Sequence 4: Rotational shot put technique of a top level athlete, demonstrated by Oliver Dück (Sequence by Helmar Hommel)
gliding shot putters. However, smaller and more powerful athletes, with a good feel for rotation and a good sense of balance, have every chance of mastering the rotational technique and achieving performances which would not be possible for them with the glide technique.

Because of the more dynamic start, the rotational technique is a genuine alternative, even for athletes with insufficient start-strength ability for the glide technique.

**Biomechanical aspect**

Through the final angular acceleration of the body and implement, the rotational technique enables a better utilization of the inertia effect of the shot for the development of a high body tension (especially in the area of the putting shoulder), on the basis of the biomechanical principles of starting strength, counter-effect and impulse preservation (Hochmuth 1981). Through (1) the initial rotational impulse from the start of the rotation, (2) the body posture taken and (3) the final rotational acceleration of the body and the implement, an efficient redistribution of the rotational energy, with a further increase, can be effectively used for the acceleration of the body and the shot.

**Aspect of training methods**

As far as the temporal sequence of a long-term preparation of the rotational shot put is concerned, the following procedure is proposed, which is based not on age group classifications but on the state of performance achieved:

- **Basic training**: Development of the technique using a walking start and of the "normal" walking start, modified standing put appropriate to the rotational technique.

- **Build-up training**: The changing technique should play a dominant role: training and development of the technique using throws from one turn (first stage); learning of the fine form using throws from the whole movement (second stage) (during build-up training the use of light competition implements should have priority).

- **Follow-up training**: Refinement of the individual rotational putting technique (the development of an optimal athletic basis is a prerequisite of this).

Start of the development of the special strength abilities; (there should still be a high proportion of exercises with light competition implements).

The performance and load build-up of young rotational shot putters does not basically differ from that of gliding shot putters. Because of the high forces acting on the athlete's putting hand, elbow and shoulder during the final acceleration of the shot, the use of exercises for strengthening the respective muscles should have priority in the course of the yearly or long-term training.

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Some thoughts on sprint relay racing from a Canadian perspective
by Lyle Sanderson

The author takes a rather general look at relay racing and emphasizes five factors which he thinks to be critical to success in the relay: (1) teamwork, (2) establishing a feeling of commitment to the relay, (3) establishing a system of relay preparation including warm-up for practice and competition, (4) maximal baton speed over the entire relay distance, (5) consideration of the demands of each relay position and the characteristics of potential team members when deciding the order of running, (6) minimal disruption of sound sprinting mechanics by the chosen technique of baton exchange.

Introduction

A great deal has been written concerning the technique and philosophy of relay racing. The presentation by George MAISSETI at the XXth European Athletics Coaches Association Congress (Rome 1996) and the article by MAISSETI (NSA 11:2-3, September 1996) have caused me to consider my observations of the event based on more than thirty years of coaching.

Canada has a history of sprint relay success going back to the 1928 Amsterdam Olympic Games where the Canadian women set a world record in winning the first Olympic gold medal in the 4x100m relay. Four years later at the Los Angeles Olympics the Canadian women ran 1.4 seconds faster than their world record but finished second, 0.1 seconds behind the U.S.A. From 1928 to 1948 Canadian teams appeared in all the men’s and women’s 4x100m relay Olympic finals. It was 1976 before Canadian teams again appeared in Olympic 4x100m finals. The Canadian women were fourth in 1976 and second in 1984. The men were eighth in 1976, third in 1984 and seventh in 1988.

In recent years the Canadian men’s 4x100m relay has established a tradition of success. In 1991 Canada reached the World Championship final and ranked eighth in the world. In 1992 the Canadian team improved to sixth in the world rankings although they did not reach the Olympic final.

1993 was the breakthrough year for the Canadian men’s 4x100m relay team. They earned the bronze medal in the World Championships at Stuttgart and ranked third in the world. The team’s 37.83 clocking moved Canada to fourth ranked nation all time. In 1994 Canada won the Commonwealth Games and ranked second in the world. In 1995 Canada won the world championships with the fastest time of the year.

In 1996 the Canadian men’s 4x100m relay dominated the Olympic Games winning the gold medal with the fastest time in the world. In spite of a less than efficient last pass and anchor runner Donovan Bailey raising his arm to signal
number one status" well before the finish line, the team's 37.69 Canadian record moved Canada to second nation on the all time list.

2 The Canadian men's 4x100m relay team's development illustrates some important points in relay success

2.1 The importance of experience as a team

Three of the four runners on the 1993 team were members of the 1991 and/or 1992 teams. Since 1993 the same six runners have teamed for all the Canadian successes.

Experience working together leads to a much better perception of the characteristics of the person that the athlete is passing to or receiving from. This leads to confidence and technical proficiency.

The first three runners on the 1996 team are the same, running in the same order, as the 1993 team. Donovan Bailey, who was the alternate on the 1993 team, replaces Atlee Mahorn at anchor. Robert Esmie, Glenroy Gilbert and Bruny Surin each provide unique abilities on the first three legs. Carlton Chambers, who ran on the Commonwealth Games champion team in 1994, ran the lead off leg in the heat and semi-final wins at the 1996 Olympic Games.

The important point that is illustrated by the success of the Canadian team is that working together over an extended period of time is a very important factor in successful relay racing.

2.2 Commitment to the relay

MAISSETTI (1996) states that "...relay team spirit can exist and that it plays a major role in the search for perfection in relay running" (p. 91). The experience of the Canadian men's 4x100m relay team supports this view. In 1993 at the World Championships at Stuttgart, men's relay coach Mike Murray worked very hard to develop a feeling of relay team loyalty. This was the beginning of what Murray terms the "Canadian relay team family." This feeling of commitment to the relay is very strong. It should be noted that the four who ran the final at Atlanta ensured that Carlton Chambers, who led off the team in the heats and semi-finals, was included in the victory celebrations. In post Olympic interviews Donovan Bailey emphasized the relay as much as his gold medal world record in the 100 metres.

It has been said that to be successful in individual events world class sprinters cannot afford to commit to a relay programme. The experience of the Canadian team refutes this. All four of the members of the Canadian team at Atlanta have won individual event medals in World Championships and/or Pan American Games indicating that individual event success is possible while committed to the relay programme. (The relay and individual event success of the Santa Monica Track Club also indicates commitment to the relay while achieving success in individual events.)

The athlete's feeling of commitment to the relay team is a very important factor in relay success.

2.3 The importance of a system

In 1973 Gerard Mach came to Canada from Poland. As national coach for sprints and hurdles and later as National High Performance Director and Head Coach until 1988 when illness led to retirement, Mach introduced a system to develop sprinters and the relays. His ideas are still incorporated by coaches throughout Canada. One concept that Mach emphasizes in all sprinting is that energy conserved in the beginning of the race will lead to improved performance later in the race. In his article in New Studies in Athletics, Mach (1991) applies this to relay racing. He states, "The standing start, using a longer check-mark of between 25-30 footlengths, allows the outgoing runners to make a less intense and therefore more controlled acceleration. This conserves energy, so that more effort can be put into sprinting once the baton has been received" (p. 70). Mach's approach to relay racing is described in this article.

2.4 Baton speed

MAISSETTI (1996) stresses the importance of baton speed through the zone as the critical factor in the French team's success. This is no doubt an important factor, but it must be evaluated in the context of baton speed throughout the race. If, as Mach states, the "controlled acceleration" prior to receiving the baton conserves energy, it could lead to the receiver achieving a higher maximum velocity during the carry and could also lead to increased maximum speed endurance. More research must be carried out in this area.

Overall baton speed from the time it is placed in the receiver's hand until it is passed or the finish line is reached is the critical factor in judging the success of the relay carry.

2.5 The demands of each leg are different

MACH (1991) outlines the considerations that apply in the selection of athletes and determination of running order. The demands of each leg are different and each relay team member requires specific skills and abilities.
The practice of judging relay efficiency by comparing the relay time to the total of the team members' best 100 metre times must be questioned. Not one relay athlete runs 100 metres in a straight line from the starting blocks. The data presented in Table 1 compares the top three teams from the 1993 World Championships at Stuttgart where the USA equalled the World record in the semi-finals.

### Table 1: Comparison of the top three teams in the men's 4x100m relay at the 1993 World Championships at Stuttgart [s]

<table>
<thead>
<tr>
<th></th>
<th>U.S.A.*</th>
<th>Great Britain</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drummond</td>
<td>10.03</td>
<td>Jackson 10.35</td>
<td>Esmie 10.25</td>
</tr>
<tr>
<td>Cason</td>
<td>9.92</td>
<td>Jarrett 10.55</td>
<td>Gilbert 10.16</td>
</tr>
<tr>
<td>Mitchell</td>
<td>9.99</td>
<td>Regis 10.15</td>
<td>Sunn 10.02</td>
</tr>
<tr>
<td>Burrell</td>
<td>10.02</td>
<td>Christie 9.87</td>
<td>Mahom 10.20</td>
</tr>
<tr>
<td>Total</td>
<td>39.96</td>
<td>40.92</td>
<td>40.61</td>
</tr>
<tr>
<td>Relay Time</td>
<td>37.40</td>
<td>37.77</td>
<td>37.83</td>
</tr>
<tr>
<td>Difference</td>
<td>2.56</td>
<td>3.15</td>
<td>2.78</td>
</tr>
</tbody>
</table>

Note: Semi-final time = WR.

Examination of the successful British team's data emphasizes the problem with using 100 metre sprint times to predict relay effectiveness. Jackson and Jarrett are not 100 metre specialists. Jackson set a world record in winning the 110 m Hurdles at these championships and Jarrett finished second to him. They are both much faster than their official 100 metres times indicate.

#### 2.6 The push-forward pass vs the upsweep pass

MAISETTI (1996) favors the upsweep pass and states "The upsweep hand-over is recommended, since it fits best with the natural movements of top speed running" (p. 77). He indicates that the upsweep pass leads to higher baton velocity through the passing zone.

MACH (1991) outlines the reasons for abandoning the upsweep pass and summarizes them as follows:

- "when compared with all other known relay pass techniques, the push-forward pass seems the most simple and natural. It is in harmony with the principles of good sprinting technique; has the advantages of the upsweep pass without the risk; maximizes the free space gained in each exchange; and maximizes the speed of the baton exchange in the exchange zone" (p. 73).

Both Maisetti and Mach are highly successful relay coaches. Both of their opinions deserve consideration.

A very important point is that the French teams, under Maisetti's direction, have probably worked together as a team more than any other national team. As a result their execution is superior. This could lead to the faster baton speed through the zone that MAISSETTI (1996) documents.

However, after more than thirty years of coaching relays at all levels, from club teams to the international level, I have come to favor the push-forward pass because it requires the least disruption of sound sprinting mechanics.

There is very little difference in the arm action of the receiver when one analyses the ideal push-forward pass (Mach) and the upsweep (Maisetti). The height of the receiver's hand is slightly higher with the push-forward pass but little if any higher than normal sprinting. It does not require the high receiving hand advocated in the down sweep pass. Both techniques, when well executed, require the receiver's arm to be back for a minimum time period hence disrupt sprinting form as little as possible. Both the upsweep and push-forward pass do require an unnaturally straight arm at the elbow of the receiving arm. The differences between the two techniques are minor with respect to the receiver and should not lead to differences in baton speed through the zone.

In my opinion the major advantage of the push-forward pass is that it is a much more natural action that is closer to normal sprinting mechanics for the passer (giver). I disagree with MAISSETTI (1996) who states, when discussing the action of the giver, that "the upsweep hand-over is recommended, since it fits in best with the natural movements of top speed running" (p. 79). My analysis is based on three considerations:

i) It is unnatural to extend the arm at the elbow on the forewinding when sprinting.

ii) Fine motor coordination is impaired when the elbow joint is locked straight. To illustrate this, try to put a key in a door lock quickly with the elbow locked straight; and

iii) MAISSETTI (1996) advocates that the giver "...reaches out with the baton and runs with a "fixed" arm for a few strides..." (p. 80). This is certainly not a natural sprinting action.

It should also be noted that of the all time twenty five best men's 4x100m relay times recorded (by teams from five different nations) only two performances, both by France, were recorded by teams using the upsweep technique.

### 3 Conclusions

> Experience working together as a team is a very important factor in successful relay racing.

> Establishing a feeling of commitment to the relay is very important. This need not be a negative factor in achieving individual sprint success.
A system of relay preparation including warm-up for practice and competition must be established and understood by all personnel.

Baton speed over the entire relay distance is the most critical factor in relay success.

The demands of each relay position and the characteristics of the potential team members must be considered when deciding the order of running.

The technique adopted in exchanging the baton should disrupt sound sprinting mechanics as little as possible and should lead to the highest baton velocity for the entire race distance.

Research is required to determine the effects of passing techniques on the baton speed throughout the entire race distance.

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Prologue

The preceding article was written prior to the Canadian men's 4x100m relay team winning the 1997 World Championships at Athens. Three quotes from the Canadian team after the win support the points emphasised in the article:

• The maturity and experience of the team is shown in a comment made by Bruny Surin who stated that the Canadian team decided to play it safe and not to go for the world record because the Americans weren't running and because the Canadian team drew lane 8. This proved to be a wise decision. When the second pass was missed on the initial attempt the added safety margin provided by the "safe early pass" philosophy left ample zone in which to recover and complete the pass.

• When asked about his decision to run the anchor leg, in spite of an injury suffered in warm up that left him limping noticeable after the race, Donovan Bailey said "There was no way I was going to let these guys (his teammates) down".

• The Canadian team was the same, running in the same order, as the 1995 World Championships and 1996 Olympic Games winners. When asked to comment on the failure of the USA relay team, Bruny Surin commented:

"The difference is that we are a team. They don't have a team. They take the four fastest guys every year and change the athletes. You cannot do that. You have to be together and train together and get along together. That's what's made us so successful."
An investigation of special jumping training in the high jump

by Wolfgang Killing

1 Introduction

Technique training primarily aims at the improvement or optimization of technique in pace with a steady increase in the level of the athlete's physical condition. The primary aim of special jumping/strength training, which, in the high jump, is first carried out in the form of pop-ups or take-offs, must be to increase specific strength for the event. Technique training and jumping-strength training, as far as their organization and objectives are concerned, are linked together in multiple ways. Technical jumps provided their number is sufficient have an effect on jumping strength; they are, as it were, the most specific form of training for the jumps. Pop-ups are also used for the correction and optimization of technique (for example, the intensive use of the swinging elements). In accordance with this double orientation - technique and jumping strength - technical jumps and pop-up jumps hold a special place in the catalogue of training means.

However, in the specialist disciplines of sport science the main focus of research has been on two-legged, (i.e. unspecific) types of jumps, from the point of view of athlete's training. In these jumps the use of the swinging elements and the redirection of horizontal velocity, which are important components in the creation of a vertical impulse in pop-up jumps, are omitted. Correspondingly, in two-legged jumps there are no overlapping effects which are difficult to separate. Therefore, two-legged jumps are easier to analyse, so that it is possible to gain a considerable amount of basic knowledge about jumping strength and the way to train for it.1

2 Outline of the problem

A good high jump is characterized by a high vertical impulse and lift, coupled with an effective bar clearance. The lift is the result of the take-off velocity or the relation between vertical impulse and body weight. This is generally understood to be the product or expression of special jumping strength. Typical jumping exercises which place special emphasis on vertical impulse...
and take-off extension are the scissor jumps and the different varieties of pop-up jumps, in which the lift is maximized at the expense of the rotation.

All high jumping techniques aim to produce an effective bar clearance. In this regard the straddle and the flop, which so far have been the most effective techniques, both on a theoretical and practical level, are characterized by a horizontal position of the body during bar clearance, with the body segments crossing the bar one after the other. This can be achieved only by means of a sufficient rotational impulse, which must be branched off, so to speak, during the take-off, at the expense of the vertical impulse. In statistical evaluations of the jumps of world-class high jumpers, DAPENA (1994) discovered that athletes with a stronger rotation about the transverse axis show a more effective bar clearance. In the flight phase (second part of the main phase) individual jumpers can achieve a lasting effect on the rotation velocity and the positioning of their bodies by moving their extremities towards their centre of mass and through apparent rotations.

The lift and rotational impulses for the subsequent flight phase are optimally prepared and developed by the three-dimensional strike-out movements downward, backwards and towards the inner side of the curve, and the corresponding straightening during the take-off. Thus, in the flop, the focus should not be on the suppression of rotations but on their optimal execution to the benefit of the whole movement. The question now is whether, or to what extent, one works on this complex task in training. To this end the basic technical characteristics of the flop technique and the special training exercises must be recorded and compared with one another. However, while there have been numerous investigations analysing the competition technique, including three-dimensional evaluations, there is a lack of corresponding studies and data of special training exercises. This deficit will be reduced by this study.

3 Design of the study

The relevant training forms have been selected from the tried and tested repertoire of exercises used by German coaches (General Training Plan, see CZINGON 1993) and the practical literature about athletics (JOHNS et al., last publication in 1995). Apart from the scissor jump and the different pop-up jumps, various other forms of series jumps are included in this catalogue of exercises. In these jumps the approach-take-off complex is replaced by depth jumps with a following take-off (cf. PRAUSE 1991). As far as these jumping forms are concerned, a provisional order of rank with regard to closeness to technique or specificity has been developed, which, because of the athletes' training and competition habits, differs from the sequence of the exercises in the study (Table 1).

The best up-and-coming young jumpers of the German Athletics Federation at that time, three of whom have succeeded in becoming world class (see Table 2), agreed to take part in a first investigation. In two groups each of two athletes, they carried out the test series presented in Table 1, each group in about 75 minutes. The jumps over the bar (flop and scissor jump) were carried out in the form of training competitions, in order to guarantee demanding heights and a high quality execution.

The jumps were observed, recorded and evaluated using two methods.

a) By means of recordings from two video cameras:

When evaluating the films of all jumping forms and all jumpers, the phases of the start of the take-off (foot touchdown = FT) and the end of the take-off (TO) were printed out as video pictures (videoprint) and measured. The backward lean, the amortisation, the forward and upward straightening, the extension phase and the use of the swinging elements were determined from the side view, while the rear view permitted evaluation of the inward (lateral) lean, the straightening towards the bar and the body lean at the end of the take-off. As quantitative parameters, the angles of backward lean and forward lean as well as the

<table>
<thead>
<tr>
<th>Table 1: The jumping forms examined and their relation to technique</th>
</tr>
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<tbody>
<tr>
<td>Flop from a long approach</td>
</tr>
<tr>
<td>Flop from a short approach</td>
</tr>
<tr>
<td>Scissor jump</td>
</tr>
<tr>
<td>Pop-ups in front of the bar</td>
</tr>
<tr>
<td>Pop-ups with landing on the take-off leg</td>
</tr>
<tr>
<td>Pop-ups with landing on the swinging leg</td>
</tr>
<tr>
<td>Multiple jumps on one leg or hops</td>
</tr>
<tr>
<td>Multiple jumps with change of leg or bounding</td>
</tr>
<tr>
<td>Ankle jumps</td>
</tr>
<tr>
<td>(in brackets: the sequence of the exercises in the study)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: The participants in the study and their high-jumping performances</th>
</tr>
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<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Ralf Sonn</td>
</tr>
<tr>
<td>Wolfgang Kreißig</td>
</tr>
<tr>
<td>Andre Pohl</td>
</tr>
<tr>
<td>Hendrik Beyer</td>
</tr>
</tbody>
</table>
as the angles of inward and outward lean were measured (Tables 3 and 4), as qualitative parameters the body posture and the position of the arms and legs were determined.

b) By means of a force platform, which recorded the force values during the respective take-offs:

Three measurements were made: the vertical force and the horizontal force parallel and vertical to the level of the bar (Figures 2 and 3)8, and also the take-off duration (Table 5)9.

4 Presentation of the results

As with the two methods of analysis, the presentation of the results is divided into a kinematic and a dynamic part. Overlapings could not be avoided and are, to some extent, even intentional.

4.1 Kinematic evaluation

As far as the flop, scissor jump and pop-up jump were concerned, it was found that the take-off lean at touch down (FT) was between 60 and 65° and, at take-off (TO), 84 and 90°10. In further exercises the take-off lean decreased up to the 90° position in the ankle jumps. However, the order of rank shown in Table 1 was maintained, with the exception for the change in the hop and the bounding run. As the take-off lean decreases, the braking impulse in the direction of movement is steadily reduced, which is confirmed by the force values shown in Table 4. This is of benefit to the series character of these jumps, an important aspect of which is the partial or complete maintenance of the horizontal velocity.

In all jumpers and all jumps, a flexion of the hips could be observed during foot touchdown. In the flop this flexion was more marked, because the shoulder adjacent to the bar runs ahead. This is in accordance with other measurements. In our own three-dimensional analyses, for example, using the APAS system, we measured hip angles of 145 to 160° in the flop (KILLING/POTT 1997).

In all exercises examined, with the exception of the ankle jumps, the angle of lift (indicated as "Diff" in Table 3) was between 22 and 30°. Since no uniform trend could be found, it can be assumed that, within this range, random differences occur. This can be explained by the similar take-off duration (0.183-0.199 sec) and the presumably similar mean horizontal velocity, since the two together determine the support distance and thus, to a great extent, the angle of straightening (cf. HUUT 1992).

Because of the uniform angle of straightening, the take-off angle (from the side view) corresponds with the take-off lean. While in the flop, scissor and pop-ups (1) an almost vertical take-off position is reached, in the series pop-ups and multiple jumps the jumpers always show a more marked forward lean. This is typical of horizontal jumps (cf. MÖSER 1990). In all jumps an almost complete straightening of the foot, knee and hip joint and of the upper body can be observed at the end of the take-off (TO), a trend which seems to confirm the measured values.

While all the flop jumpers use the leading arm technique, the arm action during the scissors and pop-ups deviates from this and is relatively arbitrary. Thus the counter-arm and double-arm movements are almost equally used. In the multiple jumps the counter-arm movement predominates, while in the hops the swinging-element character is impaired by balancing and compensatory movements.

The inward and outward lean from the back view showed clear differences between the different forms of jumping (Table 4). In the flop a straightening movement (from the inward lean) towards the bar could be observed (6°), while