Comparison of the Glide and the Rotation Technique in the Shot Put

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The I.A.A.F. scientific commission considers the biomechanical analyses of sport technique as one of the ways to improve performance in athletics legitimately. For that reason, an international team of specialists from ČSSR, Germany and Greece was set up for scientific and methodological follow-up of the 1st World Championship of Juniors in athletics (Athens, 1986).

The team was headed by PhDr. Petr Sušanka from Prague. The results were quick, with some available during the event in question. Four days after the championship a bulky report was published (17) containing biomechanical analyses of practically all athletic events. At the same time, an instruction videocassette was recorded to compliment the report by pictures. Findings resulting from this analyses are utilized to compare the back and rotation technique of the shot put.

The theoretical possibilities of shot fall distance with known parameters of the motion during the put release (v_0, a_0, h_0) have already been described several times (4, 9, 10, 19). Even the fact that the air resistance and wind velocity have only a negligible influence on the put flight distance was explained several times (10). Other theoretical studies (2, 6, 18) and analyses of specific throws (6, 7, 13, 14, 15, 16) offer findings from the geometry and kinematics of elite thrower movements. While it is very difficult to bring about changes in the technique of adult throwers, in juniors, similar efforts may help.

At the present time, the shot putters use two techniques:

1. the traditional back technique utilizing the glide

2. the turn technique utilizing the rotation movement.
Very often (and very likely unjustifiably), the first technique is simplified and conceived as a linear motion. The result (only a theoretical one) is the requirement for a linear shot motion.

The second way requires a spatial solution of the analysis (15). This fact might be the reason why some authors, in their theoretical studies (2, 3, 13), lack sufficient kinematic data to evaluate the two techniques. Others suggest all kinds of possibilities on the basis of empirical observations (1, 5, 8, 13, 20). The most frequent reason of rotation technique (9) unpopularity seems to be (apart from the above mentioned lack of data) the very low number of shot putters using it. Nevertheless, it is necessary to think about the possibilities of this way of putting and to analyze it in detail. After all — in long-term shot put standings (1984), seven out of the ten best performances of all times were achieved using the rotation; all of them beyond 22 meters.

Moreover the rotational technique of the shot has become the predominant style of shot putting in the U.S.A. In 1985 and 1986, 7 out of the top 10 performers in the U.S.A. used the rotation. At the 1986 N.C.A.A. championships, both indoor and outdoor, rotation throwers outnumbered conventional ones for the first time (20).

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 analyses. The decisive moment of the put is when the shot flies out of the fingers (in compliance with other authors this moment will be indicated as the zero moment — 0).

The contact with the support is indicated by the arrow (↑ — the moment the support is left; ↓ — tread-down on the support). The letters indicate the respective limb involved in the given moment (P — right-hand lower limb; L — left-hand lower limb). Views concerning the beginning of the final put phase are not united. In our view, this phase begins at the moment of tread-down to form a double-support position (L ↓). The final phase is divided, based on the timing of the shoulder axis swing parallel to the put direction (R II). Approximately in the same way, we divided the share of the lower and upper limbs and of the trunk in the final throw-off effort. The division or distribution of the put with rotation is analogical (1, 5). The starting phase begins when the right lower limb leaves the support (P ↑). The supportless phase (jump-over) corresponds to the shift phase. It begins with the left leg take-off (L ↑). At the right foot tread-down (P ↓), the two technique moments are identical (Table 1).

TABLE 1

Movement timing (t), length of shot path sections (s) height of shot position above the support in crucial moments (z) in relation to selected parameters of shot release

NAME OF PHASE	LUKASHENKO (L.) — URS				CRAWFORD (C.) — USA			
	Crucial moments	t (s)	s (m)	z (m)	Crucial moments	t (s)	s (m)	z (m)
	Z_{min}	0.	—	0,84	P ↑	0.	—	1,36
I. 1. single-support (start)	Z_{min} — P ↑	0,28	0,50	1,05	P ↑ — L ↑	0,31	0,90	1,40
II. supportless (glide)	P ↑ — P ↓	0,11	0,27	1,10	L ↑ — P ↓	0,12	0,17	1,35
III. 2. single-support (transitional)	P ↓ — L ↓	0,08	0,21	1,11	P ↓ — L ↓	0,24	0,33	1,34
IV. 1. double-support (shoulder swing)	L ↓ — RII	0,13	0,41	1,33	L ↓ — RII	0,07	0,17	1,41
2. double-support (delivery)	RII — 0	0,15	1,39	2,18	RII — 0	0,17	1,33	2,10
Length of shot path s_0(m) in phase IV.			1,80				1,50	
Shot velocity at release v_0(m/s)			12,72				12,07	
Angle of shot fly-up a_0(°)			42°				35°	
Height of shot release h_0(m)			2,18				2,10	

For all the above reasons, the technique of the shot put was observed at the 1st world championships (WC) of juniors using the method of spatial cinematography (11, 12). The competition was recorded by two photo sonics high speed synchronous film cameras placed in the direction of the put axis and perpendicular to the direction. By means of teodolite, the optical lens axes were arranged to intersect at the height of 1.3 m above the centre of the throwing circle. Colour negative 16 mm KODAK film was used. The frame frequency was set at 100 fr/s or at 200 fr/s in selected trials. The frame frequency was checked by the light time mark at the edge of the film strip. The real frame frequency turned out to be 102 fr/s. Assignement of individual film frames from individual cameras was carried out by means of the check mark on the other film strip edge. The scale of the projected image was determined according to the prefilmed unit lath (1.0 m). The representation scale was checked by comparing the read coordinates and the throwing-circle diameter (2.135 m).

The number and order of the read anthropometric points was determined by the algorithm of the input data storing. The reading was carried out on manual evaluation equipment and a digital coordinate display (FTVS UK) with a direct output to the pocket calculator SHARP PC 1500. The proper calculation of the spatial point motion reconstruction was carried out (coordinates x, y, z) — just as that of the remaining kinematic quantities (t, s, v, a) — by the method of the centre point determination of the shortest straight line of the two skew lines (11, 12) using the computer (SHARP MZ 3500). The program was based on the requests of the research team and designed by Václav Kohl (Physical Institute of ČSAV).

We chose the film records of two finalists in the 1st WC of Juniors: Alexei Lukadhenko (henceforward only L.) — age: 19 years; body

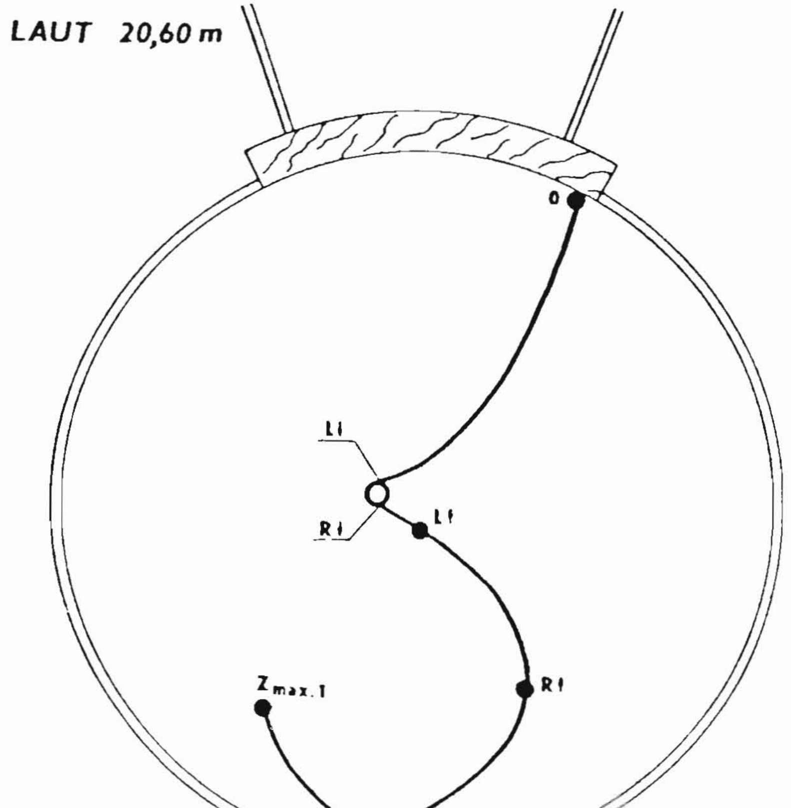

Fig. 1

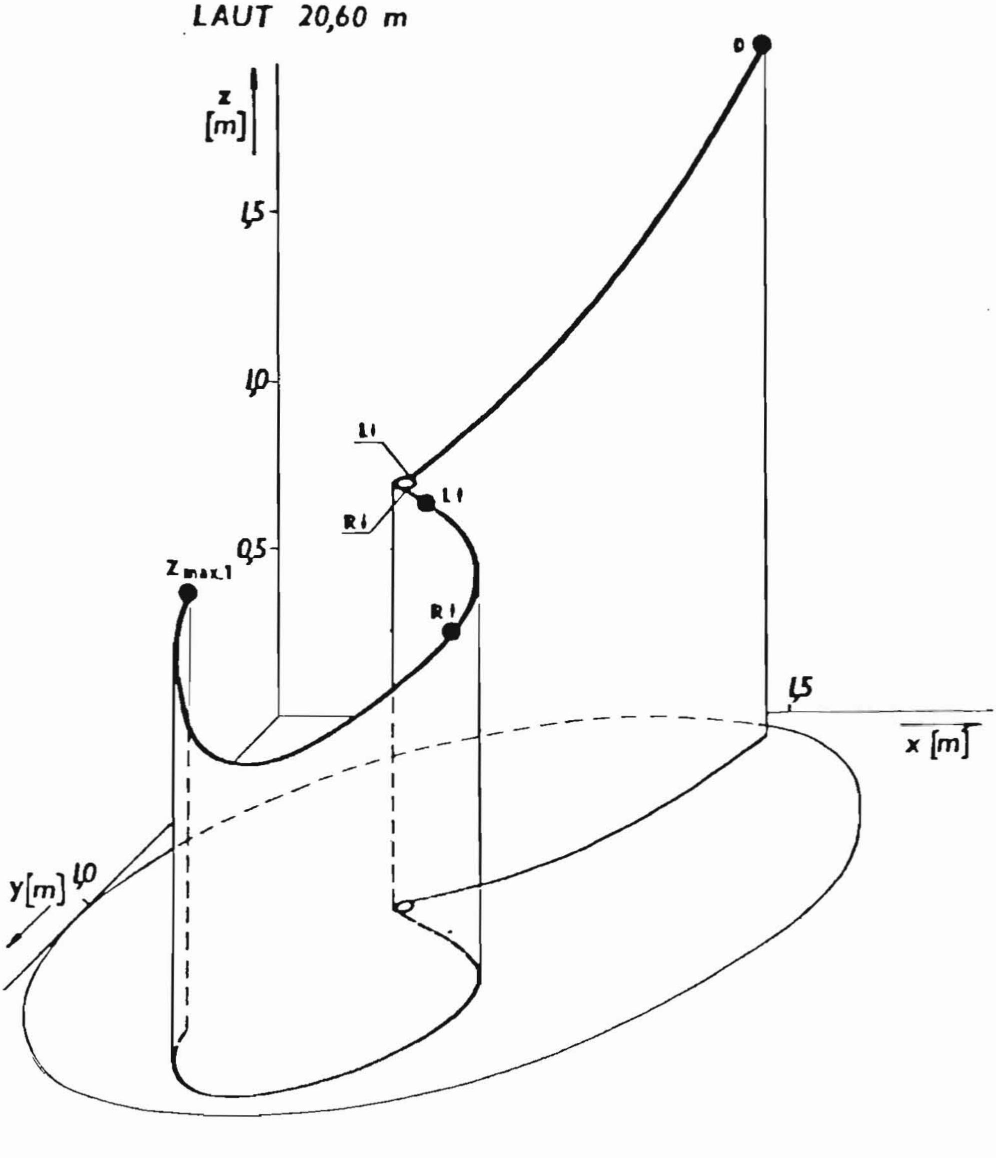

Fig. 2

height: 190 cm; weight: 102 kg. He is the representative of the glide technique. By his performance of 18.90 m he became the junior world champion. For the analysis his 2nd attempt — 18.44 m — was chosen.

For the rotation technique the subject was Darren Crawford (henceforward only C.) — 19 years; 193 cm, 109 kg. In the entire event he had only one valid attempt (16.14 m) and he did not qualify into the finals. He ranked 10th. For technical reasons his longest attempt could not be chosen for analysis. Consequently we chose one of the foul throws (3), which was a performance of about 16.50 m. The height of the two putters is a little higher than the average value found in the finalists (188 cm). The weight of the two, on the other hand, is under the average (112 kg). The performance difference (2.3 m) was not regarded as signigicant for the objective of our work. Our comparison of the two techniques is a follow-up of a similar experiment carried out in adult putters (Sarul-Laut) at the 1st WC 1983 (15).

As far as the shot path is concerned, we can observe in the two ways of shot putting quite distinctive differences in the preparatory phases (I. - III.) and, on the other hand, an unexpected similarity in the final phase of the put (IV). The graphic representation of the spatial reconstruction of the shot path is on in Figures 1.-3. From the point of view of the shot path

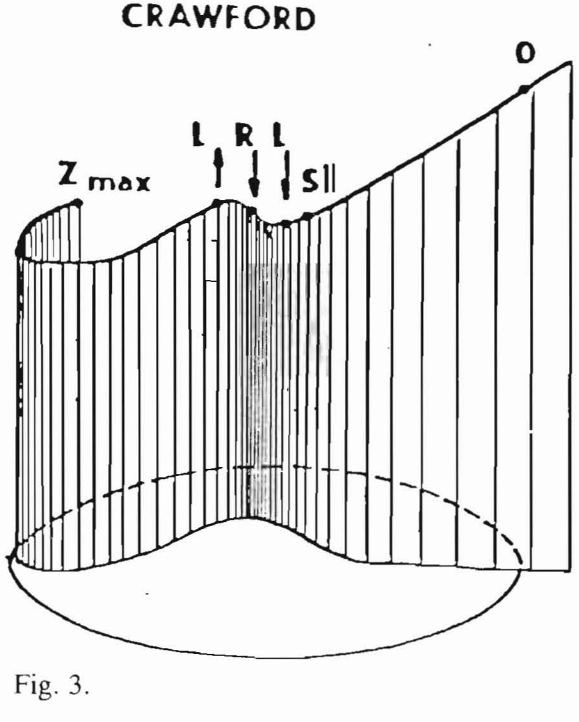

Fig. 3.

projection into the perpendicular plane, the shot path character (L.), corresponds to previous findings (6, 7, 13, 14, 15, 19). By its form it approaches the straight line. The low position of the put at the beginning of the starting phase (Z_{min}) and the relatively continuous, gradual increase of its height (Z) — shows a good utilization of the lower limbs strength. From the point of view of the third dimension, we establish a horizontal deviation from the straight direction up to 0.45 m. Other authors (7) indicate the range of this deviation from 0.20 to 0.40 m — depending on the throw technique. This motion results from the shoulder axis rotation; it cannot be qualified only as a technical error.

In accordance with our previous findings (15) and contrary to other authors (2, 3, 5, 8), the shot path can be characterized in the following way when using the rotation technique (C. — Fig. 3). As already indicated, the initial movements, from the upright posture to the beginning of the put till the moment of the right-hand foot leaving the support (P ↑), do not have an influence on the put in any considerable way; that is why we do not intend to deal with this phase. The shot path direction has then a shape of two matually linked arcs (P ↑ — P ↓) and (L ↓ — O) with great curvature radii connected by a small arc (P ↓ — L ↓) with a very small radius. Consequently, in the rotation technique concept, no loop can be observed. A number of authors (2, 3, 8) saw further possibilities of shot acceleration along a longer path. On the other hand, even in the rotation technique we observe the tendency to gradually straighten the shot path. It is no accident that the lateral deviation in the first part of the put (at C.) is only a little bigger (0.49 m) than in the second (0.45 m), where it is totally identical to the compared put with shift (L.). A moderate drop of the put in moments P ↓ and L ↓ is an obvious technical mistake and will have a negative impact.

The length of the partial put path segments (s) in relation to the motion time (t) in the individual put phases gives us further information about the character of the two ways of shot putting (Table 1). Fast execution of the initial phases (start and shift) as well as reduction of losses in the transition phase (III) represent positive elements of the technique of L putting. The relatively long time of shoulder swing bears witness to the effort to utilize rotation only in the decisive phase of the put; it brings about losses in the effective path length which is no longer utilized for acceleration.

L engages the lower limbs and the putting arm gradually and uniformly. This is documented by the well-timed final jump over.

The theoretical requirement (2, 18, 19) for the preparatory phase of the put with the shift (I. - II.) is well satisfied (Fig. 5). The velocity begins dropping moderately before the end of the take-off (P ↑); it seems this is due to a weak, short shift (tread-down in the rear half of the circle). Before the tread-down of the left foot (L ↓), the velocity starts increasing moderately due to the premature and only partial shoulder axiš swing.

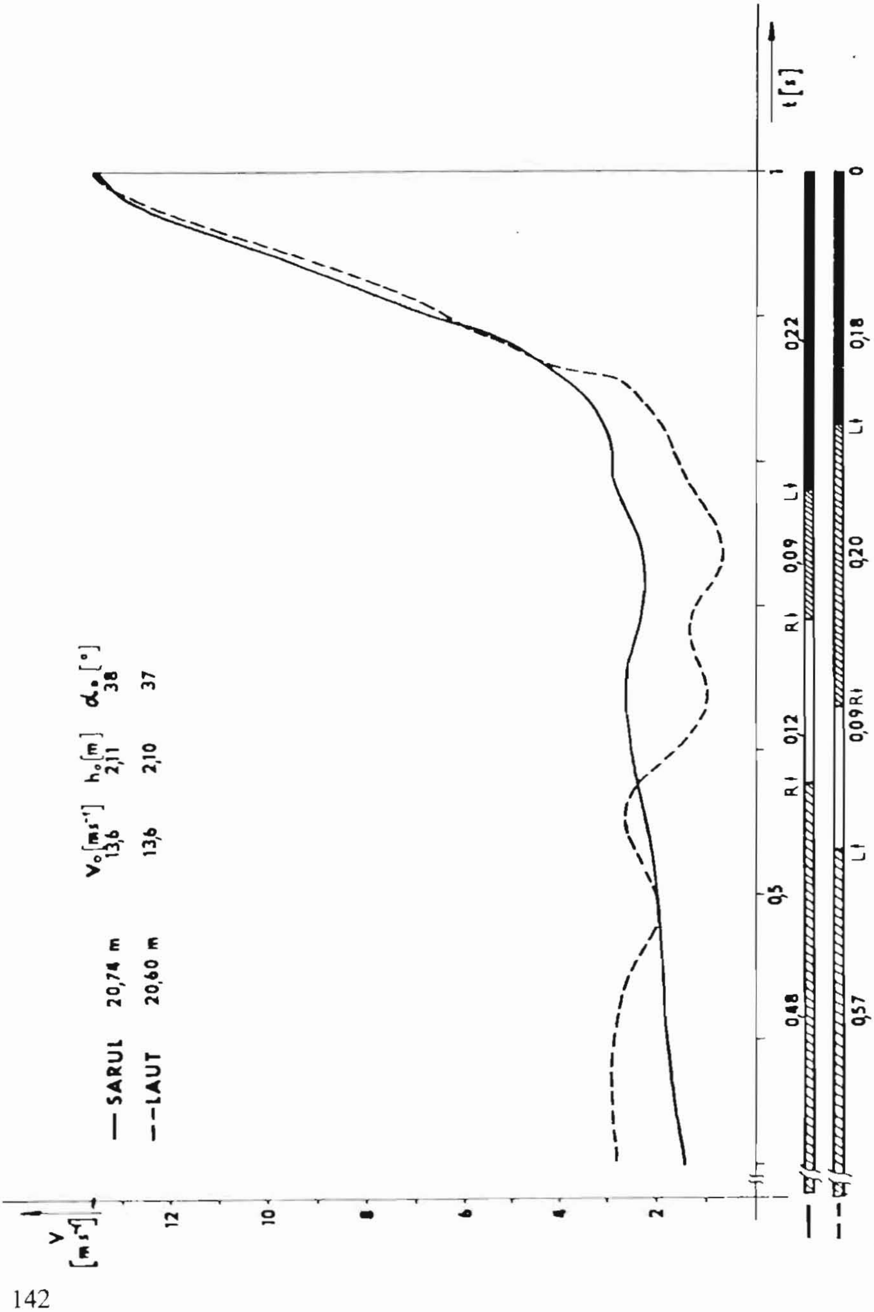

Fig. 4

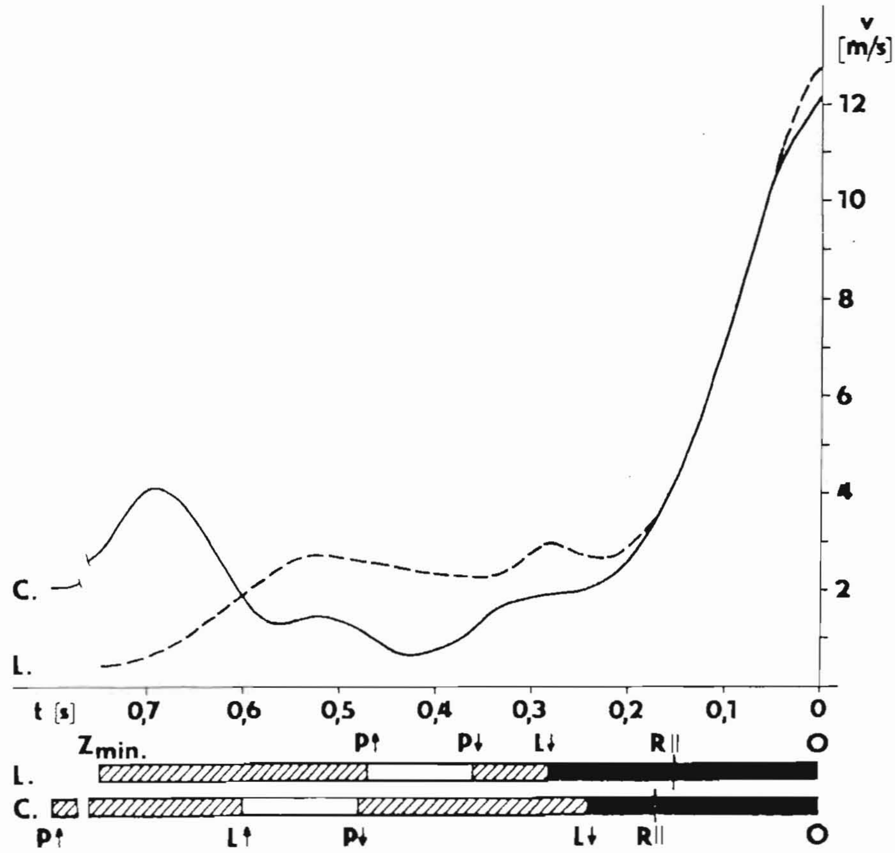

Fig. 5

After the tread-down of the left foot (L ↓) it starts dropping again. Shortening the effective length of the shot path in the throw-off phase (IV) from 1.80 m to 1.72 m and the consequent shot speed reduction reduces the performance; it can be said that L. is representative of the modern back technique. With all the above deficiencies removed, he may achieve outstanding results.

The rotation technique is based on a different mechanical principle; different is also the time structure of the movement (Table 1). The initial movements are not so fast (L), yet the shot covers nearly 1 m and the speed in the starting phase already exceeds the limit of 4 m/s. The putter turns on the tip of his left foot, he leads the right foot in a wide circle to the circle centre. At the same time he inclines his body in this direction. The take-off is completed by an extension of the left lower limb at a moment when the right foot and the upper part of the body are above the place of tread-down. In this way it is possible to cut down the ineffective part of the flight phase duration (L ↑ — P ↓) as well as the put path. The velocity of the put motion (I. - II.) drops considerably before the take-off completion by the left foot (L ↑). The reason is trunk inclination. Another moderate velocity drop can be observed at the moment of the right foot tread-down (P ↓) when the athlete turns on the pad of the sole and the angle of shoulder axis swings in relation to the pelvis axis which begins increasing. At the same time, the friction of the right sole against the support culminates. The velocity drops under the limit of 1 m/s. Owing to high mobility of the left lower limb and the above mentioned orientation of the shoulder and pelvis axis, the put acceleration begins already before the left foot tread-down (L ↓). The longer duration of the transition phase does not reduce the shot velocity. After the left foot tread-down (L ↓), the velocity does not drop anymore (as in L.). Quite the contrary, from the moment of the double-support posture, it increases rapidly. The angle of the shoulder axis orientation in relation to the pelvis axis reaches maximum (more than 50°). The effective path length of the shot increases according to the functional shot speed course compared with the mechanical read-out at the moment of left foot (L ↓) tread-down from 1.50 m to 1.61 m. The losses of the shot motion speed increments closely before its release are caused, quite probably, by an early jump-over in the final phase of the put. Due to too high a position of the put at the moment of the left foot tread-down (L ↓), the value of the throw-off angle deteriorates. As a result, the throw-off velocity (v_0) is lower.

The main difference in the mechanical principles of the back and rotation technique of shot putting consists in different concepts of the link-up between the phase of movement (I. and II.) and the phase of the put proper (III. and IV.). The putter using the shift technique tries to achieve the highest velocity. He tries to have a continuity between the rotation of the shoulders, the swing of the trunk and the forward straightening of the throwing arm. In the rotation technique, we may observe that the shot does not move at the beginning of the transition phase. On the contrary, the putter moves in a rotation around a fictitious rotation axis. The shot is on this axis or in its close vicinity. The body, with a much higher weight than the shot, acquires a relatively high angular velocity. The turning axis of the pelvis precedes the turning motion of the shoulder axis. At a moment of maximum orientation of the two axes the movement speed of the most powerful parts of the putter's body culminates. At a moment of the left foot tread-down, this movement is stopped. The kinetic energy acquired by the rotation movement of the body together with the lower limbs help straighten the putting arm.

CONCLUSIONS

1. The method of spatial cinematography has a sufficient informative value. For that reason, it is suitable to use it when analyzing movements which, until now, were analyzed only as planar movements.
2. Analyses of the sports performances of our best junior putters showed the top quality of their sporting technique and confirmed once again the necessity of systematically developing technique training during youth preparation.
3. Comparison of the back and rotation technique in the shot put of juniors confirmed that the mechanical principles and characteristic features of the two techniques are similar.
4. The difference in the mechanical principles of the back and rotation technique consist in different execution of the preparatory phases and connection of the put proper.
5. The rotation technique yields better possibilities for performances as it enables lengthening of the effective shot path to be utilized for acceleration of the shot before the tread-down.
6. At elite sports events putters using back technique usually win. This technique is less demanding and its training requires less time than the rotation technique.

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