

THE HAMMER: THE VIEW OF THE DVfL OF THE GDR ON TALENT SELECTION, TECHNIQUE AND TRAINING OF THROWERS FROM BEGINNER TO TOP LEVEL ATHLETE

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This article is from one of the main lectures of the "International Seminar on the Javelin and Hammer Throws" held in East Berlin in March 1987. The authors express the view of the DLIV on five important issues: technique, performance structure, methods and criteria of talent selection, beginners' training and top-level training. Translated from the original German by Jurgen Schiffer. Re-printed with permission from New Studies in Athletics.

Introduction

In the eighties, there has been a progressive development of the world-best performance in hammer throw (Figure 1). This has mainly been the result of the efforts of the athletes Sedykh and Litvinov from the USSR. In recent years, they have set the standards and have increased the world record by 4.94m. This rate of development is more than 2m better than that of the period from 1976 to 1980. However, apart from these athletes, there are throwers both from the USSR and from other countries who have also attracted attention.

Altogether, 25 hammer throwers have surpassed the magical 80m mark. This has been achieved by:

- 13 throwers from the URS
- 4 throwers from the GDR
- 3 throwers from the FRG

as well as by one thrower each from Poland, Finland, Bulgaria, Czechoslovakia and the USA. These performances are the result of the effective development of a high level of physical capacities and throwing technique.

Many years of hard training are necessary in order to achieve throws over 80m. Athletes and coaches, however, continually set themselves new and higher goals, and the 90m mark will certainly be surpassed soon. This means that the training process must be changed in such a way that this goal is possible. The hammer throwers of the GDR also try to improve the existing record of 82.64m.

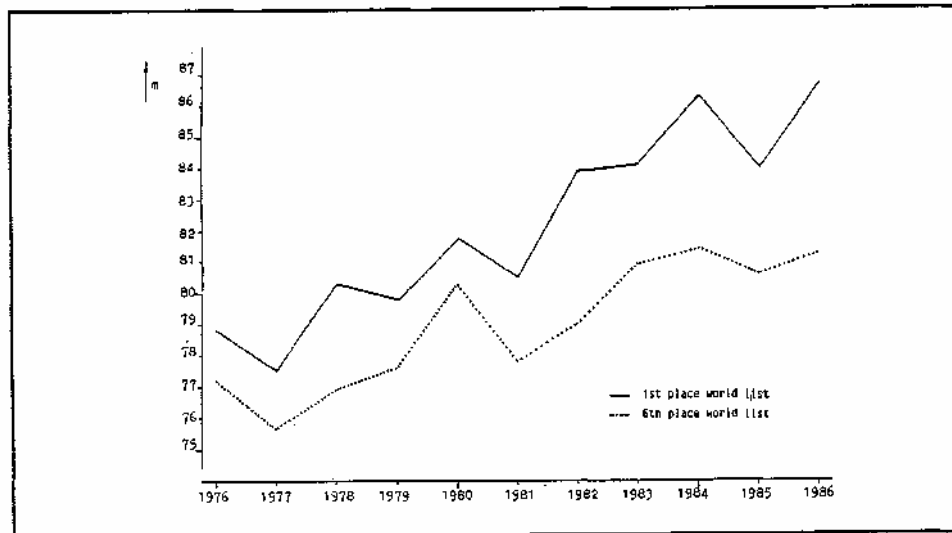


Figure 1 – Performance development in the hammer throw 1976 - 1986

In doing so, they utilize the experiences of the best East German hammer throwers of past years: former world record holder R. Theimer and J. Sachse, winner of the silver medal at the Munich Olympic Games in 1972. However, they mainly profit from the rich experiences of the Soviet hammer throwers and their coaches, with whom they have been working for many years.

Apart from the further development of top-level performances, the development of young hammer throwers must be given due attention. Although even the training of adolescent hammer throwers should be aimed at throws over 90m in later years, specific distinguishing features between the training of young hammer throwers and the training of top-level hammer throwers must be taken into consideration.

It is the objective of this article to present the ideas and views of the GDR hammer throw experts on five problems in connection with youth hammer-throw training:

1. Suitable hammer-throw technique from a methodological and biomechanical point of view.
2. Performance structure of hammer throwing.
3. Methods and criteria of talent selection.

4. Beginners' training
5. Top-level training.

1. Suitable hammer-throw technique from a methodological and biomechanical point of view

Apart from the athlete's physical and psychological capacities, the mastering of modern hammer throw technique is a basic prerequisite for the achievement of world-class performances.

Throwing distance is determined by the following factors that can be influenced by the athlete:

1. release velocity (V_o);
2. release angle (α_o);
3. release height (h_o).

The relationships between these factors can be represented by the following equation (see Tutevic, 1969):

$$L = h_o + \frac{V_o^2 \times \sin 2 \alpha_o}{g}$$

where L = throwing distance and g = gravitational constant.

As can be seen from this equation, release velocity has the greatest influence on throwing distance. For example, an athlete capable of 75m can, by an increase in release velocity of 1.4ms^{-1} (= 5%) with an unchanged release angle, increase his throwing distance to 82m.

A variation of the release angle by 5%, on the other hand, only results in an increase in throwing distance of 0.6m.

The influence of release velocity and release angle on throwing distance is shown in Figure 2. In this figure, the influence of air resistance on throwing distance is taken into account. Air resistance leads to a reduction in throwing distance of 2%. Within a distance range from 60 to 90m, the value of the release angle is 44° from a mechanical point of view, the influence of release height being taken into account. Analyses of the throws of the world-best hammer throwers, however, show that with top-level performances the release angle varies between 38 and 40° . The GDR record of 82.64m was achieved with a release velocity of 29.3ms^{-1} and an angle of release of 38° . With an angle of release of 44° , which is optimal according to ballistic laws, G. Rodehau would have attained a distance of 85m. However, the question is whether the

realization of an angle of release of 44° would have made it possible for him to achieve a release velocity of 29.3ms^{-1} .

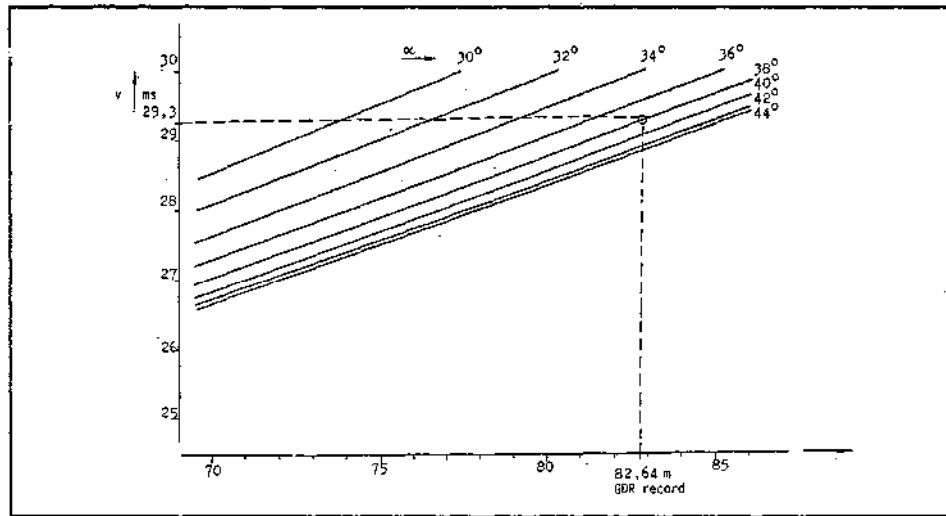


Figure 2 - Interdependence between release velocity, release angle and throwing distance

We hypothetically assume that the world-best hammer throwers cannot further improve their performances by an optimization of the release angle. A further increase in release velocity is much more important. The reason for this is that as the angle of release approaches the mechanical optimum the biomechanical conditions for achieving a high release velocity become more difficult. Release velocity is therefore the decisive factor which can be improved by training. The other factors that can be influenced by the athlete ($\alpha_0 + h_0$) should always be kept below the maximum values in order to allow the best possible conditions for attaining maximum release velocity.

A maximum release velocity can only be achieved if the hammer is imparted a maximum tangential acceleration impulse. In case of an 85m throw, this acceleration impulse is 210 Ns. This can be achieved by making the acceleration path as long as possible. In doing so, it is necessary that the hammer thrower strives for an optimum relationship between the radius of the hammer path and the angular velocity of the turning movement in order to achieve a maximally high velocity of the hammer and to keep his balance.

The necessary large radius of the hammer path is achieved by:

- The counter position of the pelvis;
- Extended arms and a relaxed shoulder girdle throughout the movement (observers should have the impression that the hammer “stretches the shoulder”), which results in a stable triangle formed by the shoulder axis and the arms.

A large radius of the hammer path guarantees a high path velocity. For example, throwers who use four turns can achieve a hammer path of 34.16m with an average hammer radius of 1.36m, or a hammer path of 40.68m with an average hammer radius of 1.62m.

The relationship between path velocity, hammer-path radius and the angular velocity of the hammer is shown in Figure 3.

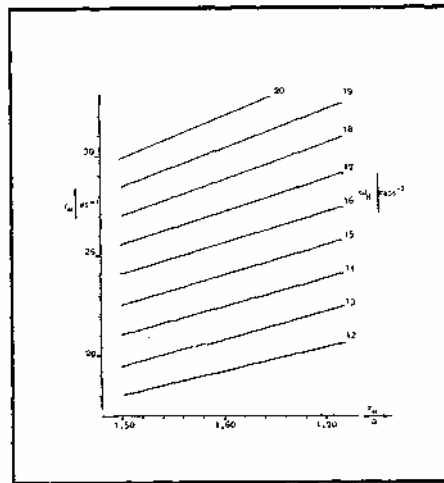


Figure 3 - The influence of angular velocity ω_H and path radius (r_H) on path velocity (v_H)

For example, a release velocity of 28m/sec can be achieved with an angular velocity of 18rad/sec and a radius of 1.55m. If, however, the radius is 1.65m, the same release velocity can be achieved with only 17rad/sec. If the premise that the radius cannot be further increased is taken as a basis, the increase of V_o from e.g. 28 to 31m/sec is only possible by an increase in angular velocity by 2rad/sec.

The real relationships between the path velocity and the angular velocity of the hammer head and the radius of its movement path is shown in Figure 4. The presentation starts off with the transition from the last preliminary swing to the first turn and finishes with the delivery. The double support phases are marked by bold horizontal lines. The changes in these parameters are based on the following physical equation:

$$\text{Path velocity} = \text{angular velocity} \times \text{radius}$$

Figure 4 shows that the increase in path velocity in a single turn is brought about by an increase in angular velocity. The angular velocity of the thrower and the hammer is reduced at the end of the acceleration path (of the individual turns).

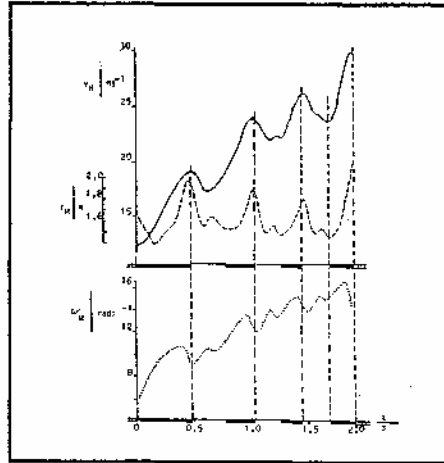


Figure 4 - Time dependent curves of path velocity (v_H), radius (r_H) and angular velocity (ω_H) of hammer movement throw by J. Sedykh (82.34m)

The velocity of the hammer head steadily increases, which is the result of the increase in angular velocity and the simultaneous reduction in radius. This is caused by the thrower's pronounced counter position, which is necessary because of the increasing centrifugal force of the hammer head.

Furthermore, the following prerequisites are necessary for achieving an optimum release velocity and release direction:

- By wide preliminary swings, a high moment of inertia of the whole system (thrower and hammer) can be achieved at the beginning of the movement sequence in order to reach a high angular momentum in connection with the, as yet, low angular velocity and the hammer movement at the beginning of the throw. On this basis, the thrower utilizes the biomechanical principle of impulse conservation in order to increase the velocity of the hammer head by a redistribution of the kinetic energy within the whole system. The effective redistribution of the rotational energy between thrower and hammer is a prerequisite for achieving a high release velocity.
- The main phase of hammer acceleration should immediately begin during the turns by grounding the trail leg (right leg). A premature start of acceleration leads to a braking phase at the lowest point, whereas a delayed start of acceleration results in an insufficient increase in velocity and creates unfavorable conditions for the preparation of the acceleration phase in the following turn. As the turns progress, the hammer is accelerated with increasing velocity of the thrower, the highest acceleration forces being at the low points of the hammer path. A difference between hip and shoulder axis of $20-40^\circ$ is created in the transition phase from the swings to the first turn. This difference should be

kept constant during all the turns. An extreme reduction in the angle difference at the beginning of the double support phases result in a shortening of the radius, a destabilization of the whole system (thrower and hammer) and braking phases at the low points. The stability of the axes, which should be kept constant during the turn, creates a pretension of the leg, trunk and arm musculature. This pre-tension is necessary in order to achieve an effective final acceleration during the last turn (whip-like movement of the arms and the trunk).

- In spite of the increasing movement velocity, the thrower must not shorten the acceleration path. There is, though, an objective shortening of the radius because there is a higher increase in the radial forces of the hammer than in the ones of the thrower. Therefore, as the turns progress, the acceleration phase should begin closer to the high point. A consequence of this is that during the last turn and the release phase, the thrower can utilize a long acceleration phase. The fact that in each turn the acceleration phase begins closer to the high point also requires that the thrower begins the one-legged support phases during the turns closer to the low points. This results in a more purposeful movement rhythm. In the presented throw, Sedykh fulfils this requirement in an exemplary way. In publications and the international exchange of experiences, the turn structure is always emphasized as being a very important factor of the throwing movement. It is usually recommended that the one leg support phases are shortened and the double leg support phases are lengthened.

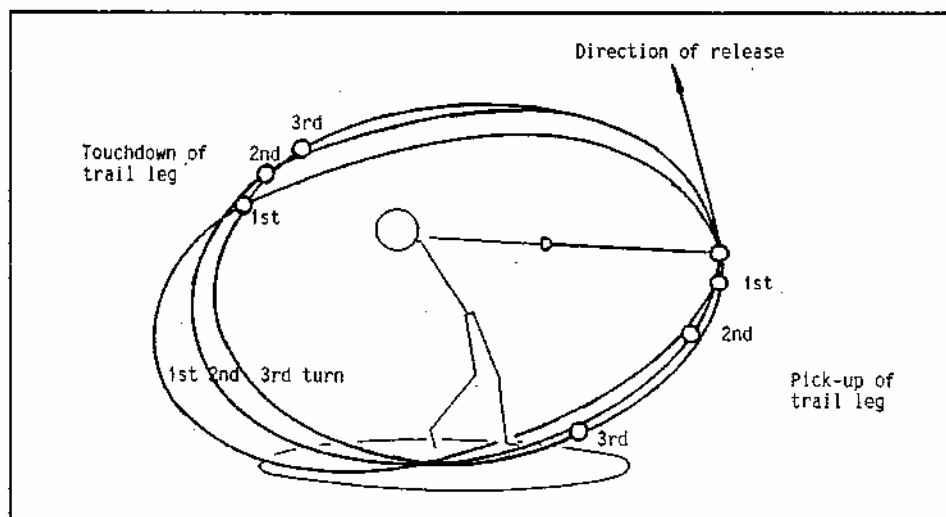


Figure 5 - Movement path of the hammer (back view of the thrower) Y. Sedykh (82.34m)

Our knowledge of this problem is based on films made using two high speed cameras from a lateral and sagittal position. The inter-individual comparison, for example, shows that there are fundamental variations regarding the structure of the support phases of top level hammer throwers. Table 1 shows the duration of the support phases of the best throw from each of six top level throwers at

different competitions. When interpreting the presented values, it must be considered that during the last turn, the double support phases were calculated from the touchdown of the right foot to the release. For this reason, the duration of this support phase appears to be 0.02 to 0.03 sec longer than the duration of the preceding support phases. Significant differences can be found between throwers using three and throwers using four turns:

- The width of variation is relatively large:
 - Last turn: throwers using four turns:
 - + 0.01 to—0.06 sec
 - Throwers using three turns:
 - + 0.02 to—0.11 sec.
- Haber gets closest to the theoretically ideal values although he is the weakest of the six throwers.

Table 1 - Duration of the support phases of selected throws of top-level athletes

Athlete	Duration of the one-legged and two-legged support phases (sec)					Total duration
	Distance (m)	1st turn	2nd turn	3rd turn	4th turn	
Litvinov	86.04	0.30/0.29	0.25/0.23	0.22/0.19	0.22/0.23	1.93
Rodehaut	82.64	0.33/0.34	0.24/0.26	0.23/0.21	0.25/0.24	2.10
Moder	80.54	0.31/0.40	0.24/0.26	0.22/0.23	0.27/0.21	2.14
Sedykh	84.92	0.28/0.23	0.23/0.19	0.24/0.26		1.43
Tamm	82.02	0.36/0.21	0.33/0.17	0.33/0.22		1.62
Haber	79.74	0.26/0.28	0.24/0.25	0.23/0.25		1.51

Intra-individual comparison does not give a definite answer to the question whether longer throwing distances are characterized by shortened one-legged and lengthened two-legged support phases. In our opinion, the duration of the support phases can be used for the regulation of technique training only with reservation. Further factors of influence should be included for the evaluation and regulation of hammer throw technique training.

The purposefulness of the movement rhythm and the effectiveness of the force transmission to the hammer can be evaluated by the force gradient, as suggested by Zaciorsky, Godik and Verhoshansky and introduced into hammer throwing by Kollody (Figure 6).

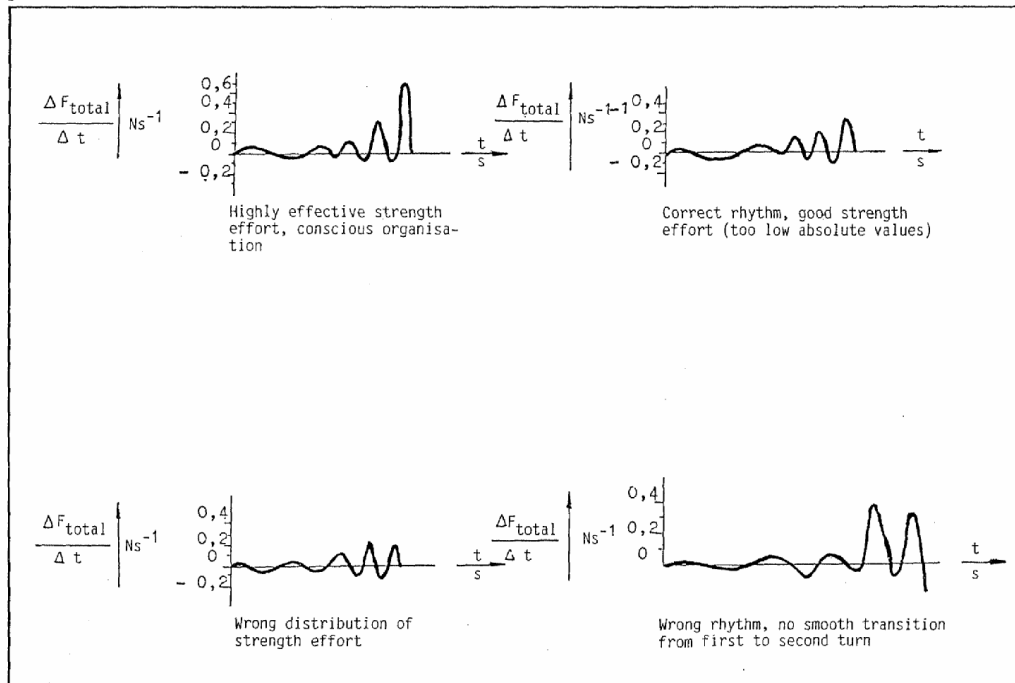


Figure 6 - Time dependent curves of the force gradient according to Kollody (1970)

The force gradient expresses the change of force in relation to time; this gradient is mathematically calculated by a differentiation of force according to time.

According to Kollody, the thrower's objective must be to achieve a progressive increase in the force gradient in the course of three or four turns with correspondingly high amplitudes (Figure 8). Discontinuities result in disturbances of the effective force transmission to the hammer, e.g. during the transition from the first to the second turn.

In practice, the curve of the force gradient is calculated by differentiation of the traction forces which are the sum of the radial and tangential force component and which are measured by a tensiometric hand grip. The analysis of a throw by J. Sachse performed with the technique in use 15 years ago shows that the force gradient decreased each turn (figure 7). Shortly before his first 80m throw, G. Rodehau showed force gradient values which met the demands on a modern purposeful throwing technique to a high degree (Figure 8).

An even better organization of the strength effort resulted in a progressive increase in the gradient. This increase is characteristic of the time before the GDR record of 82.64m (1985).

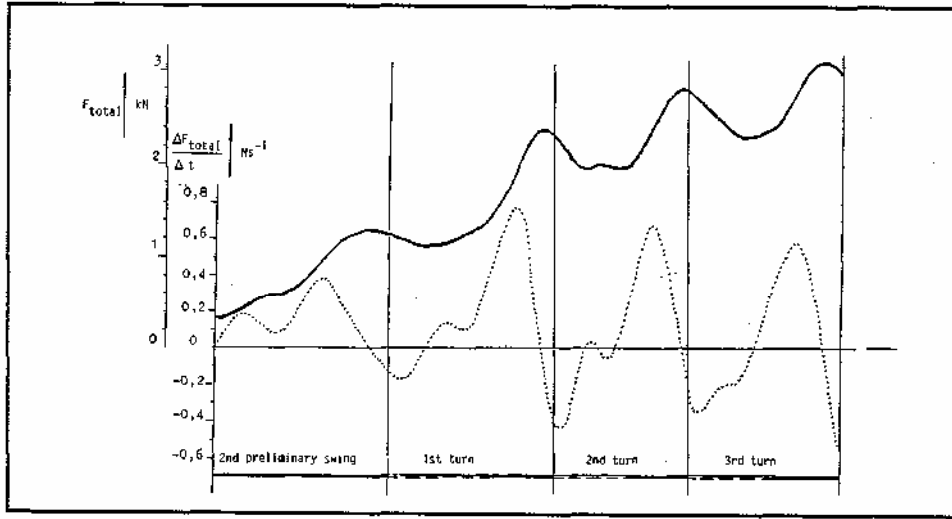


Figure 7 - Total force-time-curve (—) and force gradient-time curve (.....) of the hammer movement, throw by J. Sachse, 73.00m (1976)

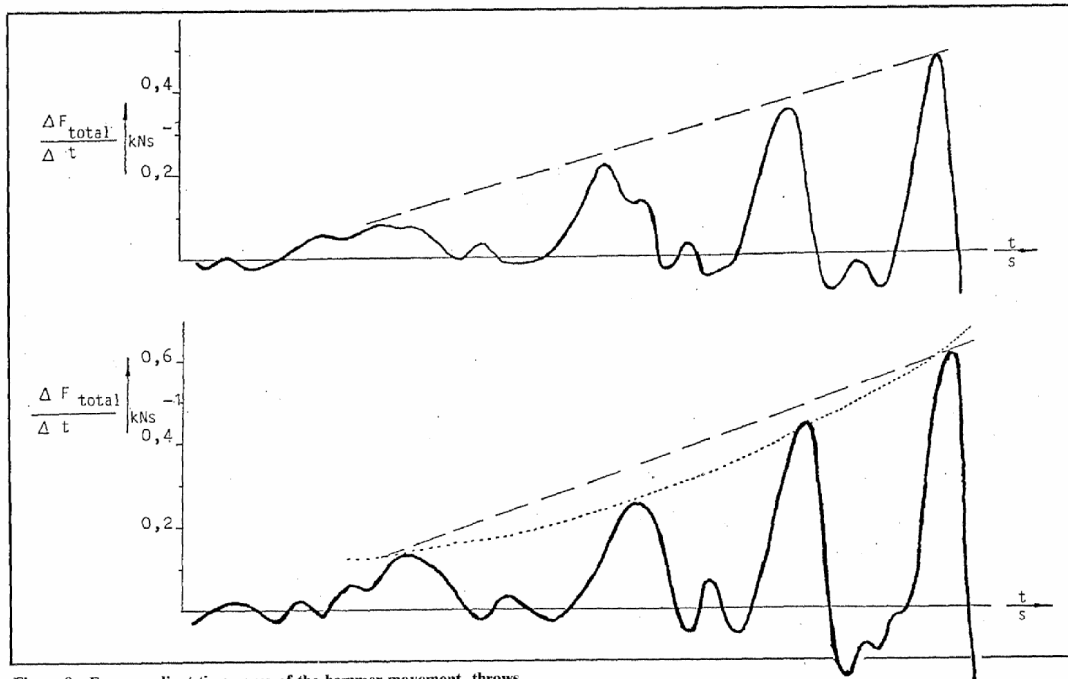


Figure 8 - Force gradient-time-curve of the hammer movement, throws
 bottom: 77.04 (1985, before personal best of 82.64m)
 by G. Rodehau top: 74.50 (1984, before personal best of 80.20m)

This efficient movement technique which approximates to the target technique is characterized by the following elements:

- The trail leg is swung closely around the pivot leg;

- The distance between the feet decreases as the turns progress: during the swings the distance is 60cm, whereas during the fourth turn it is only 19cm;
- during all turns, there is a relatively stable triangle between the arms and the shoulder axis (Rodehau was unable to extend his left arm completely because of a movement limitation in the elbow joint caused by an injury);
- The position of the shoulder axis in relation to the hip axis is relatively stable;
- The athlete's eyes are focused on the hammer head;
- The stable rhythmic organization of the first to the fourth turn is characterized by:
 - the position of the maxima of the tangential force and the angular velocity at the low points;
 - between the first and third turn, the position of the hammer head during the touchdown of the trail leg shifts in the direction of the high point;
 - as the turns progress, the low point steadily moves towards the hammer azimuth.

G. Rodehau could have improved his competition performance by optimizing his last turn. In doing so, his main aim would have been to increase the acceleration path of the final phase by an early grip.

2. Performance structure of hammer throwing

The most important structural element of hammer throw technique has been dealt with in the first section. In this section methodical test parameters which represent the development state of essential ability and skill prerequisites are dealt with in detail while bearing in mind that further components of the performance structure, for example constitutional and psychological characteristics, also essentially influence hammer throw performance. The complexity of performance development in hammer throwing is determined by the necessity to use increasing muscular forces with higher angle and path velocities in a shorter time. This means that an increase in the decisive release velocity is only possible by a purposeful development of speed-strength and maximum strength capacity. In youth and, to some extent, even in junior training, the development of speed strength parameters is at the centre of attention.

According to our experience, in this age group it is even possible to develop maximum strength by speed strength exercises (e.g. jumps).

At the transition to the senior age group, however, the increase in maximum strength becomes more important. We consider maximum strength as the primary basis of further development of the hammer throw specific speed-strength abilities since we know that throws over 80m create a force of more than 3 kN down the wire and that under these conditions the athlete must perform maximally fast movements. In the training system of our hammer throwers, the following test parameters have turned out to be control instruments (see Table 2).

Table 2 - Test performances which must be achieved by 70, 75 and 80-m-hammer throwers (the last column shows G. Rodehau's performances in 1985 when he set a GDR record of 82.64m)

Hammer throw performance (m)	70.00	75.00	80.00	82.85
8 kg hammer (m)	61.00	68.00	74.00	76.40
6 kg hammer (m)	76.00	80.50	85.00	87.70
30m flying start (sec)	3.15	3.10	3.10	3.11
Standing two-footed jumps m	9.50	10.00	10.50	3.38*
Snatch (kg)	115	130	145	
Clean (kg)	150	160	170	117.7 ^{xx}
Squat (kg)	230	260	290	310

* Performance in the standing long jump
 ** Snatch up to chin

3. Criteria and methods of talent selection

Hammer throwing is among the technically complex athletic events, which means that it makes high demands on the athlete's coordinative abilities. Furthermore, in order to achieve international top level results, genetically determined special constitutional characteristics and a predisposition to the development of speed strength abilities are necessary. When selecting children for hammer throwing, particular attention should be paid to relatively lean boys with long arms, high mobility of the shoulder girdle and stretching strength of the legs. In the GDR, talented children are selected at the age of 13 in order to make use of the good learning age for technique training. Those children are regarded as talented who meet the following demands:

Constitutional characteristics:

- Height: 1.7Dm
- Weight: 55-62kg

- Arm span: more than 5cm above height.

In order to assess the mobility of the shoulder girdle, we recommend an additional measurement: the boys stand with their backs to a wall, the back of the head, the buttocks and the heels touching the wall. The arms are horizontally stretched out to the front as far as possible. Now the distance from the chest to the joined fingertips of both hands is measured.

Conditional prerequisites:

- 30m (crouch start): 4.8sec
- 30m (flying start): 4.0sec
- 60m (crouch start): 8.8sec
- 3 two-footed hops: 6.80m
- 3kg shot throw: 11.50m

The coach's visual impressions of the explosive straightening of the legs when throwing a shot backwards and of the maximal explosive straightening of the arms when doing a two-armed support are further criteria for talent selection.

Coordinative prerequisites

The complex coordinative capabilities are estimated by watching the boys when doing sporting games, gymnastics and hurdling exercises.

Balance, orientation and the ability to couple movements have proven to be particularly important for hammer throwing.

4. Beginners' training

As hammer throwing is a technically complex discipline it is only possible to achieve top-level results after many years of hard training, the basis of which must be a genuine love for the event. The experiences of the best hammer throwers in the world show that 10 to 12 years of training are necessary for achieving top level results. Hammer throw technique makes particularly high demands on the athlete's coordinative capacities since three to four turns must be carried out as fast as possible in order to throw the hammer over 80m. In order to have a clear idea of hammer throw technique, it is important to understand the individual elements of the movement and to know the meaning of the movement tasks.

Throwing technique is not only determined by the outward form, i.e. the visual appearance of the throw, but also by its dynamics, smooth transition from one movement phase to the next one, changes of velocity and movement rhythm.

The hammer thrower must pay attention to the fact that the dynamics of the throw varies according to the state of his physical preparation and to steadily increasing weight of the hammer (3-7.25kg). Although the purposeful development of the physical capacities, i.e. the special physical preparation for top-level results, opens up new possibilities of technical improvement, putting too much emphasis on special strength preparation can result in a decrease in the level of technical abilities.

The achievement of the technical ideal must always be the main aim of training. Both coach and athlete must therefore know the target technique and always estimate the athlete's conditional and technical state correctly in order to be able to plan the further progress of training. In order to be able to achieve a high release velocity at top level age, it is extremely important to approximate to the target technique and to prepare the coordinative capacities which are necessary for carrying out the turns as fast as possible at the beginning of training.

In order to achieve throws over 90m, the athlete must have thrown that distance with a light hammer before the age of 17. For this reason, we have changed the competition rules and reduced the weight of the competition hammer for 13 year old athletes to 3kg.

Young athletes who are not able to throw 90m with this hammer will presumably never become world class. Thus, apart from being an important training means, the light hammer also gives the coach the possibility of an early selection of young athletes.

The experiences of the world's best hammer throwers show the great advantages of light implements as far as the perfection of the specific movement capacities and technique is concerned.

The aim of the training of young hammer throwers is to achieve long throwing distances without a marked degree of strength development.

In most cases, coaches teach hammer throw technique to absolute beginners because children usually have no experience of this movement. In spite of this, beginners' training focuses on the learning of the target technique. All other tasks are subordinated to this main task. The creation of a clear idea of the movement must take priority. This can be achieved by showing picture sequences and films, by analyzing the technique of experienced athletes, by demonstrations by the coach and by verbal information.

It is very important that technique is worked on each training unit. Each day, individual movement phases, postures and body positions must be practiced. These technique training units are carefully planned and meticulously carried out.

In beginners' technique training, the following training means are used: wooden sticks of 70cm length, heavy leather balls with short and long straps or wire, medicine balls and light hammers of 2kg. At the end of each training unit, the athletes must do at least 20 repetitions of the specific position exercises. The individual positions are not integrated into the turn before they are understood and carried out satisfactorily (for example, the athlete must be able to carry out the positions with eyes closed). If the athlete is not able to integrate them into the turn successfully, he must go back a step and practice the respective position on its own again. The most important task when learning the turn is the creation of the correct movement rhythm. The athletes must learn to control themselves when throwing. As soon as possible, the contents of technique training should be determined by the athlete himself.

Sprint and jump training should be combined with technique training in various ways. Reaction sprint runs with simultaneous hip rotation, sprints with subsequent and jump training with 50% of the jumps being carried out in combination with different forms of turns serve the improvement of the athlete's orientation ability.

At the beginning of the training year, general conditioning should center around endurance training; in later phases, it must support technique training. Hammer throw specific position and stretching exercises must have priority.

Parallel to the training of hammer throw technique, the abdominal and back muscles must be strengthened by various gymnastic exercises. Furthermore, the technique of weightlifting (disc barbells) must be optimized so that performance development and health are guaranteed in later years as well.

From the point of view of performance structure, the following performance parameters should be aimed at for 13 to 17 year old athletes (all these results must be achieved on the basis of a careful and successful technique training) (see Table 3).

The performance requirements with the 2 and 3 kg hammers are related to the performance norms which should be achieved in the individual age groups with the competition hammer. In this context, we would like to bring for discussion our point of view that although the achievement of such norms in youth training is an important prerequisite of world-class performances at a later age, it does not guarantee them.

Table 3 - Age and performance related goals to be achieved with light hammers

Age group (years)	Competition hammer (kg)	Distance (m)	Light Hammer (kg)	Distance (m)
13	3	55	2	60
14	4	60	3	66
15	5	62	3	74
16	6,25	62	3	80
17	6,25	68	3	86-90

5. Training of top-level athletes

Top-level training consists of a combination of exercises for technical improvement and the development of necessary physical capacities. The technique of top-level athletes is characterized by exactness, speed and stability of the competitive movement and is essentially determined by the effectiveness of the throwing rhythm. The level of maximum strength and speed-strength capacities decisively influences the dynamic structure of the competitive movement and the throwing distance. For this reason, a considerable part of the training time is devoted to strength and speed-strength training. Hammer-throw specific strength training can be divided into three complexes:

1. The throwing of hammers of different weights with one to four turns.
2. Strength exercises for shoulder, trunk and legs which are similar to the movement of the specific event: various kinds of standing diagonal throws, various kinds of jumps with extra loads and trunk exercises with extra loads in the form of swings and turns.
3. Different variants and forms of pulling and leg strength exercises with barbells. The most important exercises are: snatch, clean, pull and squats.

The yearly training cycle

For the training of top-level hammer throwers double periodization has proven very useful because it makes it possible to orient the throwers to the specificity of the special event and guarantees a good transference of the development of the athlete's physical capacities to throwing with the competition implement.

First macrocycle: preparation period: October - January; competition season: February.

Second macrocycle: preparation period: March - May; competition season: June - September.

The preparation periods consist of basic preparation phases (November / December and March / April) and special preparation phases (January and May) for the competition periods. While the basic preparation phases serve the development of the fundamental conditional prerequisites, it is the objective of the special preparation phases to improve these prerequisites and to utilize them for throwing with competition implement.

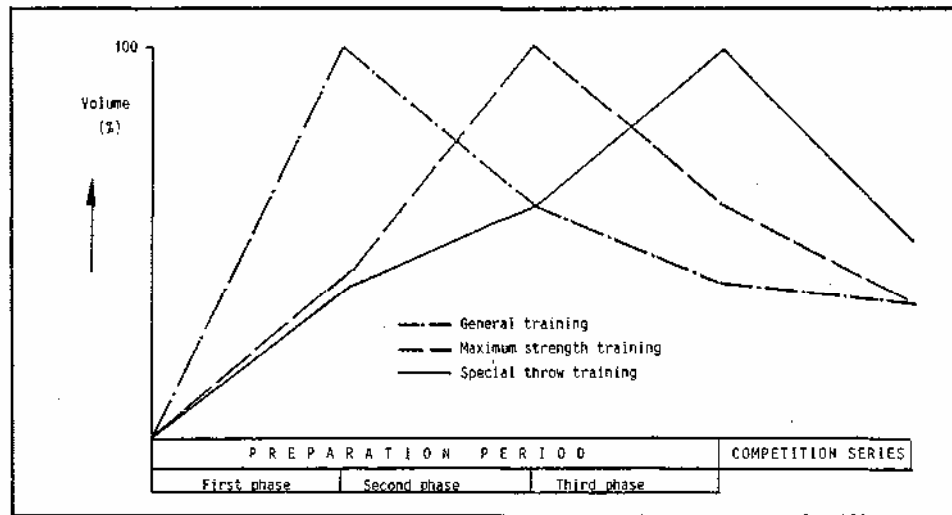


Figure 9 - Distribution of the main training contents over the training year

Forms and methods of training in the preparation phases

The training process in the preparation period is characterized by the succession of the three main training complexes: general athletic training, maximum strength training and specific throw training (Figure 9).

General athletic training is the first phase of the preparation period. By means of various training forms which positively influence the circulation system and exercises which serve the general muscular preparation, the foundations for a high load tolerance in the subsequent phase of maximum strength training are laid. This goal is mainly achieved by non-specific exercises, i.e. exercises which do not correspond with the competitive movement as far as structure is concerned.

The distribution of the training complexes in the first phase of the preparation period is as follows:

- General athletic training: 50%;
- Maximum strength training: 30%;
- Specific throw training: 20%.

In the second phase of the preparation period, 50% of the total training time is devoted to maximum strength training. 20% are allocated to the stabilization of the conditional prerequisites developed during the first phase. 30% of the training time is allocated to the specific training for the development of the specific throwing strength with heavy hammers and competition implements. Of course, these specific training contents also serve technical improvement. In this phase, training is done with a load ratio of 2:1.

The maximum strength trials with the barbell can be distributed to the various intensity zones as follows (intensity zone I is the highest level of performance):

- Intensity zone I: 15-20%
- Intensity zone II: 55-60%
- Intensity zone III: 25%

During the weeks of reduced maximum strength loads compensating training means are used.

Table 4 - Increase in the load volume of J. Sedykh in selected load complexes between 1976 and 1984

Year	1976 %	1980 %	1984 %	1984 Absolute values of the preparation period (related to 9 months)
Training days	100	125	138	222
Total number of throws	100	118	151	6332
Barbell training (tons)	100	170	198	1402

Table 5 - Training volume (main training complexes) of G. Rodehau in the preparation period (related to 9 months)

Year	1979/80	1982/83	1984/85
Competition implement (m)	74,02	78,14	82,64
Total number of maximum strength trials with the barbell	8600	7210	8340
Total number of special throws	5100	4710	5530
General training (hours)	294	275	290

In the third phase of the preparation period, specific throw training is in the centre of training (60% of the total training volume). 30% of the total training volume serves the stabilization and perfection of the maximum strength capacity, and

10% are used for the maintenance of the general athletic conditions. The first 4-6 weeks are characterized by a high number of throws. The number of throws becomes less when the competition period approaches; however, the share of intensive throws, in particular with the competition implement, becomes higher.

The cyclic alteration of load and regeneration, in particular during the high intensity training phase, guarantees the dynamic improvement of competition performance.

The load organization within the framework plan is of course determined by the thrower's individual characteristics, his training age the main tasks of the respective training

Forms and methods of training in the competition series

The main task of the competition period is to improve the performance with the competition implement in connection with training and competition, to stabilize and develop the conditional form under various outward conditions, to gain competitive experience and to achieve psychological steadfastness. In this period, the main emphasis shifts even further towards throw training (70% of the total training volume) while the rest is allocated to strength training and to general or compensation training.

All superfluous ballast is discharged. In the week before important competitions, the training load is reduced to 30% and the emphasis is almost exclusively on throws. In the week after an important competition, the athlete's training is similar to his training during the phase of special preparation. In this week, the volume of special throw and strength training can be identical. The variation of this weekly load depends on the time of the most important competitions and must be planned by the coach with great foresight in order to do justice to the main task, namely the improvement of the competition performance.

In the competition periods, the share of throws with maximum intensity increased 40-50% as compared with the preceding training phases. In the competition weeks, 65% of the throws are performed with maximum intensity and 35% with medium intensity. In the following weeks, this relationship again changes to 35%: 65%.

Load volumes

Striving for better performances always leads to questions regarding load parameters. It is no secret that during the course of the last Olympic cycle load volumes have further increased.

Even the world's best hammer throwers, such as Y. Sedykh, have improved their performances mainly by an increase in load volume. According to Bakarinov

(1987), Sedykh increased his training volume from 1976 to 1984 as follows (see Table 4).

Between 1980 and 1985, the volume of the various training forms performed by our best hammer thrower developed as shown in Table 5.

The relatively low values in the training year 1982 / 83 can be ascribed to the careful new beginning of training after a long training pause which was caused by an injury in 1982.

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