TRAINING OF TECHNIQUE AND SPECIFIC POWER IN THROWING EVENTS

By Dr. Klaus E. Bartonietz

Dr. Bartonietz, a biomechanic and training advisor at the Rhineland Olympic Training Centre, Germany, presents some biomechanical findings and their practical application in throwing events, including the problems in the use of heavy implements. The author, who until 1990 worked at the Research Institute of Sports in Leipzig, former German Democratic Republic, has written over 50 practically orientated Scientific studies, lectured in several countries and is the co-author of a number of track and field textbooks. Re-printed with permission from Modern Athlete and Coach.

The technique of the competition movements is in all track and field events the most important base of the performance. The technique determines the effectiveness of the interaction between all factors, influencing the result. Technique and abilities are the two sides of one complex phenomenon: the athlete's movement. The technique is therefore developing continuously with the growing abilities and inverted, growing abilities demands changes in technique.

MORE POWER FOR A GREATER RANGE

To reach a greater range the athlete must be able to realize a higher power level for acceleration (P_a) in order to transplant more kinetic energy (ΔE_{kin}) in a shorter time interval (Δ_t) to the segments of the body and to the implement:

$$P_a = \frac{\Delta E_{kin}}{\Delta t} \quad (W)$$

The kinetic energy increases because the velocity of the release must be faster. A more intensively accelerated and decelerated movement of body parts are the pre-condition for higher muscular pre-tension during the deliveries. With growing performance the time for the movement is shortening as the result of a higher level of velocity, It should be noted here that the athlete must also perform work to lift the implement and therefore also the power to lift the implement in the vertical direction.

A greater power level requires the ability to perform more work as soon as possible under event specific conditions. Athletes achieve this by using heavy weights and specific strength exercises. The available power is the key problem of training, because skills and abilities are in unity expressed in the power.

In the end, problems with the performance in different movement conditions (throws from the stand, short run up, light and heavy implements) in relation to the competition movement, or using different techniques, can be explained by the available power level. That will be shown with the help of the following examples.

Exercises with greater power demands are the effective way to develop special power abilities. Heavier implements are challenging greater power values and contribute to develop a greater power level than the competition exercise. Figure 1 illustrates the higher power demands of heavy implements for a discus thrower. The same principle applies to other events — top shot putters reach with the 8kg implement a higher power level than with the 7.26kg-shot, analogically female athletes with the 5kg shot (BARTONIETZ 1987, 1992).

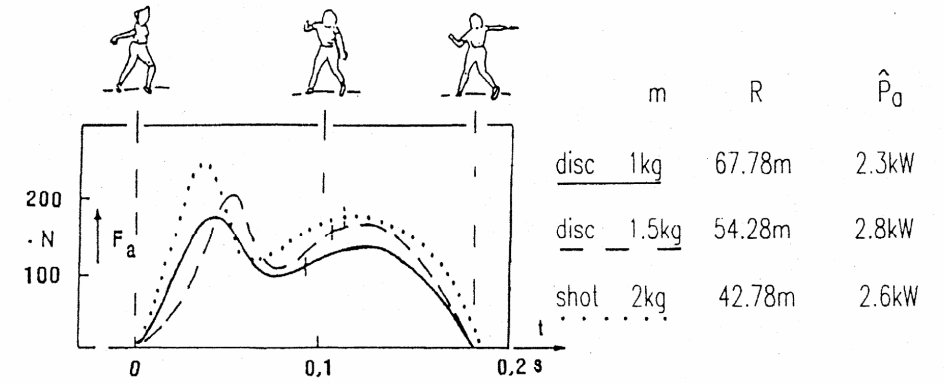

FIG. 1. Force-time relation and power data of a discus thrower using different weight implements.

The data in fig. 1 shows the highest power demands and how the effectiveness of very heavy implements depend on the level of performance. If Baryishnikov could use a 10kg shot (PALM 1990) it would not indicate general effectiveness for a top athlete to employ such an implement. We must here take into consideration substantial changes in the movement pattern in an un-welcomed direction (accent on upper body work, poor conditions for the left leg work). Palm's conclusion that the right leg activity is the decisive element (analyzing Baryishnikov) must be corrected. The right leg has a triggering function as the decisive element during the delivery is the bracing left leg. This is valid not only for the rotational technique.

A greater application of power to the implement is the result of a greater power available for the leg and trunk work, creating a higher pre-tension of the muscle groups for the final arm movement (javelin, shot, discus) or for the impetus during the double support phases (hammer). It is well known from experience that each throw must be built up from the legs. Problems with the base (the legs) decrease the range in each case. Figure 2 indicates in single positions the clear differences in the leg work (compare the knee and hip angles), partially responsible for the reached ranges. It also shows the unity of skills and abilities.

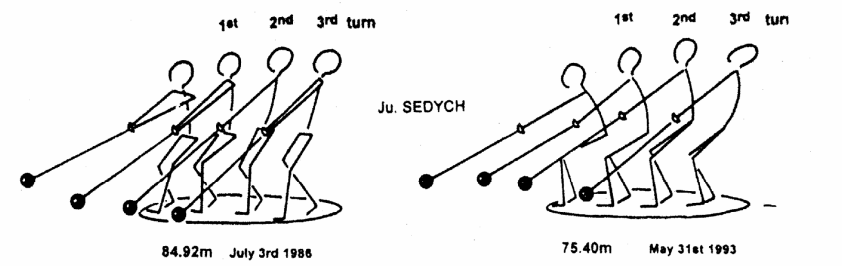

FIG. 2. Position of the thrower (lowest point of the hammer path) going into the first turn and during the turns after several years of training.

We can often observe predominant work of the upper parts of a thrower's body with a bent left knee, a counter-movement of the lower part of the trunk (hips are set back) and a flat angle of the release. It is necessary to understand here the correct coordination. Biomechanical knowledge of the event is needed for correction of faults and learning.

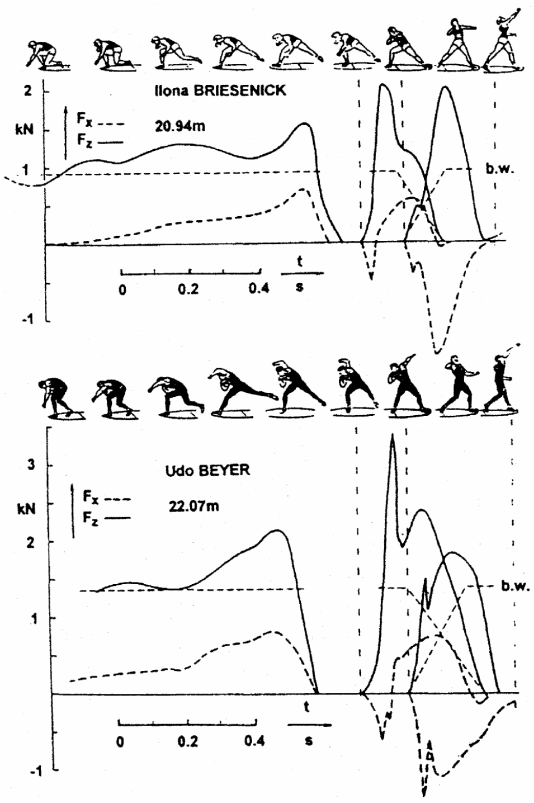

FIG. 3. Ground reaction forces in the shot put (Bartonietz 1987).

During the delivery the demands for the right and left leg work are the exact opposite: the right leg gives an accelerating impetus on the body and the left leg decelerates as much as possible the velocity (javelin, discus, shot). In the javelin the bracing left leg work starts after the acceleration of the right, in shot, discus and hammer the right acts against the left leg. Figure 3 illustrates these demands on the leg work, showing two different actions from the platform data:

- With a very effective work of the left leg (see above: an extended bracing leg, the vertical component of the ground reaction forces reaches more than the double of the body weight) and

- With an inferior body tension as a result of the bending left knee (see below: the vertical force component from the left leg is clearly lower).

What is not shown in fig. 3 are the calculations from the platform data together with data from video analysis showing that the necessary power level (power as energy per time unit) for the bracing of the left leg is sometimes higher than for the right leg. This is a simple explanation that the working capacity of the left leg limits the volume of throwing exercises within one training unit. Therefore the working capacity of the left leg is one of the key points in training.

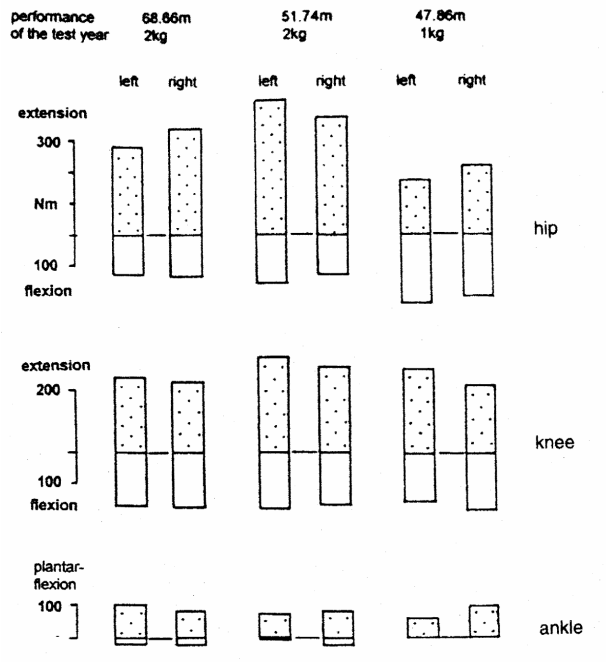

FIG. 4. Test data from the isokinetic KIN-TREX System (60 degrees/s).

An insight into the structure of the leg performance is available from the data of testing machines like Cybex (USA), Kin-Trex (Switzerland) and others. Figure 4 shows the maximum of the force momentums of the hip, knee and ankle extensions and flexions of discus throwers (right a young female discus thrower, in the middle a junior, and left a world-class athlete). The junior reached values comparable to the world-class athlete (hips, knees) but was about 15m shorter because about a 3m/s lower release velocity. This indicated after testing that young athletes have to develop a more balanced relation between flexors and extensors by sprinting and two and one legged jumping exercises through a more specific strength and power training.

This data also gives a picture about the power output of the joint flexors and extensors, because in rotational movements the power is calculated by force

momentum and angular velocity. By given angular velocities (like 60 deg/s in figure 4) the momentum is proportional to the power. It should be noted that the performance of the ankle impetus has a key function in all throwing events. The ankle must compensate the effects from upper body, hip and knees (NEWTON: action and reaction) and must give in addition its own impetus. The data in figure 4 shows a low performance of the young throwers' ankle in relation to the hips and knees.

The effectiveness of the glide in relation to the rotational technique in the shot put is better to understand from the analysis of the power demands. The power demands of the rotation technique are higher (about 20% comparable ranges) because the path for the shot and the thrower's body during the delivery is shorter and the velocity of the shot is lower at the start of the delivery (BARTONIETZ 1 983, 1 990). But the athlete can create the conditions for the necessary conversion of kinetic energy per time unit (the power) with the help of leg work. It's the base for an explosive angular acceleration of the upper body, creating a necessary very high muscular pretension.

For this reason there must be some differences in specific power training between gliders and turners. Different from the glide, it is very difficult to use the rotational technique without special preparations. However, the use of rotational technique is by no means a must.

LEARNING THE RIGHT TECHNIQUE AND AN EFFECTIVE CORRECTION OF FAULTS

Only a small number of recent top throwers have realized the demand for an approach to an ideal technique. To be among the world's best throwers doesn't mean automatically an effective technique. Take Andrei Abduvaliev, winner of the Olympic Games hammer throw with 82.54m. A few months after the Games his defective technique was still responsible for throws over 80m. His biomechanical parameters in table 1 show among other aspects a later catching of the hammer from turn to turn and therefore a shortening of the double support phases in relation to single support phases.

	Turns			
Parameter	1st	2nd	3rd	4th
Duration(s) Single support Double support	 0.32 0.38	 0.26 0.26	 0.26 0.18	 0.26 0.20(!)
Position catching the hammer (degree)	235	245	255	280
Inclination of the hammer plane (degree)	30	36	41	46
Angle of release (degree)				40

Table 1: Biomechanic parameters of a 81.20m-throw of A. Abduvaliyev (May 31st 1993)

Coaches and athletes must get a clear picture about the source of the faults in analyzing technique and detecting faults. The following factors are noteworthy:

Effective learning and improvement of technique

The initiation of changes in learning and improving technique can be rather complicated because most of the recent textbooks use illustrations of real athletes with their individual peculiarities and in some cases with noticeable faults.

One of the important factors to emphasize is a reproducible and effective starting position for the delivery in all throwing events, as deviations of an effective starting position or the movements preceding the release are often a source for faulty deliveries:

- Javelin — decreasing of the run-up speed during the last strides, cross (or impulse) stride too short. Consequences: upper body too upright when the right foot is planted, insufficient time for throwing preparation.

- Shot put — starting the glide with a predominantly swinging movement of the left leg (supported by the left arm). Consequences: not a glide but a jump, long amortization with great loss of velocity, premature movement of the upper body (lower pre-tension).

- Discus — careless action going into the turn over the left leg. Consequences: clear jumping movement with a fall of the right leg, missing of the torque for turning on the ball after planting the right foot in the middle of the circle, planting the left leg too late.

- Hammer — shortening of a maximally wide hammer path going into the first turn. Consequences: shortening of the hammer's radius during the turns that leads to a shortening of the hammer path for acceleration.

The improvement of the delivery must therefore start by finding the above mentioned sources for faults and not by the final appearance. Coaches must here have a clear internal picture of the technique, and athletes the knowledge about the interplay of movements. They must *see* the desired key positions (for example, with the help of stick figures like in fig. 5) and these by imitation and other training exercises.

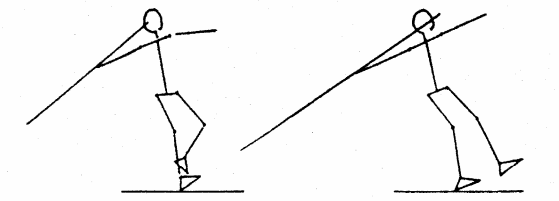

FIG. 5. The body position at the planting of the right foot after the impulse stride _ left training throw of 85m and right, a defective position as a guide to technique training.

Development of the abilities corresponding with target skills

Improvement of the leg work capacity by the development of knee and hip extensors by using squats and the shortcomings in the bracing left leg work, or the reactive power capacity of the ankle, often go hand in hand. Also, successful athletes often open a “gap” between the performances of training exercises and the competition movement. This isn’t the result of an ineffective “transformation” of general abilities to specific abilities. A transformation can’t take place because specific abilities are not developed. The realized forces are the result of a given power level and not the source of the performance. Consequently, the conclusion for top athletes must be more specificity in all spheres of training.

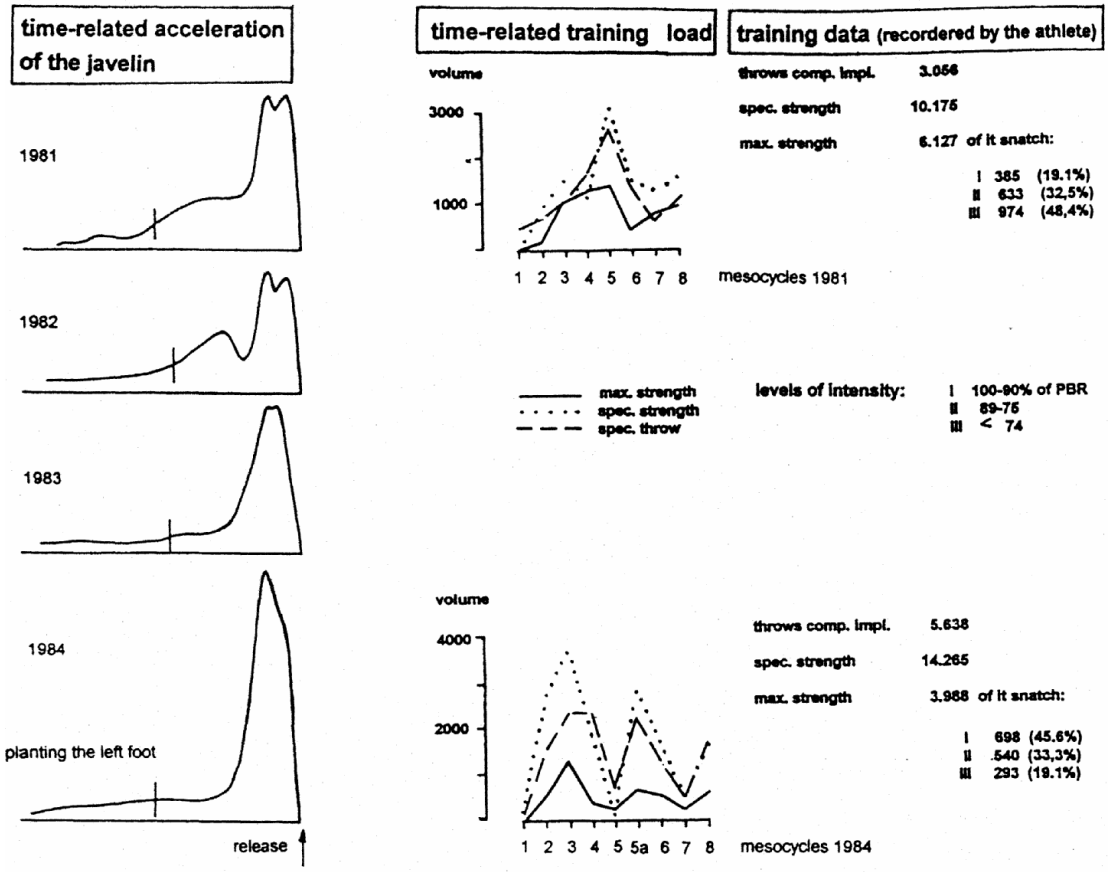

FIG. 6. The final javelin acceleration of Petra Felke and the main aspects of her training over two years (Bartonietz 1992, based on data from Schuler 1986).

The realization of this motto can be seen in fig. 6. It includes increased specificity in:

- an increase of throwing loads in comparison to strength training loads,
- the use of exercises that correspond to the demands of the competition exercise (short and explosive snatches, squats with a final extension of the ankle etc),

- a growing quality of technique training.

Adaptation to short, medium and long term training loads.

Each training exercise has an effect on the movement pattern of the competition exercise (on the movement structure). This effect is dependent on the movement pattern of the training exercise. The interacting of different training exercises and loads for days and weeks produces the final adaptation.

Problems with the competition implement after the use of heavy implements is a well-known factor when specific training loads are employed. Such short term adaptations are deliberate. Real problems start only with a stable bending knee or the stabilization of the so called “heavy implement technique”. An external sign of the last is a small difference between the ranges in the use of competition and heavy implements.

Heavy implements create in all throwing events deviations from the competition movement (BARTONIETZ/HELLMANN 1985, BARTONIETZ 1987). Here is a tendency towards a shortening of the path of the implement’s acceleration, because the weakest “motors” are located at the end of the open kinematic chain. It’s a positive effect that the greater inertia of such implements can create a higher pre-tension (however, by a lower level of velocity) for a more powerful delivery. However, the work of the left leg can be ineffective (bent left knee), if the leg power level is too low, or the load too heavy. This leads to some deviation from the target coordination of the movements.

High demands on the technique, particularly on the leg work, are necessary in the use of heavy implements. Keep also in mind that the potential training effects of a given exercise are not automatic and the target directed execution of movements plays an important role.

Athletes and coaches must take into consideration the growing difficulties in the development of technique after several years of training with improved strength capacities. However, it is possible to reach changes, as shown in fig. 6, representing the training of Petra Felke. Her training was directed to improve conditions for the delivery, especially a more pronounced delay of the throw.

In the classification of training exercises in different training cycles (strength training, training of specific power, special throwing training), it is necessary to take into consideration the movement pattern and the specific training effect of these exercises (the movement structure).

RECOMMENDATIONS FOR TRAINING

- Skills and capacities form a given unit. There is no technique without capacities and no capacities without technique. This is the leading principle for strength and technique training.

- Knowledge about an effective technique is a must for coaches and athletes.

- The athlete needs realizable guidelines for individual movement patterns for a positive orientation in technique training.

- Improvement and correction of technique demands the consideration of the total training contents.

- Heavy implements should always be used together with competition implements, taking into consideration the individual performance level. Too heavy implements lead to negative results. Also, stress the technical demands in the use of heavy implements.

- Changes of different mass implements prevent undesired adaptations.

- Set higher demands to the work of the bracing left leg by using higher movement velocity in the preparation phases (run-out glide, turn and heavy implements) or additional resistances (vests, cuffs etc.).

- Reduce the number of throws from the standing position. They have a place only in
  a special warm-up. Use standing throws only in the target directed work of the left leg.