NSA 1: 44-60, 1990

Model technique analysis sheets for the throwing events PART IV: The Shot Put

Günter Tidow

4.1 Introduction

The statement that the rotational technique is a genuine alternative to the linear technique (see box on page 44), is only true as far as the preliminary acceleration of the system 'putter-implement' is concerned. In any case, the starting position (with hips and shoulders square to the rear), level of acceleration and power position of the rotational technique are closely related to the O'Brien technique or even derived from it. Therefore, in this article and the accompanying anyalsis sheet, the phases of the 'original' linear technique will be presented and discussed as a basis as it were.

In Figure 1 (see p.46), the reader is given a general impression of the O'Brien technique.

4.2 Starting position and preliminary movement

The initial phases serve to lower the total system 'athlete-shot': The 'starting point' of the diagonally rising acceleration path is only reached with the transition from phase 3 to phase 4 (see Fig.2 on p.46). The downward directed preliminary phases (phases 1 to 3) will not be discussed in detail here, the reasons being:

- there is no significant relationship between

Translated from the original German by Jürgen Schiffer

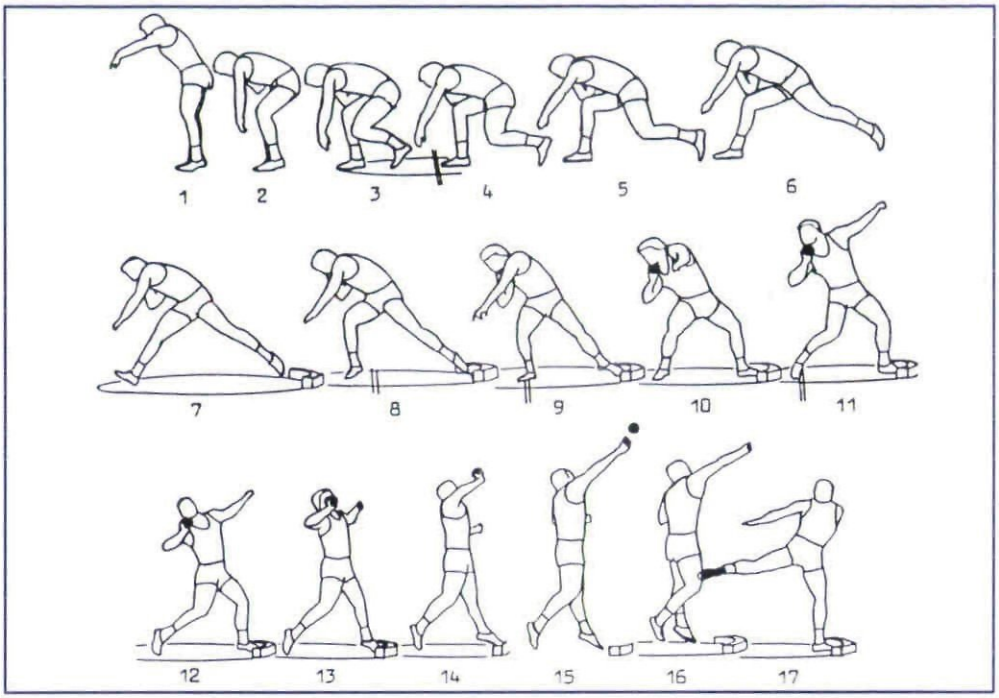


Figure 1: The O'BRIEN technique divided into 17 phases (athlete: P. SHMOCK [USA])

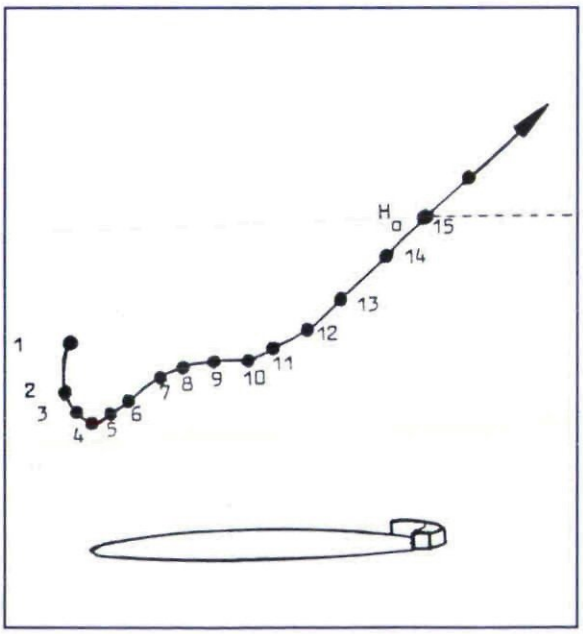


Figure 2: The path of the shot in a 20m put. This put is the basis of the technique model described in the analysis sheet. Each numbered dot represents the position of the shot in the respective movement phase in chronological order.

- Phase 4: starting squat
- Phase 7: beginning of glide
- Phase 9: power position
- Phase 15: delivery.

In phase 4 - i.e. the lowest point of the path - the shot is approx. 82 cm above the level of the circle. It is delivered at a height of 227 cm. The angle of release is 41°, the preliminary acceleration path (phase 4 to 9) is 90 cm long, and the main acceleration path (phase 9 to 14) is 182 cm long. Between phase 4 and 9, the shot is lifted 36 cm, from phase 9 to the delivery `lift' is 109 cm (athlete's body height: 1,90 m).

the quality of the preliminary phases and the throwing distance;
- there have always been athletes who, after the preliminary phase, rest for a short time in the so-called starting squat and only then really start the glide from this low position.

Although a fluent overlapping of the preliminary phases and the beginning of the glide seems to be more efficient and to lead to a lighter load on the supporting leg, these aspects seem to be relatively insignificant taking into account the strength levels of current specialists and the transmission losses that must be compensated for after the glide.

Therefore, the use or non-use of the T-position - which scarcely influences the shot path - will not be further dealt with here. The comparison of both preliminary phases presented in Figure 3 (see p.48), shows that both variants lead to an identical crouch position, called the starting crouch.

Doubtlessly, not using the T-position is the more direct way to attain the crouch position and although the two-footed position at the rear of the circle gives the athlete a greater feeling of security, there are some points which favour use of the T-position. It anticipates the extension of the swinging leg - which is necessary at the beginning of the glide - on a 'higher level' as it were. This results in a preliminary rhythm that can easily be performed particularly by learners: extension (into the T-position) - lowering (into the starting crouch) - extension (action of the swinging leg at the beginning of the glide).

As already mentioned, all this is unimportant as far as top level athletes are concerned; it should, however, be taken into account when teaching the glide to beginners.

4.3 From the starting crouch to the beginning of the glide

The starting crouch is a favourable position for the putter to direct the line of propulsion of the implement right from the start to the optimal angle of release and to accelerate the total system efficiently. This is done primarily by a 'low' vigorous use of the swinging leg in the direction of the stopboard, which leads to this leg's complete or almost complete extension. The term 'low' is used because, deviating from the original O'BRIEN technique, the knee of the swinging leg is no longer moved to the knee of the support leg, but to the calf (see Figure 4.1).

So an almost flat push backward of the (lower) swinging leg, which is almost parallel to the ground, is possible. This action of the swinging leg, which through the pull at the pelvis leads to a backward and downward movement of the total system, is partially overlapped by the push-off of the gliding leg. This push-off is done vigorously and is aided by the downward pull of gravity. In other words: the impulse of the swinging leg, which is directed diagonally downward, triggers of a 'fall' backwards, which is actively enforced by the almost simultaneous extension of the driving leg (abbreviated by "g" on the analysis sheet). The result of this 'joint action' of swinging and driving leg as well as gravitation is the taking up of another sort of T-position that, contrary to the T-position mentioned above, is 'tilted' toward the stopboard (see Figure 4.5). This tilt is caused by the fact that (normally) contact is broken at the back of the circle by the heel (see Figure 4.5). This position is sometimes called the A-position.

If the free arm is held downward in front of the body, it is guaranteed that the 'closed' trunk position of the starting crouch is not changed (see Figures 4.1 to 4.5). This is very important because the shot - as well as the shoulder axis - must stay behind the pelvis when, during the glide, this is rotated 90° in the direction of the throw. This rotation of the pelvis is anticipated as it were by a slightly outward turned foot of the swinging leg (see Figure 4.5). This means that the extended swinging leg performs a slight outward rotation so that the foot is grounded (at the stopboard) in the optimal position.

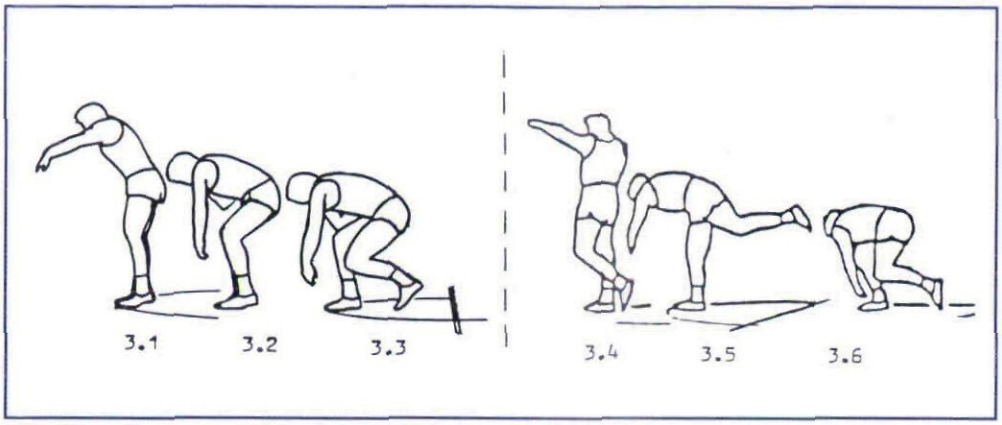


Figure 3: The preliminary movement with (3.1 to 3.3) and without T-position (3.4 to 3.6). In both cases, the total system is lowered against the (normal) throwing direction in order to get into the 'starting crouch' (see 3.3 or 3.6). In this position, the 'first one-legged support phase' is begun, which is also the starting point for the diagonally upward directed path of the shot

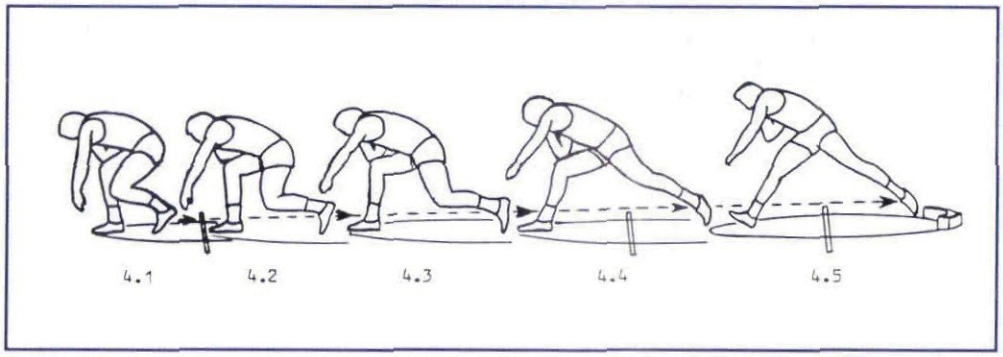


Figure 4: The first one-legged support phase from the starting crouch (4.1) to the beginning of the glide (4.5)

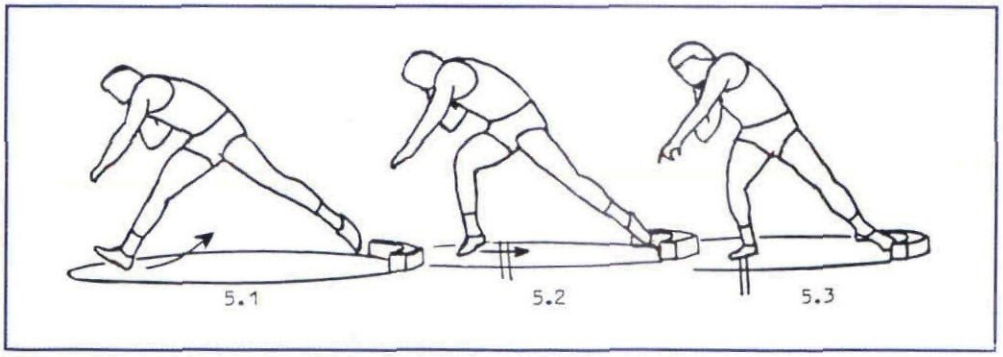


Figure 5: From the beginning of the glide (5.1) to the power position (5.3)

4.4 From the beginning of the glide to the power position

The fact that, in the O'Brien technique, the path of the shot can be divided into three phases, as indicated in Figure 2, inevitably results in a deviation from the theoretically ideal straight line path of propulsion. The 'curved path', demonstrated in Figure 2, is primarily caused by the fact that the excellent, diagonally upward directed phases of preliminary acceleration (phases 4 to 7; see also Figure 4) and the corresponding phases of final acceleration (phases 10 to 14) are connected by a mid-phase. This mid-phase is represented by the contourograms in Figure 5.

The main cause of this 'saddle' (cf. Gehrmann 1981) is that the first positive acceleration phase is completed when phase 7, which is shown in figure 5.1, is reached and the 'passive' (when compared with the velocity curve of the total system) glide begins. It would be possible to achieve a quasi linear continuation of the first path of propulsion, by a continuous rising of the trunk during this phase of support without drive However, such a movement behaviour - which is sometimes demonstrated even by top level putters - would inevitably lead to a *relatively high position of the shot in the* following performance-determining power position. The power position is decisive for throwing performance, since 90% of the distance thrown with a glide can be reached from the standing position alone. A shortened acceleration path in the power position would certainly offset the advantage resulting from the almost linear rise of the shot.

So the gliding phase - in the course of which the shot travels about 30 cm and is accelerated to 2 to 3 m/sec (cf. Ballreich & Kuhlow 1986) - is primarily used for two other tasks. The first task is to cause a rotation of the pelvis by contraction of the oblique trunk muscles, until the pelvic axis points exactly in the normal throwing direction. This leads to a pre-stretching of the antagonistic oblique external and internal (abdominal) muscles. When taking up the power position, the shot putter is therefore in a 'torqued state'. The build-up of this torque is made possible through a strong 'freezing' of the trunk position during the glide. The 'closing' action of the free arm against the throwing direction (see Figures 5.1 to 5.3) supports this movement. From this it follows that, in the case of an optimal performance of the glide, the shoulder axis remains square to the normal throwing direction until the foot of the swinging leg hits the ground right in front of the stopboard.

This can, however, only be realized if *this (front) foot is grounded almost* synchronously with the rear foot (as demonstrated in Figure 5). Only then can the 'transition phase' (cf. Bauersfeld & Schroeter1986) be left out. The term 'transition phase' is used for describing the time interval between the landing of the gliding foot in the centre of the circle and the grounding of the swinging foot at the stopboard.

As early as 1972, top class putters showed a tendency to shorten this phase (cf. Kuhlow & Heger 1975). If, right at the beginning of the glide, the swinging leg is flatly and accurately directed to the stopboard, the 'landing-asynchrony' - and together with this the transition phase - can be reduced to a few milliseconds at the most. Only so can the driving leg take up its turn-push function against the resistance of the left leg without loss of time.

Next, during the glide, the rear leg must pass rapidly from full extension to flexion, in order to get into an effective position as a driving force, once the power position is reached. This flexing coincides with the rotation of the hips described above. The movement produced in this process resembles an 'underswing' that is performed actively and fast by the lower part of the rear leg with a simultaneous inward rotation of the foot. At the same time, this foot is tilted downwards. At the beginning of the glide the last contact with the surface of the circle was made by the heel, but it is the ball of the

foot that first contacts the ground at the end of the glide

In order to avoid frictional losses and braking effects during the glide - in the course of which the rear foot travels about 70 cm (measured from the heel to the tip of the foot) - a low, shallow hop (as presented in Figure 5.2) is more useful than a continuous contact with the ground as is suggested by the term 'glide'.

4.5 From the power position to the sideways putting position

The primary function of the glide is to shift of the total system to the front half of the circle. The secondary function is to achieve an optimal position for the following main acceleration. The power position provides the putter's effective stance. The term 'power position' implies an immediate, explosive effect on the shot. On closer examination, however, the situation is different. A further reason for the deviation of the shot from the ideal path mentioned above is the fact that the putter must delay the 'lifting' of the shot until he has shifted his pelvis (through a turning and pushing action of his rear leg) into the 'bridge position'. Only when both legs have firm contact with the ground and the free leg can fulfil its resisting function at the stopboard, may the athlete - while continuing to turn and push - begin to raise his trunk and the shot. The clearly visible rise of the shot in phase 11 (see Figure 6.3 on p.51) indicates this process. The importance of the turn and push is based on functional-anatomical reasons: Only a two-legged, firm support allows the athlete to conserve or even intensify the pre-tension of the trunk, that has been achieved in the power position. Here the shift, caused by the primarily horizontally directed turn and push, must first be applied to the pelvis so that the trunk remains low and behind the 'driving' leg when the bridge position has been achieved. Only so can three separate tasks be optimally fulfilled:

1. The putter must perform a pivoting movement in order to move from the back to the frontal position.
2. The putter must also perform a lift and extension movement in order to achieve the optimal release angle of the shot.
3. The putter must shift his bodyweight in order to move from the power position ('from the rear and low') to the throwing position ('to the front and high').

The difficulty is that all of these tasks must 'actually' be fulfilled at the same time.

The 'overlapping' of the shift, pivot and lift resulting from this cannot be altered as far as their sequence is concerned: The horizontal shift and rotational movement of the pelvis during the glide are immediately continued by the rear leg as it lands in the power position. The turn-push that is necessary for this takes the athlete into the bridge position and after this into the sideways position. Many athletes, such as Werner GÜNTHÖR (SWI), make this a turn - tilt - push, because the leg extension can produce acceleration only if the knee is in front of the foot. The trunk, which, in the power position, was quite low and behind the driving leg, 'follows' this change of position. The active raising of the free arm supports this simultaneously performed turn-push movement. The process described here becomes clear if one compares the position of the free arm and driving leg in the power position (see Figure 7.1) with that in the sideways position (see Figure 7.3).

In order to avoid an early 'opening', the putter should direct his eyes toward the rear during the turn-push. In doing so, he avoids the 'running forward' of his putting shoulder. Correspondingly, the perpendicular projection of the centre of gravity of the shot should meet the ground near the driving foot, which guarantees an effective and long 'shoulder hit' from the sideways position (see Figure 8 on p.52).

If one considers again the path of the shot presented in Figure 1, it becomes obvious that only in the sideways position a

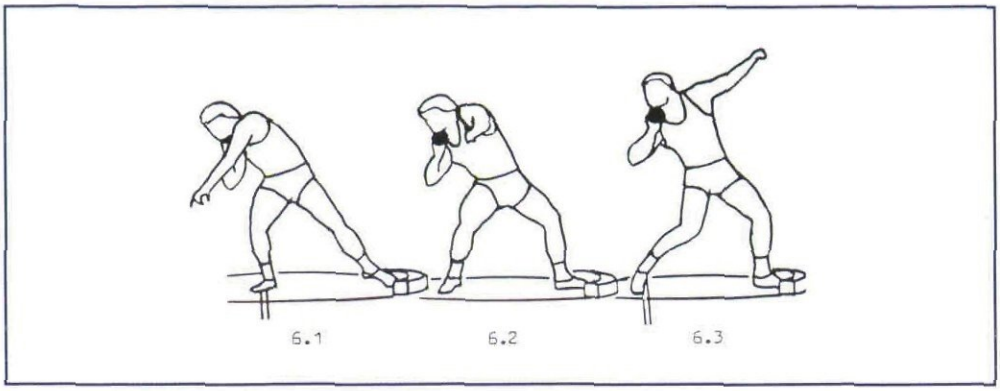


Figure 6

lifting movement starts that is exactly directed to the release angle. This leads to the conclusion that the sequence 'shift', 'pivot' and 'lift' mentioned above is indeed true.

Beginning the lift immediately after having reached the power position by an extension of the driving leg (particularly favoured by putters whose trunk muscles are not so strong) results in a decrease of performance: A good 'bridge' position cannot be developed in this way. Correspondingly, it is inevitable that the main acceleration phase becomes a 'one-legged put'. A possible pre-tension of the trunk cannot be conserved or made use of since the front foot only touches the ground lightly and for a very short time. The result is that this leg can neither be used as a lever nor as a driving force for the explosive final extension of the whole body. The immediate, vertical extension of the driving leg also leads to neglect of the pivoting movement. Consequently, the trunk must be used as 'motor' and pulls the lower body along with it. This is, however, a perversion of the correct movement process.

The solution regarding the behaviour of the driving leg presented here has been disputed for a long time. So Werner (cf. Werner 1965) and Heger (cf. Kuhlow & Heger 1975) favour the vertical extension of the driving leg while Grigalka, (cf. Grigalka 1980) recommended that the

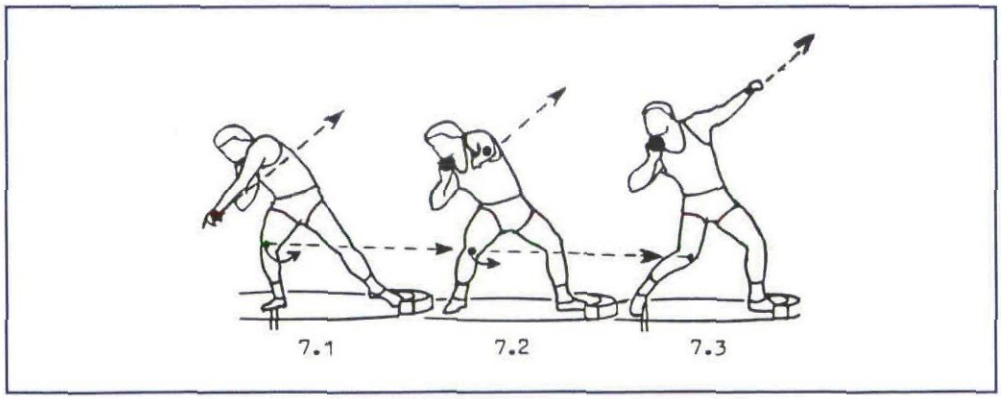


Figure 7: Turn-push of the gliding leg and 'diagonal rise' of the free arm. These two actions take place almost simultaneously

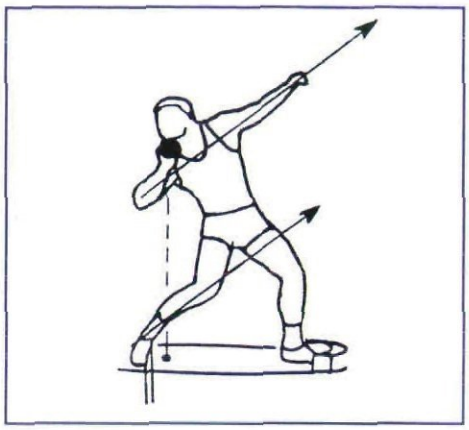


Figure 8: Sideways position as starting position for the 'lift'. The arrows show that the lines of the shoulder axis, putting and free arm as well as the lower part of the driving leg are now parallel. Even here, their direction is identical with the release angle

extension of this leg "... should be simply forbidden". However, the statement made by Lindner as early as in 1967 remains irrefutable, namely that the parallel curve of shot and pelvis in the movement phase under discussion is characteristic of "the less qualified putting technique" whereas specialists demonstrate a rather opposite trend. This means that, in the case of specialists, the shot rises while the pelvis is slightly lowered (cf. Lindner 1967). This finding at least indirectly confirms the justification of the Grigalka's 'ban on the extension of the rear leg' in the movement segment under discussion.

Figure 9 was constructed in order to verify this statement. The characteristic lines in this figure have been drawn on the basis of a put by the former Olympic gold medallist and world record holder Randy Matson (USA). The comparison of the lines shows that, at the beginning, the path of the shot runs parallel to the ground (phases 1 to 3). Then it rises slightly (phases 3 and 4) and finally steeply, while, simultaneously, the pelvis and the knee of the driving leg move slightly downward.

Doubtlessly, the cause of this is the turn-push of the driving leg, as has been mentioned several times in this article. A vertically upward directed extension of this leg, during this phase at the start of the power position, cannot be seen in the majority of the current top level shot putters.

The occasional persistance of an immediate extension impulse is, apart from strength deficits, perhaps also caused by a wrong over-emphasis on the standing put, both during the learning stages and in technique training. It goes without saying that the quasi 'static conditions' of the standing put make a basically different, primarily vertical use of the rear leg appear sensible. Much repetition of the standing put could lead to the development of a motor stereotype that could also show itself in gliding puts. In any case it is considerably easier to perform the turn-push when some momentum has been gained. This note should, however, not hide the fact that, even in standing puts, the athlete must also perform the initial 'shifting work' in a primarily horizontal direction.

4.6 From the sideways stance to the delivery

The sideways stance, which, in fact, can be observed only for a very short time, is the starting position for the explosive-ballistic final acceleration of the shot. Since at this moment the acceleration of the trunk is greater than that of the pelvis, the torque between shoulder and pelvic axis is released during the 'lift'. So in the frontal position - which from now on is called 'delivery position' - both axes are parallel to each other and vertically above each other. The explosive extension of the putting arm should take place only after the abrupt stopping of the free arm which had been pulled diagonally upwards. This abrupt stopping produces an additional positive acceleration of the putting shoulder. After the energetic 'pull upward' along the line of the release angle, the free arm is bent at the elbow and fixed at the side of the trunk. In Figure 10

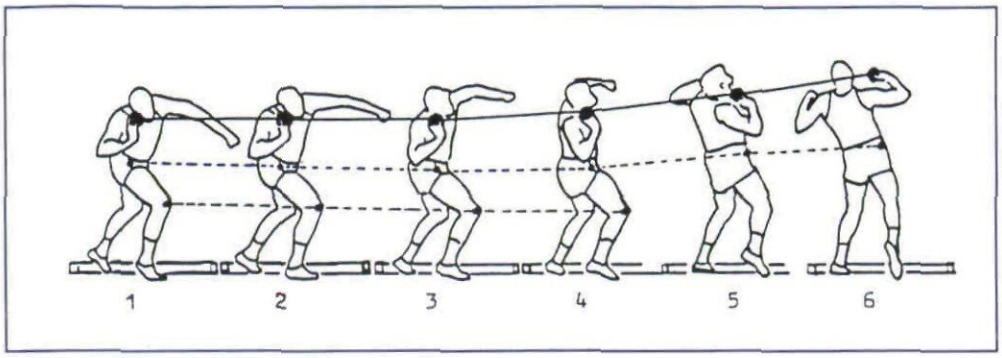


Figure 9: Movement behaviour and resulting characteristic lines of the shot, pelvis and the knee from the power position to the delivery position. The comparison of the lines makes their opposite course obvious (figure according to TIDOW 1983)

this movement process is presented in three phases.

It becomes obvious that the demand made above that the putting arm should only be extended when the putter's breast/ shoulder axis is square to the (normal) putting direction is not fulfilled completely (see Figure 10). The premature opening of the elbow joint of the putting arm, which is already indicated in phase 10.3, is sometimes more pronounced in the case of throws between 21 and 23m. It is unlikely that this *is a simple fault. The presently achieved* load- strength relationship might rather be so favourable that an 'ideal' arm movement, i.e. an arm movement that is optimal as far as timing is concerned (see Figure 11), could even lead to a reduction of distance.

Since nowadays the best putters are able to perform one-arm lifts with 100 kg weights (bench press), 7.25 kg shots are in the area of 7% (!) of the maximal strength of the putting arm. If the relative explosive strength has been optimally developed under these conditions, it at least seems to be possible to coincide the delivery movement with the 'shoulder hit'.

Regardless of the time of innervation and the speed of contraction of the extensor muscles of the arm, it is an elementary rule to lift the elbow of the putting arm at least to

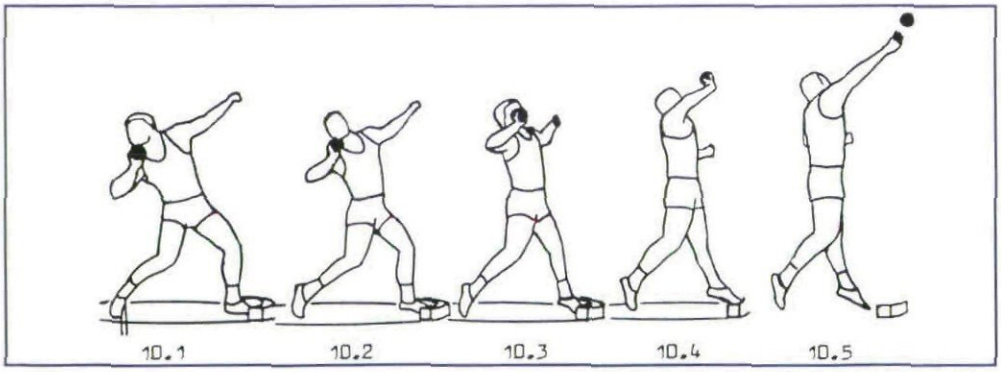


Figure 10: From the sideways stance (10.1) through the delivery position (10.3) to the actual delivery (10.5). The movement section depicted here takes only 150 ms. Sideways stance and frontal position (10.3) are therefore only very short 'transition phases'

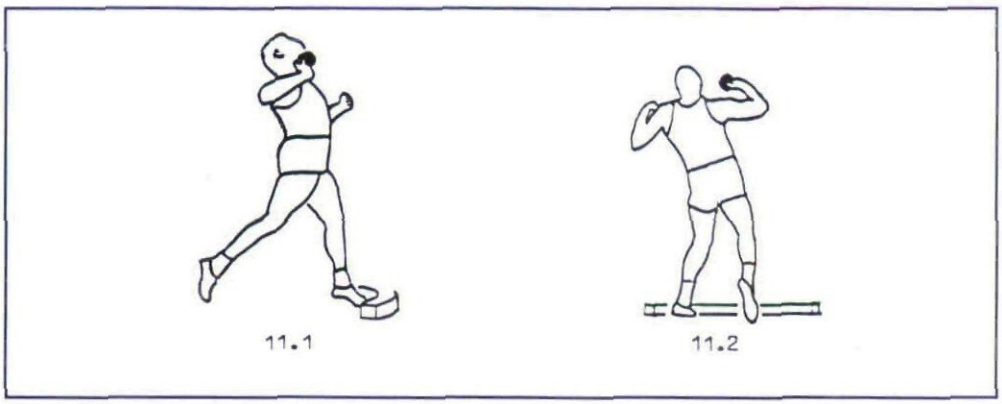


Figure 11: 'Ideal' delivery position from side and rear. Figure 11.1 shows the pre-tension of the chest muscles and the still clearly bent putting arm, which has been lifted to shoulder height. Here, putting hand and shot are in front of the shoulder

shoulder height after the shot has passed the shoulder (see Figures 10.1 to 10.5 and Figure 11).

The reason for this rule is that the raised elbow guarantees that the whole body stays behind the implement all through the delivery action. It also permits a final impulse to be given to the shot by means of a 'horizontal' volar flexion of the wrist (see Figure 12).

If the putter imagines that, directly besides or in front of him, is a shoulder high ball of foam material, which he is not allowed to contact with his putting arm, he will generally succeed in achieving the correct high elbow position. However, this is only true if sufficient torque has been built up in the power position and if this torque has not been released too early. The following fast swing of the shoulder axis into the delivery position will then press the shot into the putting hand firmly enough. Otherwise the elbow must be lowered to prevent the shot falling from the hand.

During the delivery itself the whole body should be extended (see Figure 13). In this way it is guaranteed that the final extension impulse of both legs, which is mainly vertical, really 'hits' the shot.

A falling away or lowering of the hips would shatter this intention. In any case the putting arm needs a firm support in order to utilize its power effectively. The locking of the free arm, already mentioned, is another essential element of the build-up of this support, which is completed by the firm locking of all trunk muscles. In this way, a too great rotation of the shoulder axis can be avoided, and a bending of the trunk toward the side of the free arm can be eliminated.

The required rapid extension of the whole body also contributes to the maximization of the release height Ho. This parameter influences the throwing distance of the shot in direct proportion to height (cf. Ballrecich & Kuhlow 1986).

Whether the delivery should be done with or without ground contact of at least the front support leg is hardly disputed any longer. It is also undisputable that, when 'springing out the shot' (Nett 1969), the athlete's body must compensate, according to Newton's law, for the 'action' of the putting arm. However, the disadvantage arising from this is obviously more than compensated for.

A delivery without ground support makes a dynamic 'follow-through' possible because only then can the following 'reverse' be performed with the whole body in the putting direction. Moreover it seems unavoidable for the shot putter to lose the contact with

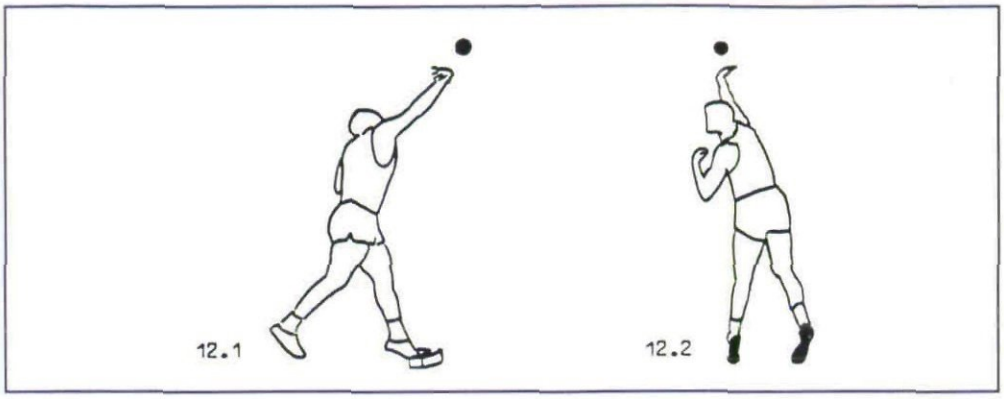


Figure 12: The release of the shot. Here the elbow of the putting arm is lifted, and the wrist of the putting hand is in volar flexion. This movement is directed horizontally and outward

the ground just prior to the delivery, if the power and coordination of the extensor muscles of the leg and hips are to be fully expoited.

If one analyses the movement behaviour of the current top level shot putters, it becomes obvious that the majority deliver the shot having lost foot contact. In contrast to this, the result of the analysis of the women's shot put is not so uniform. Hypothetically it can be assumed that here, because of a clearly more favourable strength-load-relationship (bodyweight approx. 85 kg/shot weight 4 kg = 21:1 as compared to 116 kg/7,26 kg = 16:1), the acceleration conditions are different. This makes a slinging movement of the trunk, which is similar to that in the javelin throw, possible. This slinging movement of the trunk is facilitated by a rangey power position with a strong pre-tension of the trunk and a "genuine" use of the bracing leg. This is particularly the case when the short-long rhythm is used. The fact that some female shot putters do not lift the elbow of their putting arm higher than their shoulder further supports the assumption that the difference in the men's and women's movement behaviour mentioned above is indeed true.

Whether these characteristics can be attributed to different teaching methods must remain an open question. The fact that in many countries - but not everywhere - there are men's and women's shot put coaches who, separately from each other, rather intuitively develop optimal movement patterns and variants of solution in close cooperation with their athletes supports and explains the tendency for differentiation mentioned above.

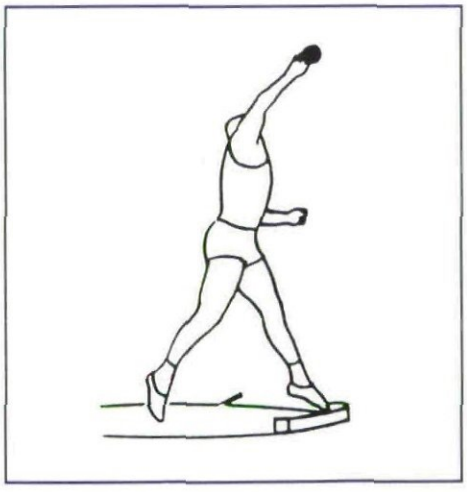


Figure 13: Delivery of the shot. The accentuated loss of contact with the ground shown in this figure is typical of the *movement behaviour of current top level* shot putters

4.8 Delivery and reverse

The explosive extension of the leg, which leads to the delivery of the shot, and the long 'shoulder hit' almost automatically lead to the reverse. During the reverse the rear leg is brought forward to a spot close to the stopboard where, just prior to this, the foot of the front leg has been. The main function of this movement behaviour is to avoid stepping over the stopboard. However, additionally, this movement makes a dynamic follow-through possible (see Figure 14).

The 'springing out' of the shot and the following change of leg position must be seen as a 'unit'. When the short-long-rhythm is used, the reverse is not so necessary or can even be left out completely. The reason for this is that the wide support, and correspondingly more pronounced bracing function of the front leg, in this technique effectively slow down the forward and upward 'shift' of the total system.

4.9 Summary

The phases or phase elements presented, as well as the corresponding assessment criteria of the 'modern' O'BRIEN technique are summed up in the shot put analysis sheet. Since what is observed is to a great extent dependent on the onlooker's position (cf. TIDOW 1983), it is recommended that the shot putter should be observed not only from the side but also from the rear. Here, further details, such as the behaviour of the putting arm from the initial position at the back of the circle (including the correct hold and position of the shot at the neck) to the delivery can be closely observed. The judging of the position of the feet in relation to each other (in the power position, criterium: "15 cm staggered') demanded in phase element 23 requires the view from the rear. Only then is it possible to see the degree of sideways deviation of the front foot from the normal putting position (in relation to the rear foot).

Since, in the linear shot put technique the movements are presented a period of between 800 and 1,000 ms, it is necessary to concentrate on only two to three details per attempt or only on certain faults.

However, as far as consideration of the technique model is concerned, and in the diagnosis of the filmed movement sequence, the analysis sheet should be used in a complex way, i.e. from phase to phase and on the element level as well.

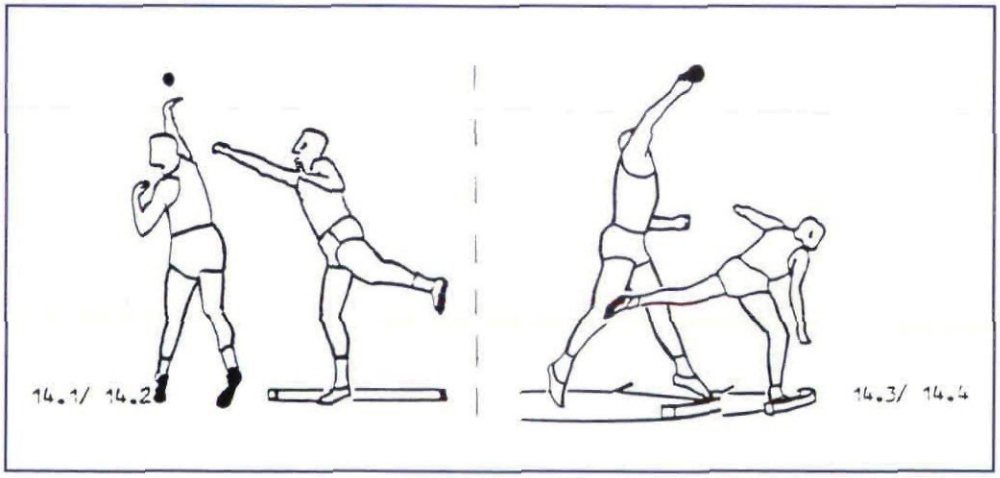


Figure 14: From the delivery of the shot to the reverse (on the left from the rear view, on the right from the side view)

REFERENCES

BALLREICH, R., KUHLOW, A.: *Biomechanik des Kugelstoßes*. In: Biomechanik der Sportarten. Vol. 1: Biomechanik der Leichtathletik. Stuttgart 1986, 89-109

BAUERSFELD, K.-H., SCHROETER, G.: *Grundlagen der Leichtathletik*. Berlin (East) 1986

BOSEN, K.O.: *Comparative Study Between the Conventional and the Rotational Techniques of Shot Put*. In: Athletics Asia 1 (1984)

GEHRMANN, C.: *Überlegungen und Erfahrungen zum Kugelstoßtraining*. In: AUGUSTIN, D., MÜLLER, N. (Ed.): Leichtathletiktraining. Niedernhausen 1981

GRIGALKA, O.: *Zur Technik des Kugelstoßes*. LdLa 23 (1980), 667-670 and 24 (1980), 699-702

HOMMEL, H.: *Lehrbildreihe Nr. 968 (Pete Shmock, USA)*. In: LdLa 6 (1981), 236-237

HOKE, R.J.: *Geschichte und technische Entwicklung des Kugelstossens*. In: LdLa 47 (1966), 1489-1492 and 48 (1966), 1538

KUHLOW, A., HEGER, W.: *Die Technik des Kugelstoßens der Männer bei den Olympischen Spielen 1972 in München*. Beiheft 'Leistungssport' 2 (1975)

LINDNER, E.: *Sprung und Wurf*. Schorndorf 1967

NETT, T.: *Die Technik beim Stoß und Wurf*. Berlin (West) 1961

NETT, T.: *Kernphasen der Kugelstoßtechnik*. In: LdLa 26 (1969) 907/910 and 27 (1969) 945/947 f.

TIDOW, G.: *Der Einfluß pädagogischer Aspekte auf den Zehnkampf*. In: DLV-Kongressbericht 'Mehrkampf'. Ed.: HOMMEL, H., Darmstadt 1978, 17-21

TIDOW, G.: *Modell zur Technikschulung und Bewegungsbeurteilung in der Leichtathletik*. In: Leistungssport 4 (1981), 264-277

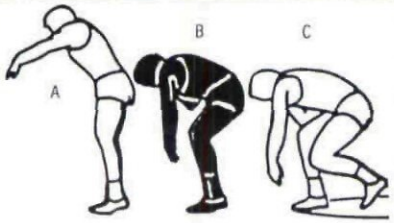
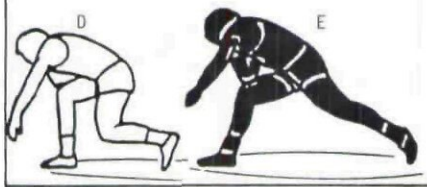
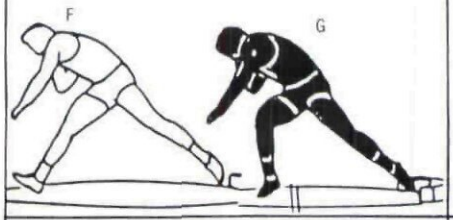
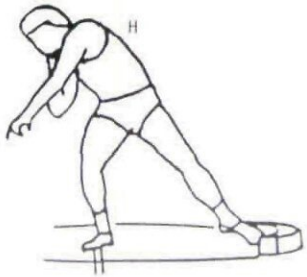
TIDOW, G.: *Beobachtung und Beurteilung azyklischer Bewegungsabläufe*. Ahrensburg: Czwalina 1983

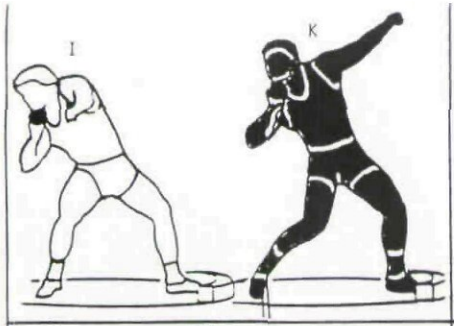
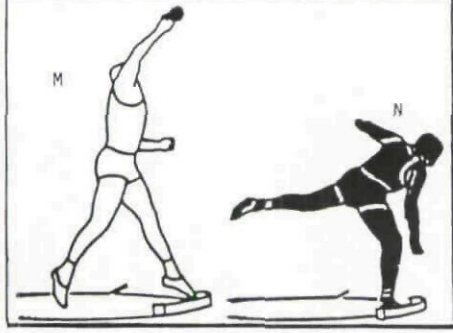
TSCHIENE, P.: *Eine neue Auffassung von der Technik des Kugelstoßens?* In: LdLa 17 (1973), 593-596

WERNER, E.: *Nur dosiertes Hanteltraining führt zum Erfolg*. In: LdLa 3 (1965), 71-72

WILT, F.: *Shot Putting Analysed*. In: The Scholastic Journal 8 (1977), 46-47

ZACIORSKIJ, W.N.: *Biomechanische Probleme des Kugelstoßens*. In: Leistungssport 2 (1980), 132-142

O'BRIEN TECHNIQUE	PHASE	REFERENCE	CRITERION	ASSESSMENT
	PRELIMINARY PHASE	A 1 feet//heels	parallel position at the rear of the circle//in throwing direction	
		AC 2 free arm	is 'closed' against throwing direction	
		A 3 bodyweight	primarily on driving leg	
	STARTING SQUAT	BC 4 hips/knees	bending/swinging foot is lifted	
		C 5 back/shoulder	horizontal	
		C 6 knee of free leg	close to calf of driving leg	
	SWING - FALL - START	DE 7 swinging leg	vigorously kicking backward and downward	
		DE 8 body	'tilting' toward stopboard	
		DE 9 free arm	'closes' trunk	
		DE 10 knee of driving leg	actively extending	
		DE 11 trunk	unchanged/'closed'	
	GLIDE	F 12 body	in tilted 'T-position'	
		F 13 centre of rotation	heel of gliding leg	
		FG 14 lower part of driving leg	snatching up	
		FG 15 driving foot	turning inward	
		FG 16 pelvic axis	turning in throwing direction	
		G 17 swinging foot	turned outward/directed to stopboard	
	POWER POSITION	H 18 eyes	focused to the rear	
		H 19 swinging arm	still closed	
		H 20 shoulder axis	square to throwing direction/behind gliding foot	
		H 21 pelvic axis	in throwing direction	
		H 22 knee of gliding leg	bent/over tip of the foot/loaded	
		H 23 feet position	in 'V-formation'	
		H 24 driving foot	at the centre of the circle/heel unloaded	

	BRIDGE POSITION	IK 25 eyes	focused to the rear
		IK 26 free arm	dynamically opening diagonally upward
		IK 27 driving leg	turn-push-extension movement
		IK 28 front foot	flat on the ground
	SIDEWAYS STANCE	K 29 lower part of front leg	vertical
		K 30 lower part of driving leg	diagonal position
		K 31 trunk	right hip thrust forward/pre-tension
		K 32 free arm	'pulling upward'/pointing in throwing direction
	FRONTAL POSITION	L 33 shoulder axis	square to throwing direction
		L 34 throwing arm	bent/lifted (at shoulder height)
		L 35 throwing hand	turned inward/fingertips: inward
		L 36 chest	pre-tensed
		L 37 free arm	bent/locked/at the side of the trunk
		L 38 pelvis//hips	square to throwing direction//'in front'
		L 39 rear foot	turned outward/vertically on toes
		L 40 legs	extending
	RELEASE	M 41 throwing arm	lifted elbow/'follow-through'
		M 42 body	full extension/'rigid'
		M 43 free arm side	fixed
		M 44 *ankle//feet*	*overextended//supportless (or: on the tips of the toes)*
	REVERSE	MN 45 legs	'change of legs' (in the air)
		N 46 support leg// support foot	braking recovery//at stopboard
		N 47 free leg	compensating/long