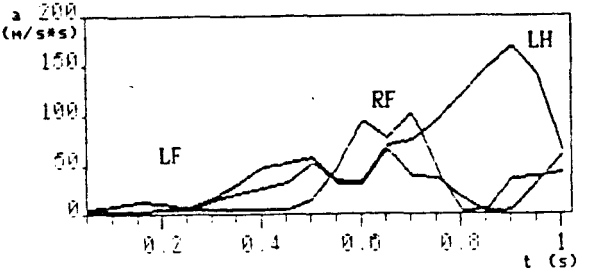


Figure 10: Ulf TIMMERMANN 22,47 m

The glide technique shot putter utilizes a mild linear swing of left hand and left foot at the start phase. He must accelerate the movement of the whole body, including the shot, as a relatively rigid system.

At the glide phase he accelerates only the right foot.

After the touch down of the right foot he tries to have a continuity between the horizontal velocity of the centre of gravity, the swing of the trunk and the touch down of the left foot.

At the left foot landing, the putter musts gradually stop the forward movement of the body and accelerate the swing of the left hand, the rotation of the shoulders and accelerate the shot movement as much as possible through the arm extension.

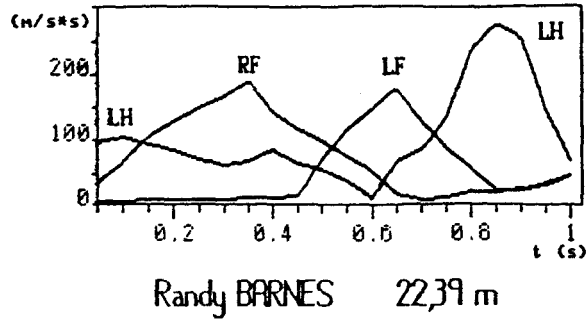


Figure 11:

It the spin technique, the shot putter utilizes a relatively mild swing of the left hand and powerful swing of the right foot at the start phase. He has to give his extremities as much as possible high circumferential velocity.

At the spin phase the rotation movement of the body continues by the swing of the left foot.

In the spin technique, we may observe that the shot practically does not move at the beginning of the transition phase. On the contrary, the putter moves in a rotation around a fictious rotation axis. The shot is on this axis or in its close vicinity. Before the left foot landing the left hand accelerates once again.

At the shoulder rotation and at the final delivery phase the body, with a much higher weight than the shot, acquires relatively high angular velocity. The turning axis of the pelvis precedes the turning motion of the shoulder axis very naturally.

At the moment of maximum orientation of the two axes the movement speed of the most powerful parts of the athlete's body culminates. At the moment of the left foot tread-down, the rotational movement of the lower extremities is stopped. The angular momentum aquired by the rotation movement of the extremities and the body together with extension of the lower limbs and putting arm are transferred to the implement.

CONCLUSIONS

The difference in the mechanical principles of the glide and the turn technique consist in utilizing the different ways of acceleration of the shot:

- the glide technique - prevails linear momentum,
- the spin technique - prevails angular momentum.

Both analysed throwers (representatives of two different techniques: the glide and the spin one) are able to accelerate the shot slightly before the left foot landing in the double-support position.

Probably, the spin technique yields better possibilities for performances as it enables:

- higher increasing of the shot velocity along shorter effective acceleration path,
- to achieve better position of the body at the acceleration phase by natural way,
- better utilization of a swing movements of the extremities.