CONTENTS

Editorial 3

Sprints

Overview by Jürgen Schiffer 7

Biomechanical Analysis of the Sprint and Hurdles Events at the 2009 IAAF World Championships in Athletics by Rolf Graubner and Eberhard Nixdorf 19

The Bolt Phenomenon by Mike Rowbottom 55

Modeling a Sub-10 second 100m Sprinter Using Newton’s Equations of Motion by Jeremy Richmond 69

Foot Placement by Elite Sprinters During Bend Running by Oleg Nemtsev 79

Phenomenology of Sprinting and Endurance: Toward a Uniform Performance Assessment Model by Wim Westera 87

Biomechanical Factors of Competitive Success With the Rotational Shot Put Technique by Severin Lipovšek, Branko Škof, Stanko Štuhec and Milan Čoh 101

The Critical Role of Core Strength and Balance in Preventing Spinal Injuries by Bob Adams, Frederic Depiesse, Jack Ransone 113

Conference Report - The 1st European Race Walking Conference 119

Development Spotlight – Brazil by Helmut Digel 131

The Formation of Cuban Track and Field Champions by Ariel Muñiz Sanabria 137

Phenomenology of Sprinting and Endurance: Toward a Uniform Performance Assessment Model by Wim Westera 87

Biomechanical Factors of Competitive Success With the Rotational Shot Put Technique by Severin Lipovšek, Branko Škof, Stanko Štuhec and Milan Čoh 101

The Critical Role of Core Strength and Balance in Preventing Spinal Injuries by Bob Adams, Frederic Depiesse, Jack Ransone 113

Conference Report - The 1st European Race Walking Conference 119

Development Spotlight – Brazil by Helmut Digel 131

The Formation of Cuban Track and Field Champions by Ariel Muñiz Sanabria 137

The Evolution of the Combined Events: Is a One-Day Decathlon Possible? by Anatoliy Fatieiev 145

Selected and Annotated Bibliography 151

Book review 187

Website Review 195

Technology Report 199

Abstracts 203

Preview 223
Focus on the Sprints

The sprints, especially the 100 metres, have traditionally been the blue ribbon events of athletics, attracting the attention of sports fans and casual observers alike with any activity or fact related to the fastest man, or woman, in the world. In this respect, our sport is currently enjoying a golden age because of both the general high level of performance and especially the star power of Usain Bolt, who has redefined what is possible for a sprinter.

Almost since the last time it was our Special Topic back in 2009, we have been planning an issue of New Studies in Athletics with the sprints as the focus. The centrepiece was to be the report on the biomechanical analysis of the sprint events at the 2009 IAAF World Championships in Athletics. As we prepared for publication, a number of other great articles became available and it was clear that we would need to produce another double issue, our second in a row, to make sure everything could be included. The result, I am proud to say, is that our Special Topic section offers a master class for sprint coaches.

With that point made, I do need to apologise for the delays in the appearance of NSA. I assure you that we are diligently working to solve the problems we have faced since the change in our publishing arrangements at the beginning of last year. Our aim, of course, is to get back on schedule as soon as possible. I thank all our subscribers for their understanding and patience and I hope that the overall quality of this issue, and indeed all the others that we have produced, will go some way towards compensation for the inconveniences caused by late deliveries.

I should also point out that the other aspects of the IAAF Development Programme have continued to advance at a more than satisfactory pace. The most notable examples include:

- The IAAF Academy courses for coaches, the highest level of the CECS, have now been adopted for use by the federation in the United States;

- The IAAF Kids’ Athletics Programme is making inroads in India, where we hope it is laying a foundation for the popularisation of the sport in the world’s second most populous country;

- The IAAF High Performance Training Centres (HPTCs) continue to provide support for talented athletes whose countries lack the infrastructure, coaching and other resources needed for them to fully develop their abilities – already in 2011 at least 94 athletes from 25 countries have joined our full-time residents for short-term stays at the IAAF World Pole Vault Centre in Formia, Italy, and at the end of the year 10 jumpers and five coaches will spend five weeks training at the IAAF World High Jump Centre in Cologne, Germany.

With the support of the IAAF Council and Development Commission, we will continue our efforts in these and other aspects of the programme. And, as always, I look forward to your thoughts and comments on both NSA and the IAAF Development Programme.

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Sprints

Contents

- Overview
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  by Mike Rowbottom

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  by Jeremy Richmond

- Foot Placement by Elite Sprinters During Bend Running
  by Oleg Nemtsev
Training to Overcome the Speed Plateau

By Jürgen Schiffer

Introduction

The axiom that sprinters are born and not made is still popular with many coaches. However, the widespread notion that speed is an inherited trait that cannot be measurably improved by training is not true. Although there is no doubt that genetic gifts above and beyond the norm are required to become a great sprinter, speed capacities can be maximised using scientifically based training methods. However, training for success in the sprints can be challenging and complicated. Elements include high-velocity running, speed endurance, strength and power, flexibility, neuro-muscular programming and mental preparation.

One of the biggest challenges faced by most athletes and coaches is what is known as the speed barrier or speed plateau, where the athlete has extreme difficulty to increase his or her running velocity despite increases in the volume or quality of training. The purpose of this paper is to provide an overview of the current literature about this aspect, both as a general guide and a starting point for further discussion. It includes a description of the speed plateau, the basic training approaches for overcoming it and a detailed look at one of the most currently used methods: supramaximal or tow training.

The Speed Plateau

As an athlete advances in a speed development programme, it becomes increasingly important to select the proper drills and exercises specific to his/her particular event, because as skill and performance increase, the available range of exercises that optimally stimulate improvement narrows. Thus, the training programme shifts from general preparation to more specific preparation for the competitive activity. Sprinters, for example, require specific exercises that include running at maximal velocity for short (20-80m) and long (150-300m) distances. To be effective, these exercises require a great number of repetitions (TABACHNIK, 1992). High-velocity sprinting is the most event-specific exercise that sprinters can do and should be the backbone of the training programme during all phases of the training year (DARE & KEARNEY, 1988).

However, numerous repetitions of the same exercises form a dynamic stereotype in the central nervous system. The roots of this phenomenon, which in sprint training is called the speed barrier or speed plateau, are in the intensive, highly focused training that usually leads to monotony and creates both psychological and physical fatigue. In addition, maximal speed indicators are stabilised and, after some time, restrict the transfer toward a higher level of speed (TABACHNIK, 1992).
altering the timing of the nervous impulses to the effector muscles. In other words, they create some anticipatory firing, which enhances intramuscular coordination. This is confirmed by JAKALSKI (2000), who states: “the neuron recruitment level is definitely increased after overspeed towing.” Assisted methods also make the legs more responsive to ground reaction. It is theorised that the increase in horizontal momentum resulting from assisted sprinting alters the capacity for joint stabilisation at the ankle and knee, thereby allowing for a greater transmission of force (JAKALSKI, 2000).

It should be kept in mind that the running velocity achieved under assisted conditions must be such that the athlete at some time in the future will be capable of showing the same velocity under normal conditions (KURZ, 2001).

With both assisted and resisted methods, it is important to stay within the so-called 10% neural window. This means that athletes should not be slowed down or accelerated more than 10% from their current sprinting velocity because as the resistance becomes greater or lesser, “the body breaks down the correct biomechanical style of running, which will increase their chances of injury and decrease their stride length” (CUNNINGHAM, 2001). In terms of towing force, CLARK et al. (2009) suggest that towing forces in excess of 3.8% of the athlete’s body weight should be avoided.

Dangers

Although assisted sprinting can improve stride rate and elastic energy production, some athletes have a tendency to allow themselves to be pulled while running passively. According to CISSIK (2005), this means that the athletes run with submaximal effort, which defeats the purpose of the exercise.

DINTIMAN et al. (1998) recommend continuous supervision when training with surgical tubing for assisted sprinting. Tubing can break if stretched too far, and belts can come loose if they are carelessly fastened. JAKALSKI (2000) also holds that “over-speed training using surgical tubing is dangerous […] Not only is
there an obvious risk of having the cable snap back on the runner, especially if the end slips out of a partner’s hand, but because the tubing can’t be released from the sprinter’s body, as it returns to its pre-stretched position, athletes must often step gingerly in their coast-and-stop phase to avoid getting tangled. It is not uncommon to see sprinters forced into awkward and precarious movements at the end of a tow in an attempt to avoid tripping over long sections of uncoiled cable caught between their legs.”

Downhill sprinting will increase horizontal velocity and stride length. However, declines greater than 3% may lead to excessive stride lengths that will result in increased braking during the sprint (CISSIK, 2005). Sprinting with the wind has major limitations because it is impossible to control either the velocity or availability of wind. Further, since the wind velocity is never constant, it is hard to keep sprinters within the 10% window (JAKALSKI, 2000).

In general, CISSIK (2005) recommends that when doing assisted sprints the following guidelines should be observed:

1) When being towed, distances should not be longer than 30-40m.

2) Downhill sprints should not exceed an angle of 2-3° to prevent changes in mechanics.

3) Athletes should not achieve velocities greater than 106-110% of their maximum velocity to prevent changes in running mechanics.

4) Sound technique must be emphasised during assisted sprinting.

The latter point is also emphasized by JAKALSKI (2000): “If an athlete has an unstable motor pattern, sprint-assisted work will only make his mechanics worse by magnifying errors. Unless coaches have a clear method for keeping athletes within the 10% zone, runners can generate so much speed that they begin braking actions in an effort to avoid falling forward. As soon as athletes initiate any kind of braking action, they are being taught to stay on the ground longer, and their bodies quickly adapt to this incorrect stressor.” Because of the potential risks when doing assisted sprints, JAKALSKI recommends avoiding these exercises, unless athletes are highly advanced in training age.

Variation and Contrast

Description

The other approach to overcoming the speed plateau is the variation or contrast method. This method is based on the fact that the speed the central nervous system forgets the various characteristics of the dynamic stereotype is different for each characteristic. Spatial characteristics (form of movement) are remembered longer than temporal characteristics (speed and timing of movements). If the speed exercises are not performed for a certain time, memory of the time links characteristic for running at a certain velocity may disappear even if the form of movement is still intact. It takes 10-14 days after speed training is stopped for an athlete’s running velocity to noticeably decrease. If during this period of rest from sport-specific speed exercises the athlete does directed general speed and strength exercises, his/her speed may increase afterwards (KURZ, 2001).

According to JAKALSKI (2000), contrast training, i.e., combining assisted and resisted running activities within a training session and then finishing with regular maximum velocity sprinting, is a unique way to target the athlete’s neuro-motor pattern. When using this method, it is very popular to use exercises that are similar to the competitive activity and improve special muscle strength. It is here that resistance running becomes relevant. Examples include:

- uphill running;
- running in sand or in water;
- running with a weighted belt;
- pulling, for example, a sled, tire or parachute.

The rationale behind resisted sprints exercises is that they force the athlete to exceed the usual level of driving effort, which improves muscle power, specifically take-off power and special muscle strength, which in turn leads to an improvement in stride length in normal
These findings show that overdoing resisted sprint exercises can have detrimental effects on sprinting mechanics. Therefore, CISSIK (2005) recommends that these exercises should be used sparingly, with little resistance, and during specific times in the year in accordance with the following guidelines:

1) The resistance should not slow down the athletes by more than 10%; any more than that will alter the mechanics of running and potentially create bad habits.

2) Resisted sprints should cover 15-20m and provide for a gradual release to free running for 20-25m.

3) Proper sprinting mechanics must be emphasized throughout the performance of the exercise or the athlete may inadvertently be taught to run slowly and with bad technique.

As far as training children and adolescents is concerned, it is proposed “that horizontal resisted sprint methods (towing a sled) are only appropriate for fully mature, high-performance or elite sprinters. There are two theoretical reasons for this. First, if the resistance alters stride mechanics, as acute observations have shown, then an athlete who is still developing a solid foundation in sprinting movement should not be exposed to this type of training. Quite obviously, an elite athlete with a decade of experience in sprinting is unlikely to suffer biomechanically from short interventions of this type of overload, as their motor abilities are hardened and much less prone to adaptations that the resisted load may impose. Second, it would seem illogical to implement such special training methods for athletes that have yet to optimise their force and power outputs using general and specific strength and power training. Importantly, prematurely advancing an athlete to this type of specialised training may retard their ultimate performance levels. Although there has been anecdotal evidence from coaches that some level of short-term success using these methods with developing athletes, the athlete’s overall potential may be sacrificed by introducing these advanced overload methods prior to the training to overcome the Speed Plateau.

running. It is believed that the exercises will recruit more muscle fibers and require more neural activation. Over time, this increased recruitment and activation will be transferred to non-resistant sprints, leading to an increase in running velocity (CISSIK, 2005).

One should also keep in mind that a coach cannot introduce this kind of training, have the athlete do it a few times, and then think a training stimulus has been evoked. Sprinters should contrast-train two times per week for a six- to eight-week period. They should never do back-to-back sessions, because the nervous system takes longer to recover than the cardiovascular system. There should be at least 72 hours for recovery between contrast training sessions.

**Dangers**

According to LETZELTER (1995), “competition exercises with additional loads are, as the ‘most specific of specific exercises,’ important training means. In sprinting, this applies in particular to towing resistance runs. However, precise information on the length of the runs and the level of additional loads is not available. Also missing is biomechanical information on the kinetic and dynamic influence values that bring about changes to the sprinting movements.”

With that said, LOCKIE, MURPHY & SPINKS (2003) have compared 15m sprints where the athletes dragged unloaded sleds, sleds loaded with 12.6% of body weight, and sleds loaded with 32.2% of body weight. The 32.2% load resulted in a lowering of running velocity by almost 23%, a decrease in stride length by almost 24%, an increase in trunk lean by 15% (leading to an incomplete hip extension), and an increase in ground contact time by almost 20% (leading the athletes to spending more time on the ground). This confirmed earlier results with female sprinters showing that sled towing runs over 30m with 2.5kg, 5kg and 10kg loads “did not only produce slower times, but also changed stride frequency and, even more, stride length. Also noteworthy were increased support times, changes in the upper body lean and the tendency of ‘sitting’ strides” (LETZELTER, SAUERWEIN & BURGER, 1995).
mastering of proper sprint kinematics, and optimising the adaptation of the muscular and nervous system through general and specific training” (see SHEPPARD, 2004 and MÄDE, 2007).

**Tow Training and Treadmill Training**

Of all the assisted sprinting exercises, perhaps the most currently widely used are supramaximal or tow training and treadmill training. The following sections provide descriptions of the more popular products currently in use.

**History of Tow Training**

Although the use of tow training can be traced back as far as the 1920s and the era of Paavo Nurmi, it is generally agreed that the man primarily responsible for bringing it to a level of sophistication was Australian coach Cecile Hensley. In the mid-1950s, Hensley worked with sprinters and middle-distance runners and was constantly in search of new ways to make his athletes run faster. After exhausting the list of conventional speed-training methods, he came upon the idea of towing athletes behind his car.

As a coach and physiologist, Hensley knew that one of the keys to running velocity was stride rate, the number of steps one could take in a given period of time. One of the mechanisms that controls stride rate is the central nervous system. Hensley believed that tow training might condition the brain or central nervous system to alter the rate of impulses to the muscles and thus induce an accelerated stride rate. A few years later, research studies indeed showed that tow training could increase the athlete’s stride rate and running velocity. By that time, however, Hensley had already used the tow training method to help develop several world-class athletes out of a band of formerly less-than-outstanding performers. That was in 1956, and although the sports world has not exactly witnessed a tow training renaissance, the method has been and continues to be used rather extensively in many countries (MILLER, 1984). According to DINTIMAN et al. (1998), “towing to force runners to take more steps than would otherwise be possible has improved stride rate and 40-yard dash times by more than 0.6 second.”

However, despite the theoretical and demonstrated benefits of over-speed devices, it must not be concealed that some coaches categorically refute their use. FRANCIS (1997), for example, says that over-speed methods “are dangerous due to altered running mechanics and overstretching of muscles, and are based on the fallacy that stride length and stride frequency must be enhanced simultaneously”. The only method of over-speed training he advocates is running with the wind.

**Surgical Tubing**

Surgical tubing can force the athlete to take faster and longer steps and complete a 40m sprint at world-record velocity simply by providing a slight pull throughout the high-speed portion of the sprint. A 6m to 7.5m piece of elastic tubing is attached to the sprinter’s waist by a belt. The opposite end can be attached to another athlete or to a stationary object such as a tree or a goalpost to allow the athlete to train alone. The athlete first backs up to stretch the tubing 15m (about 20m total from the partner or stationary object) and then runs at three-quarter speed with the pull until he/she learns to adjust by keeping his/her balance and using proper sprinting form. After four or five practice runs, the athlete should be ready for the full stride (DINTIMAN et al., 1998).

**Surgical Tubing Drills**

1) One end of the tubing is attached to a goalpost and the other to the athlete’s waist with the tubing tied in front. The athlete stretches the tubing by walking backward about 20m. He/she then jogs forward toward the goalpost with the pull. This drill is repeated four times, two with a three-quarter speed run and two with a full-speed sprint. Within the next three sprints, the athlete backs up an extra 4-7m each time to increase the pull and the speed of the sprint.

2) The last part of the preceding drill is repeated, emphasising a high knee lift.
3) The knot that ties the tubing to the belt must be examined to make certain that it is firmly in place and secure.

4) After having attached the belt to the waist, a knot must be tied with the remaining portion to make certain it cannot come loose.

5) Standing with the tubing fully stretched for more than a few seconds must be avoided. During this stretch phase, knots can come loose and tubing can break.

6) Tubing that attaches to a belt around the waist should be preferred to a harness. With only slight differences in height between the athlete being towed and his/her partner, a broken tubing or a loose belt could snap upward and strike the sprinter in the eye. Tubing attached to the waist that does come loose when stretched is unlikely to produce any serious injury.

7) The first several workouts should be run wearing shoes without spikes. Spikes are only allowed after the athlete has fully adjusted to the high speed and can complete each repetition with correct form.

8) Surgical tubing should be used on a soft grassy area only (DINTIMAN et al., 1998).

**The Ultra Speed Pacer**

The Ultra Speed Pacer is a simple pulley device that relies on leverage. The pulley (fulcrum) is fastened to a fixed object in the gym or on the athletic field. Each side of the rope going through the pulley is attached to an athlete using a belt. As one athlete sprints at a 45° angle away from the pulley, the other athlete is forced to sprint toward the pulley while receiving considerable pull. After a few trials, both partners will easily determine how fast the angle athlete should run to increase or decrease the pull. The device has the potential to provide a strong pull and produce very high stride rates, stride lengths, and sprinting velocity. Because this device merely provides a straight pull at various velocities, one cannot use the drills described for surgical tubing with this device (DINTIMAN et al., 1998).
The Sprint Master

The Sprint Master, which was developed by John Dolan and Michael Watkins, is precisely engineered to pull athletes at speeds faster than any human can sprint. It attaches to the goalposts of a football or soccer field or to the wall in a gymnasium and provides controlled, variable speed for each athlete. It is safe and allows the athlete to merely release his or her grip if balance is lost. The Sprint Master also allows full arm use while being towed at speeds of up to one second faster than the athlete’s best flying 40m time.

According to DINIMAN et al. (1998) operating the Sprint Master is easily learned. Speeds can be individually determined for each athlete, and the operator can make the pull safely. However, most of the towing drills described previously for surgical tubing cannot be used with the Sprint Master because this device allows only straight-ahead sprinting at various speeds.

The following steps should be used to start an over-speed program with the Sprint Master:

1) Athletes should use the workout schedule shown in the table below two to three times per week (every other day).

2) The athlete should have his/her coach or friend pull him/her at approximately half of a second faster than his/her best flying 40m time. The operator quickly learns how to judge pace and can group athletes of similar speed together. It is also quite simple to place two marks 40m apart and time athletes as they are being pulled. The set screw on the machine can then be fixed at the proper speed.

<table>
<thead>
<tr>
<th>Week</th>
<th>Reps</th>
<th>Over-speed distance (m)</th>
<th>Rest (minutes)</th>
<th>Progression</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3-5</td>
<td>10-15</td>
<td>2</td>
<td>Three-quarter speed runs only to acclimatise</td>
</tr>
<tr>
<td>2</td>
<td>3-5</td>
<td>10-15</td>
<td>2</td>
<td>Maximum speed</td>
</tr>
<tr>
<td>3</td>
<td>5-7</td>
<td>15-20</td>
<td>3</td>
<td>Maximum speed</td>
</tr>
<tr>
<td>4</td>
<td>7-9</td>
<td>20-25</td>
<td>3</td>
<td>Maximum speed</td>
</tr>
<tr>
<td>5</td>
<td>7-9</td>
<td>20-25</td>
<td>3.5</td>
<td>Maximum speed</td>
</tr>
<tr>
<td>6-9</td>
<td>7-9</td>
<td>25-30</td>
<td>3.5</td>
<td>Maximum speed with weighted vest that progresses from one to five pounds over three weeks. Used for the final two reps of the workout only.</td>
</tr>
</tbody>
</table>

Table 1: Over-speed training using surgical tubing or the Sprint Master (from DINIMAN et al, 1998)

Table 2: High-speed treadmill sprint program

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Speed</th>
<th>Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acclimation</td>
<td>90% of maximum</td>
<td>6-20 at 2-minute intervals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for 10 seconds</td>
</tr>
<tr>
<td>Entry practice</td>
<td>75% under maximum</td>
<td>10-30 for two seconds</td>
</tr>
<tr>
<td></td>
<td>90% under maximum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At maximum speed</td>
<td></td>
</tr>
<tr>
<td>Improved stride rate</td>
<td>0.4-0.8m/sec and 1.3-1.7m/sec</td>
<td>2-6 for 3-5 seconds allowing</td>
</tr>
<tr>
<td></td>
<td>above maximum speed</td>
<td>full recovery after each</td>
</tr>
</tbody>
</table>
### Training to overcome the Speed Plateau

#### Table 3: Eight-week sprint-assisted program (based on Dintiman, Ward & Tellez)

<table>
<thead>
<tr>
<th>Week</th>
<th>Workout</th>
<th>Overspeed distance</th>
<th>Repetitions</th>
<th>Rest interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>½-speed runs toward the pull for 15m emphasising correct sprinting form. ½-speed backward runs toward the pull for 20m.</td>
<td>5 3</td>
<td>1 min 1 min</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>¾-speed runs for 25m. ¾-speed backward runs toward the pull for 25m. ¾-speed turn-and-runs at a 45° angle for 25m (left and right).</td>
<td>5 3 3</td>
<td>2 min 2 min 2 min</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>¾-speed runs toward the pull for 15m. Maximum-speed sprints toward the pull for 15m.</td>
<td>3 5</td>
<td>2 min 2 min</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>¾-speed runs for 25m. Maximum-speed sprints for 25m.</td>
<td>3 6</td>
<td>2 min 3 min</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>¾-speed runs toward the pull for 15m. Quick feet, short step, low knee lift sprint for 15m with rapid arm-pumping action. Quick feet, short step, high knee lift sprint for 15m with rapid arm-pumping action. Maximum-speed pulls for 30m rapid arm-pumping action.</td>
<td>3 3 4</td>
<td>1 min 2 min 3 min</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>High-speed stationary cycling. With the resistance on low average, warm up for 5-7 min until you perspire freely. Pedal at ¾ speed for 30 sec. Pedal at maximum speed for 2 sec as you say &quot;one thousand and one, one thousand and two, one thousand and three.&quot; Pedal at maximum speed for 3 sec as you say &quot;one thousand and one, one thousand and two, one thousand and three.&quot; Pedal at maximum speed for 5 sec.</td>
<td>3 7 3 6</td>
<td>1 min 2 min 2 min 2 min</td>
</tr>
<tr>
<td>7</td>
<td>13</td>
<td>Repeat workout 11. Two-man pull and resist drill for 90m. Maximum-speed sprints for 25m.</td>
<td>2 6</td>
<td>4 min 3 min</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>¾-speed runs toward the pull for 15m. Quick feet, short step, low knee lift sprint for 15m with rapid arm-pumping action. Quick feet, short step, high knee lift sprint for 15m with rapid arm-pumping action. Maximum-speed pulls for 30m. Maintenance programme: ¾-speed runs toward the pull for 15m. Quick feet, short step, high knee lift sprint for 15m with rapid arm-pumping action. Maximum-speed pull forward for 20m, plant right foot and sprint diagonally left for 20m. Repeat, planting the left foot and sprinting diagonally right for 20m. Maximum-speed pulls forward for 30m.</td>
<td>3 5 2 3 5</td>
<td>1 min 2 min 2 min 2 min 3 min</td>
</tr>
<tr>
<td>9</td>
<td>16</td>
<td>Maintenance programme: ¾-speed runs toward the pull for 15m. Quick feet, short step, high knee lift sprint for 15m with rapid arm-pumping action. Maximum-speed pull forward for 20m, plant right foot and sprint diagonally left for 20m. Repeat, planting the left foot and sprinting diagonally right for 20m. Maximum-speed pulls forward for 30m.</td>
<td>5 2 3</td>
<td>3 min 2 min 2 min</td>
</tr>
</tbody>
</table>
6-8 practice attempts, sprinters can easily enter at high speeds. The so-called greyhound effect allows athletes to reach maximum speed in approximately two seconds.

The sample high-speed treadmill sprint programme presented in Table 2 has been used in a number of experiments and has proved effective.

Although generally supporting treadmill sprinting, DINTIMAN et al. (1998) admit that this method is not without special problems. The sprinting action produces a slight breaking or slowing effect each time the foot strikes the tread-belt; however aiding factors predominate and allow a faster rate for most individuals even without training. The braking effect when each foot strikes the tread-belt has been found to be greater for heavier athletes (over 90kg) and for athletes of all sizes in the initial stages of training. It tends to be eliminated as acclimation occurs and format instruction is given. At speeds beyond one’s maximum velocity (in early training sessions), the braking effect almost reduces tread-belt speed to the athlete’s maximum velocity. However, most of the problems of treadmill sprint training can be overcome for athletes of all sizes by using an ample number of practice sessions at various velocities (acclimation), seeing that athletes master proper sprinting form, and avoiding a tread-belt speed too far beyond the subject’s present maximum velocity (the point at which proper sprinting form cannot be maintained). Ongoing research with high-speed treadmill sprinting continues to show improvements in stride rate and length, with this effect carried over to unassisted sprinting.

A longer-term, versatile sprint-assisted programme is presented in Table 3.

All the methods and devices discussed are described in more detail by DINTIMAN, WARD & TELLEZ (1998) and by FACCIONI (1994). More detailed information can also be found in KO-SZEWSKI (2000) and LETZELTER (2001).

Finally, it should be stressed once again that the use of assisted means in sprint training should only be conducted with highly coordi-
nated athletes to be effective. This means that the athlete must already be technically quite proficient (see MOUCHBAHANI, GOLLHOFER & DICKHUTH, 2004).

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REFERENCES


Biomechanical Analysis of the Sprint and Hurdles Events at the 2009 IAAF World Championships in Athletics

By Rolf Graubner and Eberhard Nixdorf

(Translated from the original German by Jürgen Schiffer)

ABSTRACT

The 2009 IAAF World Championships in Athletics in Berlin presented German sport scientists with a rare opportunity to study the world’s best athletes in a top-level competition at a venue close to home. A team of 18 researchers from six institutions around the country planned, organised and carried out a major biomechanics research project at the championships with the support of the German athletic federation (DLV) and the IAAF. The project’s objectives included making detailed analysis of the finals of all the individual sprint and hurdle events for both men and women. Video recordings using digital camcorders positioned in the stands around the track were made in order to obtain split times of the races and study other aspects such as stride length and stride frequency. In addition, laser measurement systems were used to obtain continuous velocity measurements in the men’s 100m final. This report, prepared specially for NSA, provides analysis and commentary on the data obtained by the project team, with sections on each of the events. In addition, there is a special analysis of the men’s 100m final based on the laser measurement data.

AUTHORS

Rolf Graubner is scientific co-worker and senior lecturer for athletics at the Martin-Luther University Halle-Wittenberg (Germany). He provides performance diagnostic services in sprint, hurdle and relay disciplines for the German national athletics team.

Eberhard Nixdorf works at the Olympic Training Centre (OSP) Hessen, Germany, and provides performance diagnostic services in several disciplines for the German national athletics team.

Introduction

The 2009 IAAF World Championships in Athletics in Berlin presented German sport scientists with a rare opportunity to study the world’s best athletes in a top-level competition at a venue close to home and thereby carry on a tradition of scientific work at major athletics events stretching back more than 30 years. With the support of the IAAF and the German athletic federation (DLV), a team of 18 researchers from six institutions around the country planned, organised and carried out a major...
Following the world record performances of Usain Bolt (JAM) and other great performances one year earlier at the Olympic Games in Beijing, there was great anticipation surrounding both the men’s and women’s sprint and hurdles events in Berlin, and these, naturally, became a focus for the project team. Their objectives included making detailed analysis of the finals of all these events, plus the earlier rounds in most cases. Video recordings using digital camcorders positioned in the stands around the track were made to obtain split times of the races and study other aspects. Much of the data gathered by the project team was made available during the championships in Berlin and a complete compilation was published on the IAAF website in the following months.

The purpose of this report is to provide additional analysis and commentary. In the following sections, each of the individual sprint and hurdle events is covered. In addition, there is a special analysis, based on data from the laser measurement equipment, of the men’s 100m final, where Bolt bettered, the record he set in Beijing.

The video measurement team consisted of Rolf Graubner (Martin-Luther University Halle-Wittenberg, Germany), Dr. Ralf Buckwitz (Olympic Training Centre Berlin), Mirko Landmann (Martin-Luther University Halle-Wittenberg, Germany) and Anja Starke (Martin-Luther University Halle-Wittenberg, Germany).

**Measurement Methods**

The basic equipment system selected for the project consisted of eight static CCTV colour cameras recording at 50Hz, which were aligned orthogonally to the running track at 10 positions, alternating depending on the event, and up to four semi-professional 3CCD cameras used for panning (see Figure 1). This system was chosen both for the fact that it could provide data that could be quickly analysed and presented to the public and for its cost effectiveness, making it possible to study a wide range of events at the championships.

The video signals were provided using manual selective switches, a video timer (ForA VTG-33 with synchronisation through the starting signal, which was supplied by the competition

![Figure 1: Schematic presentation of camera positions used at the 2009 IAAF World Championships in Athletics](image)
time measurement system/SEIKO) and a signal converter (Canopus ADVC 100) and then recorded on up to three notebook PCs. A single cable system for electric power supply and signal transmission was used and all the cameras were connected to a central unit in the grandstand by a cable over 800m long.

Because of the exact synchronisation of the timers with the start, no additional measures for the event synchronisation of the video signals were necessary. The CCTV cameras used included an automatic system-internal synchronisation (Gen-Lock) via the joint electric power supply modules.

The positions of the cameras are shown in Figure 1 and the allocation of the cameras to the various events is given in Table 1.

Table 1: Allocation of the cameras to the events and switching sequence of shots at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Event</th>
<th>100m</th>
<th>200m</th>
<th>400m</th>
<th>100m H</th>
<th>400m H</th>
<th>4x100m</th>
<th>4x400m</th>
<th>10Dec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rounds</td>
<td>4/5/7/8</td>
<td>1/3/6</td>
<td>11/13/14/16</td>
<td>11/12</td>
<td>11/13/14</td>
<td>11/13/14</td>
<td>11/13/14</td>
<td>11/13/14</td>
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<tr>
<td>Athletes</td>
<td>33</td>
<td>28</td>
<td>27</td>
<td>17</td>
<td>14</td>
<td>8</td>
<td>8</td>
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<tr>
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<td>84</td>
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<td>51</td>
<td>51</td>
<td>51</td>
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<tr>
<td>Total</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</table>

Table 2a: Overview of the analyses for the studied women’s events at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Women</th>
<th>100m</th>
<th>200m</th>
<th>400m</th>
<th>100m H</th>
<th>400m H</th>
<th>4x100m</th>
<th>4x400m</th>
<th>7Hep.</th>
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</thead>
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<tr>
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<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
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<td>2</td>
<td>2</td>
</tr>
<tr>
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<td>30</td>
<td>28</td>
<td>27</td>
<td>17</td>
<td>14</td>
<td>8</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>Analyses</td>
<td>84</td>
<td>55</td>
<td>28</td>
<td>40</td>
<td>32</td>
<td>11</td>
<td>9</td>
<td>40</td>
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<tr>
<td>Total</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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</table>

Table 2b: Overview of the analyses for the studied men’s events at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Men</th>
<th>100m</th>
<th>200m</th>
<th>400m</th>
<th>110m H</th>
<th>400m H</th>
<th>4x100m</th>
<th>4x400m</th>
<th>10Dec.</th>
</tr>
</thead>
<tbody>
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<td>Rounds</td>
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<td>3</td>
<td>3</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Athletes</td>
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<td>24</td>
<td>14</td>
<td>9</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
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<td>52</td>
<td>49</td>
<td>31</td>
<td>11</td>
<td>9</td>
<td>64</td>
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<tr>
<td>Total</td>
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<td></td>
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<td></td>
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</tr>
</tbody>
</table>
The 100 Metres

Methods and Procedures

The video measurement system for the 100m races used four of the cameras described in Figure 1 to obtain data at uniform intervals of 20m (no. 4 = 20m / no. 5 = 40m / no. 7 = 60m / no. 8 = 80m). Using this method normally enables the recording of all participants in a race at all four measuring positions because of sufficiently long interval times, and it also enables a fast evaluation because of the direct synchronisation of the video timers with the start. In the semi-finals and finals, additional video recordings were made with Camera 13. This data was used for the analysis of stride lengths and stride rates.

Results and Comments – Men

As at the 2008 Olympic Games, the men's 100m final was dominated by Usain Bolt. In Berlin he improved the world record he set in Beijing by 0.11 sec to 9.58 sec (see Table 3). It was the largest improvement ever of the 100m world record. In second place, Tyson Gay (USA) set a national record of 9.71 sec, just 0.02 sec slower than the previous world mark, to become the second fastest man ever. In general, the finalists demonstrated a very high performance level. The average of the first three placed runners was 9.71 sec, far better than ever achieved previously (for comparison, the average for the first three in the final at the 2004 Olympic Games was 9.86 sec; in the 2008 Olympic Games it was 9.83 sec). Leaving place 8 (Patton (USA), 10.34 sec) out of consideration, the average time for the first seven placers was 9.86 sec, the first time a mark below 9.90 sec had been achieved (2004 Olympic Games: 9.93 sec; 2008 Olympic Games: 9.92 sec).

The split and interval times for the finalists are given in Table 4. Figure 4 shows Bolt's position at each of the four split points. The screen shots illustrate his comprehensive performance in all sections of the race. Unlike previous top-level sprinters (i.e. Carl Lewis, Donovan Bailey), Bolt matches, or beats, his competitors in the acceleration phase of the race. In the phases of maximal velocity and sprint-specific endurance, he sets new standards.

Bolt's performance differs considerably from other athletes with respect to the times for measured intervals in the race. He recorded best values for 10m sections of 0.83 sec and in individual cases 0.82 sec (where comparative analysis is influenced by the problem of measurement and margin of error; see page 24). In the Berlin, he achieved a time of 3.28 sec for the 40–80m section, which corresponds with four successive 10m intervals in 0.82 sec (average velocity: 12.2 m/sec).

Table 3: Results of the men’s 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usain Bolt (JAM)</td>
<td>9.58</td>
<td>0.146</td>
<td>4</td>
</tr>
<tr>
<td>Tyson Gay (USA)</td>
<td>9.71</td>
<td>0.144</td>
<td>5</td>
</tr>
<tr>
<td>Asafa Powell (JAM)</td>
<td>9.84</td>
<td>0.134</td>
<td>6</td>
</tr>
<tr>
<td>Daniel Bailey (ANT)</td>
<td>9.93</td>
<td>0.129</td>
<td>3</td>
</tr>
<tr>
<td>Richard Thompson (TRI)</td>
<td>9.93</td>
<td>0.119</td>
<td>8</td>
</tr>
<tr>
<td>Dwain Chambers (GBR)</td>
<td>10.00</td>
<td>0.123</td>
<td>1</td>
</tr>
<tr>
<td>Marc Burns (TRI)</td>
<td>10.00</td>
<td>0.165</td>
<td>2</td>
</tr>
<tr>
<td>Darvis Patton (USA)</td>
<td>10.34</td>
<td>0.149</td>
<td>7</td>
</tr>
</tbody>
</table>
Table 4: Split and interval times (sec) of the men's 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th></th>
<th>RT</th>
<th>20m</th>
<th>40m</th>
<th>60m</th>
<th>80m</th>
<th>100m</th>
<th>20-40m</th>
<th>40-60m</th>
<th>60-80m</th>
<th>80-100m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt</td>
<td>0.146</td>
<td>2.88</td>
<td>4.64</td>
<td>6.31</td>
<td>7.92</td>
<td>9.58</td>
<td>1.76</td>
<td>1.67</td>
<td>1.61</td>
<td>1.66</td>
</tr>
<tr>
<td>Gay</td>
<td>0.144</td>
<td>2.92</td>
<td>4.70</td>
<td>6.39</td>
<td>8.02</td>
<td>9.71</td>
<td>1.78</td>
<td>1.69</td>
<td>1.63</td>
<td>1.69</td>
</tr>
<tr>
<td>Powell</td>
<td>0.134</td>
<td>2.91</td>
<td>4.71</td>
<td>6.42</td>
<td>8.10</td>
<td>9.84</td>
<td>1.80</td>
<td>1.71</td>
<td>1.68</td>
<td>1.74</td>
</tr>
<tr>
<td>Bailey</td>
<td>0.129</td>
<td>2.92</td>
<td>4.73</td>
<td>6.48</td>
<td>8.18</td>
<td>9.93</td>
<td>1.81</td>
<td>1.75</td>
<td>1.70</td>
<td>1.75</td>
</tr>
<tr>
<td>Thompson</td>
<td>0.119</td>
<td>2.90</td>
<td>4.71</td>
<td>6.45</td>
<td>8.17</td>
<td>9.93</td>
<td>1.81</td>
<td>1.74</td>
<td>1.72</td>
<td>1.76</td>
</tr>
<tr>
<td>Burns</td>
<td>0.165</td>
<td>2.94</td>
<td>4.76</td>
<td>6.52</td>
<td>8.24</td>
<td>10.00</td>
<td>1.82</td>
<td>1.76</td>
<td>1.72</td>
<td>1.76</td>
</tr>
<tr>
<td>Chambers</td>
<td>0.123</td>
<td>2.93</td>
<td>4.75</td>
<td>6.50</td>
<td>8.22</td>
<td>10.00</td>
<td>1.82</td>
<td>1.75</td>
<td>1.72</td>
<td>1.78</td>
</tr>
<tr>
<td>Patton</td>
<td>0.149</td>
<td>2.96</td>
<td>4.85</td>
<td>6.65</td>
<td>8.42</td>
<td>10.34</td>
<td>1.89</td>
<td>1.80</td>
<td>1.77</td>
<td>1.92</td>
</tr>
</tbody>
</table>

Table 5: Stride analysis for Usain Bolt in the 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Interval time [sec]</th>
<th>Average stride length [m]</th>
<th>Average stride frequency [strides/sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20m</td>
<td>2.89</td>
<td>1.78</td>
</tr>
<tr>
<td>20-40m</td>
<td>1.75</td>
<td>2.52</td>
</tr>
<tr>
<td>40-60m</td>
<td>1.67</td>
<td>2.67</td>
</tr>
<tr>
<td>60-80m</td>
<td>1.61</td>
<td>2.77</td>
</tr>
<tr>
<td>80-100m</td>
<td>1.66</td>
<td>2.85</td>
</tr>
</tbody>
</table>
Using the data obtained from the final in Berlin, a question that was frequently discussed after the 2008 Olympic Games can be acceptably answered: What could Bolt have achieved in Beijing if he had run through the finish line without slowing to celebrate? In the analyses of Beijing (http://www.sportscientists.com), an 80m split time of 7.96 sec is given, which is 0.04 sec slower than the same split in Berlin. It is reasonable to assume that he could have finished the race at the same velocity as he did in Berlin and therefore, it is possible to estimate that his time in the 2008 Olympic final running at full effort through the finish could have been 9.63 sec.

An outstanding characteristic of Bolt can be identified on the basis of the analysis of his strides (see Table 5). Whereas his stride frequency can be considered as quite normal for a sprinter of his body height, his average stride length of up to 2.85m is a novum and meant that his total number of strides for the race was 40.92. This, ultimately, is the biomechanical explanation of his performance advantage.

### Laser Measurement Analysis of the Men’s 100 Metres Final

The laser measurement team consisted of Eberhard Nixdorf (Olympic Training Centre Hessen), Falk Schade (Olympic Training Centre Rhein-Arena), Regine Isele (Olympic Training Centre Hessen), and Luis Mendoza (Olympic Training Centre Hessen)

#### Introduction

In addition to the video-based analyses, three laser measurement systems (LAVEG Sport and LEM 300, JenOptik) were used during the men’s 100m final. These use laser distance measurement to determine the distance to an object at any point in time, i.e. the sprinters, during the whole race. From the distance-time curve, the split and interval times can be calculated at a finer resolution (10m intervals) as well as the mean interval velocities and the momentary velocities.

Due to the completely differing measurement approach, the split times determined through the method of laser distance measurement can be expected to differ slightly from those obtained through video-based measurement.

#### Methodology

The procedure is based on the infrared laser measurement of the distance to the athlete. Since the wavelength of the emitted light is in the invisible range, the measuring point itself cannot directly be seen on the athlete. During the measurement, a precise lens and a cross-hair is used to focus on a point in the athlete’s lumbar region and to follow that point during the complete run, right through the finish. The measurement is conducted at 50Hz (LAVEG Sport) and 100Hz (LEM 300), i.e., according to their type of construction, the systems measure 50 or 100 distances to the targeted object per second.

The raw data are filtered using a digital Butterworth low-pass filter (cut-off 7 Hz). In doing so, the intracyclical velocity changes of the running strides are maintained (blue curve). This data is used to calculate the 10m split times, the 10m interval times and the 10m interval velocities. The calculation of the first 10m interval velocity (V0-10) is done without taking into account the reaction time. Because of the start from behind the starting line, this section is slightly longer than 10m. This effect could not be taken into account so that for the start section a distance of 10m was assumed and for the calculation of the interval time only the reaction time was subtracted.
Using a harder low-pass filter (cut-off 1 Hz), the intracyclical velocity changes can be completely filtered out, so that the momentary velocity without the cycle effects (red curve) is the only information left. Now, the maximal velocity and the place where the maximal velocity is reached as well as the corresponding values for 99% of the maximal velocity can be easily calculated.

The calculation of the velocities is made by simple differentiation from the distance measurement. As no linkage was possible, the synchronisation with the official time measurement was made using the run through the finish line.

The three laser measurement systems were operated at a distance of about 15m behind the starting blocks from the spectator areas. The height was between 2.3m and 2.7m above the starting line to get over a fence and an advertising board. Each system was calibrated, so that the different heights and distances to the starting line could be compensated for.

**Note on Measurement Accuracy**

Although ideally, the results of the video split-time measurement and the LAVEG laser measurement should generally lead to identical results, there can be slight differences, which are due to the shortcomings of the technical measurement systems and the people conducting the measurements.

In the video measurement there are two noteworthy sources of error:

1) Errors with the adjustment of the cameras orthogonally aligned with the running track. This source of error was only of inferior importance in the present analysis, because the distance between the cameras and the running track was more than 100m (a deviation of 1m in the position of the camera corresponds with a deviation of 1cm in the position of the athlete to be measured on the track = ca. 1/1000s).

2) Because of the 50Hz frame rate there are minimally measurable differences of 0.02 sec, which require an interpolation in the case of slight deviations (0.01 sec) from the measurement position. Although the subjective factor of the evaluator is of a certain importance in the interpolation, this can generally be compensated for through experience.

In laser measurement systems there are also two fundamental sources of error:

1) Inaccuracies in targeting and tracking the athlete over the complete measurement distance.

2) Deviations in the calculation of parameters as a result of the smoothing procedure that must be applied to the original measurement values (choice of smoothing factor).

Although there is no intention to continue the error discussion on a scientific level any longer, it must be stated that, with a cross-comparison of results from the two measurement procedures, an immanent error measure of at least 0.01 sec must be assumed for each procedure. Therefore, a difference of 0.02 sec in total for any result should not be worth discussing. This means that, on the basis of error consideration, a content-related discussion of deviations of 0.01 sec between two 10m interval times is generally pointless.
Results

Table A: Split times (sec) of the medallists in the men’s 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Name</th>
<th>T10</th>
<th>t20</th>
<th>t30</th>
<th>t40</th>
<th>t50</th>
<th>t60</th>
<th>t70</th>
<th>t80</th>
<th>T90</th>
<th>t100</th>
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</thead>
<tbody>
<tr>
<td>Bolt</td>
<td>1.88</td>
<td>2.88</td>
<td>3.78</td>
<td>4.64</td>
<td>5.47</td>
<td>6.29</td>
<td>7.10</td>
<td>7.92</td>
<td>8.74</td>
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</tr>
<tr>
<td>Gay</td>
<td>1.91</td>
<td>2.93</td>
<td>3.84</td>
<td>4.70</td>
<td>5.54</td>
<td>6.36</td>
<td>7.19</td>
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<tr>
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<td>2.90</td>
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<td>5.56</td>
<td>6.40</td>
<td>7.24</td>
<td>8.09</td>
<td>8.95</td>
<td>9.84</td>
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</table>

Table B: Interval times (sec) of the medallists in the men’s 100m final at the 2009 IAAF World Championships in Athletics

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<tr>
<th>Name</th>
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<th>T20</th>
<th>t30</th>
<th>t40</th>
<th>t50</th>
<th>t60</th>
<th>t70</th>
<th>t80</th>
<th>T90</th>
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<tr>
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<td>0.90</td>
<td>0.86</td>
<td>0.83</td>
<td>0.82</td>
<td>0.81</td>
<td>0.82</td>
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<td>0.84</td>
</tr>
<tr>
<td>Gay</td>
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<td>1.02</td>
<td>0.91</td>
<td>0.86</td>
<td>0.84</td>
<td>0.82</td>
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<tr>
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<td>0.88</td>
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<td>0.84</td>
<td>0.84</td>
<td>0.85</td>
<td>0.86</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Table C: Mean interval velocities (m/sec) of the medallists in the men’s 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Name</th>
<th>V0-10</th>
<th>V10-20</th>
<th>V20-30</th>
<th>V30-40</th>
<th>V40-50</th>
<th>V50-60</th>
<th>V60-70</th>
<th>V70-80</th>
<th>V80-90</th>
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<td>Gay</td>
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<td>9.80</td>
<td>11.04</td>
<td>11.65</td>
<td>11.85</td>
<td>12.16</td>
<td>12.09</td>
<td>12.05</td>
<td>11.93</td>
<td>11.76</td>
</tr>
<tr>
<td>Powell</td>
<td>5.73</td>
<td>9.78</td>
<td>10.79</td>
<td>11.41</td>
<td>11.75</td>
<td>11.90</td>
<td>11.84</td>
<td>11.80</td>
<td>11.61</td>
<td>11.20</td>
</tr>
</tbody>
</table>

Table D: Maximum velocity (99% and 100%) and location of maximum velocity of the medallists in the men’s 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Name</th>
<th>V99%</th>
<th>location</th>
<th>Vmax</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt</td>
<td>12.22</td>
<td>51.27</td>
<td>12.34</td>
<td>67.90</td>
</tr>
<tr>
<td>Gay</td>
<td>12.09</td>
<td>52.45</td>
<td>12.20</td>
<td>55.23</td>
</tr>
<tr>
<td>Powell</td>
<td>11.87</td>
<td>52.55</td>
<td>11.99</td>
<td>53.75</td>
</tr>
</tbody>
</table>
Figure A: Momentary velocity vs location for Usain Bolt in the men’s 100m final at the 2009 IAAF World Championships in Athletics

Figure B: Momentary velocity vs location for Tyson Gay in the men’s 100m final at the 2009 IAAF World Championships in Athletics

Figure C: Momentary velocity vs location for Asafa Powell in the men’s 100m final at the 2009 IAAF World Championships in Athletics
Biomechanical Analysis of the Sprint and Hurdles Events at the 2009 IAAF World Championships in Athletics

Results and Comments – Women

As with the men, the women’s 100m final Berlin was of very high quality, with the winner Shelly-Ann Fraser-Price (JAM) achieving the fourth fastest time in history and the best mark for comparable competitions since the year 2000 (see Table 10). The mean time for the first three was 10.79 sec and it was 10.95 sec for all eight finalists, the first time this value has been below 11.00 sec.

However, in comparison to Jeter and especially Stewart, Fraser-Price’s early acceleration advantage of 0.09 sec (at 30 and 40m) is more pronounced than her velocity loss from 60m to the finish line.

As far as the position of the fastest sections is concerned, there is an analogy with the men, even though previous studies lead to the assumption that women tend to achieve their definite velocity maximum earlier in the race.

The average velocities calculated for the 20m intervals are in the same range of instantaneous velocities obtained using LAVEG laser equipment. Here, Stewart’s mean velocity of 10.75 m/sec for the 20m from 60m to 80m is an absolute top value.

The split and interval times for the finalists are given in Table 11. The comparison between the medal winners shows interesting individual dispositions of the 100m performance structure. Fraser-Price, had a very high acceleration ability, which is particularly clear in the calculated 30m time of 4.02 sec – a value that is almost at the same level as that of male sprinters with a performance ability in the 10.40 sec–10.60 sec range. Although Stewart (JAM) and Jeter (USA) achieved approximately the same velocity level as Fraser-Price in the 40–60m section of the better semi-final race, they were then able to accelerate even more and then to maintain their pace (see Table 12, Table 13 and Table 14).

The stride analysis (see Table 15) leads to an expected result. The two shorter sprinters, Fraser-Price (body height: 1.60m) and Jeter...
Table 10: Results of the women’s 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Shelly-Ann Fraser-Price (JAM)</td>
<td>10.73 WL</td>
<td>0.146</td>
<td>3</td>
</tr>
<tr>
<td>2 Kerron Stewart (JAM)</td>
<td>10.75 PB</td>
<td>0.170</td>
<td>4</td>
</tr>
<tr>
<td>3 Carmelita Jeter (USA)</td>
<td>10.90</td>
<td>0.160</td>
<td>5</td>
</tr>
<tr>
<td>4 Veronica Campbell-Brown (JAM)</td>
<td>10.95 SB</td>
<td>0.135</td>
<td>6</td>
</tr>
<tr>
<td>5 Lauryn Williams (USA)</td>
<td>11.01 SB</td>
<td>0.158</td>
<td>8</td>
</tr>
<tr>
<td>6 Debbie Ferguson-McKenzie (BAH)</td>
<td>11.05</td>
<td>0.130</td>
<td>2</td>
</tr>
<tr>
<td>7 Chandra Sturrup (BAH)</td>
<td>11.05</td>
<td>0.137</td>
<td>7</td>
</tr>
<tr>
<td>8 Aleen Bailey (JAM)</td>
<td>11.16</td>
<td>0.173</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 11: Split and interval times (sec) of the women’s 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>RT</th>
<th>20m</th>
<th>40m</th>
<th>60m</th>
<th>80m</th>
<th>100m</th>
<th>20-40m</th>
<th>40-60m</th>
<th>60-80m</th>
<th>80-100m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser-Price</td>
<td>0.146</td>
<td>3.03</td>
<td>4.98</td>
<td>6.88</td>
<td>8.77</td>
<td>10.73</td>
<td>1.95</td>
<td>1.90</td>
<td>1.89</td>
<td>1.96</td>
</tr>
<tr>
<td>Stewart</td>
<td>0.170</td>
<td>3.11</td>
<td>5.07</td>
<td>6.96</td>
<td>8.82</td>
<td>10.75</td>
<td>1.96</td>
<td>1.89</td>
<td>1.86</td>
<td>1.93</td>
</tr>
<tr>
<td>Jeter</td>
<td>0.160</td>
<td>3.13</td>
<td>5.09</td>
<td>7.01</td>
<td>8.91</td>
<td>10.90</td>
<td>1.96</td>
<td>1.92</td>
<td>1.90</td>
<td>1.99</td>
</tr>
<tr>
<td>Campbell-Brown</td>
<td>0.135</td>
<td>3.12</td>
<td>5.12</td>
<td>7.06</td>
<td>8.97</td>
<td>10.95</td>
<td>2.00</td>
<td>1.94</td>
<td>1.91</td>
<td>1.98</td>
</tr>
<tr>
<td>Williams</td>
<td>0.158</td>
<td>3.14</td>
<td>5.13</td>
<td>7.08</td>
<td>9.00</td>
<td>11.01</td>
<td>1.99</td>
<td>1.95</td>
<td>1.92</td>
<td>2.01</td>
</tr>
<tr>
<td>Ferguson-McKenzie</td>
<td>0.130</td>
<td>3.15</td>
<td>5.16</td>
<td>7.12</td>
<td>9.06</td>
<td>11.05</td>
<td>2.01</td>
<td>1.96</td>
<td>1.94</td>
<td>1.99</td>
</tr>
<tr>
<td>Sturrup</td>
<td>0.137</td>
<td>3.11</td>
<td>5.11</td>
<td>7.07</td>
<td>9.02</td>
<td>11.05</td>
<td>2.00</td>
<td>1.96</td>
<td>1.95</td>
<td>2.03</td>
</tr>
<tr>
<td>Bailey</td>
<td>0.173</td>
<td>3.24</td>
<td>5.27</td>
<td>7.23</td>
<td>9.18</td>
<td>11.16</td>
<td>2.03</td>
<td>1.96</td>
<td>1.95</td>
<td>1.98</td>
</tr>
</tbody>
</table>

Table 12: Split and interval times (sec) of the women’s 100m medallists in their semi-finals at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>RT</th>
<th>20m</th>
<th>40m</th>
<th>60m</th>
<th>80m</th>
<th>100m</th>
<th>20-40m</th>
<th>40-60m</th>
<th>60-80m</th>
<th>80-100m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser-Price</td>
<td>0.156</td>
<td>3.06</td>
<td>5.03</td>
<td>6.94</td>
<td>8.84</td>
<td>10.79</td>
<td>1.97</td>
<td>1.91</td>
<td>1.90</td>
<td>1.95</td>
</tr>
<tr>
<td>Jeter</td>
<td>0.144</td>
<td>3.12</td>
<td>5.09</td>
<td>7.00</td>
<td>8.89</td>
<td>10.83</td>
<td>1.97</td>
<td>1.91</td>
<td>1.89</td>
<td>1.94</td>
</tr>
<tr>
<td>Stewart</td>
<td>0.155</td>
<td>3.09</td>
<td>5.06</td>
<td>6.94</td>
<td>8.87</td>
<td>10.84</td>
<td>1.97</td>
<td>1.88</td>
<td>1.93</td>
<td>1.97</td>
</tr>
</tbody>
</table>
(body height: 1.63m), exhibit a higher stride frequency than Stewart (body height: 1.74m), whereas Stewart shows a correspondingly greater stride length and subsequently a lower total number of strides for the 100m distance. However, in comparison to female sprinters of a similar body height, Fraser-Price and Jeter exhibit a well developed stride length: in the past, for comparable female sprinters (e.g. Gladisch-Möller, 1987) exemplary frequency values > 5/sec were measured on the one hand and significantly shorter stride lengths on the other hand. As compared with the measurements obtained at the 2008 World Athletics Final 2008 in Stuttgart (Fraser-Price 10.94m, Stewart 11.06m), a significant improvement of both parameters was found.

Table 13: Comparison of selected intervals of the women’s 100m medallists at the 2009 IAAF World Championships in Athletics (The data for Jeter is from her semi-final race.)

<table>
<thead>
<tr>
<th></th>
<th>30m [sec]</th>
<th>20-60m [sec]</th>
<th>60-100m [sec]</th>
<th>dV [m/sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser-Price</td>
<td>4.02</td>
<td>3.85</td>
<td>3.85</td>
<td>10.39</td>
</tr>
<tr>
<td>Stewart</td>
<td>4.11</td>
<td>3.85</td>
<td>3.79</td>
<td>10.55</td>
</tr>
<tr>
<td>Jeter (SF)</td>
<td>4.12</td>
<td>3.88</td>
<td>3.83</td>
<td>10.44</td>
</tr>
</tbody>
</table>

Table 14: Maximal velocities and their positions for the women’s 100m medallists at the 2009 IAAF World Championships in Athletics (The data for Jeter is from her semi-final race.)

<table>
<thead>
<tr>
<th></th>
<th>dt 20m [sec]</th>
<th>Interval</th>
<th>V max [m/sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser-Price</td>
<td>1.89</td>
<td>60-80m</td>
<td>10.58</td>
</tr>
<tr>
<td>Stewart</td>
<td>1.86</td>
<td>60-80m</td>
<td>10.75</td>
</tr>
<tr>
<td>Jeter (SF)</td>
<td>1.89</td>
<td>60-80m</td>
<td>10.58</td>
</tr>
</tbody>
</table>

Table 15: Stride analysis for the medallists in the women’s 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th></th>
<th>Number of strides</th>
<th>0-20m SL</th>
<th>0-20m SF</th>
<th>20-40m SL</th>
<th>20-40m SF</th>
<th>40-60m SL</th>
<th>40-60m SF</th>
<th>60-80m SL</th>
<th>60-80m SF</th>
<th>80-100m SL</th>
<th>80-100m SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser-Price</td>
<td>49.58</td>
<td>1.59</td>
<td>4.15</td>
<td>2.09</td>
<td>4.91</td>
<td>2.19</td>
<td>4.82</td>
<td>2.18</td>
<td>4.86</td>
<td>2.20</td>
<td>4.65</td>
</tr>
<tr>
<td>Jeter</td>
<td>47.46</td>
<td>1.59</td>
<td>4.05</td>
<td>2.17</td>
<td>4.70</td>
<td>2.28</td>
<td>4.65</td>
<td>2.33</td>
<td>4.62</td>
<td>2.42</td>
<td>4.29</td>
</tr>
<tr>
<td>Stewart</td>
<td>49.48</td>
<td>1.52</td>
<td>4.21</td>
<td>2.10</td>
<td>4.83</td>
<td>2.22</td>
<td>4.71</td>
<td>2.22</td>
<td>4.76</td>
<td>2.27</td>
<td>4.54</td>
</tr>
</tbody>
</table>

SL = Stride Length [m], SF = Stride Frequency [sec]
The 200 Metres

Methods and Procedures

The analysis for the 200m races was made from video split-time measurements using three cameras (no. 1 = 50m/no. 3 = 100m/no. 6 = 150) so that the performance was divided into four equal sections of 50m each. As in the 100m, additional video recordings (camera 13) were made in the finals for the stride length and stride frequency analysis.

Results and Comments – Men

As in the 100m, the men's 200m final in Berlin was dominated by Usain Bolt. Again he shattered his own world record from Beijing, this time running 19.19 sec into a slight headwind of -0.3 m/sec. His margin over second placer Alonso (PAN) was 0.62 sec, greater than the sum total of the winning margins of the five previous editions of the race. Bolt's dominance was all the more impressive when one considers that it was the strongest 200m field ever: the mean time of the three medallists was 19.62 sec, the first five placers finished below 20.00 sec and the mean time of all finalists was 20.05 sec (see Table 16).

The 100m split and 50m interval times for the finalists are given in Table 17 and Table 18.

Table 16: Results of the men's 200m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Usain Bolt (JAM)</td>
<td>19.19 WR</td>
<td>0.133</td>
<td>5</td>
</tr>
<tr>
<td>2 Alonso Edward (PAN)</td>
<td>19.81 AR</td>
<td>0.179</td>
<td>6</td>
</tr>
<tr>
<td>3 Wallace Spearmon (USA)</td>
<td>19.85 SB</td>
<td>0.152</td>
<td>4</td>
</tr>
<tr>
<td>4 Shawn Crawford (USA)</td>
<td>19.89 SB</td>
<td>0.148</td>
<td>8</td>
</tr>
<tr>
<td>5 Steve Mullings (JAM)</td>
<td>19.98 PB</td>
<td>0.146</td>
<td>3</td>
</tr>
<tr>
<td>6 Charles Clark (USA)</td>
<td>20.39</td>
<td>0.158</td>
<td>7</td>
</tr>
<tr>
<td>7 Ramil Guliyev (AZE)</td>
<td>20.61</td>
<td>0.165</td>
<td>1</td>
</tr>
<tr>
<td>8 David Alerte (FRA)</td>
<td>20.68</td>
<td>0.161</td>
<td>2</td>
</tr>
</tbody>
</table>

For the athletes placed 6-8 the split times presented are from their semi-finals, where they ran faster. As in earlier analyses, the fastest interval for all the participants was the section from 50m to 100m.

Bolt's ability to run the bend is very atypical for an athlete who is 1.96m tall. As can be seen in Table 17, at the 50m point in Berlin he was already 0.1 sec ahead of the Mullings (JAM), the second fastest. By the 100m split, the lead had increased to 0.23 sec (9.92 sec to 10.15 sec for Crawford (USA)). It is almost certain Bolt was the first person to run the first 100m in a 200m below 10.00 sec in his 19.30 sec world record race in Beijing in 2008 (9.98 sec – 9.32 sec); in Berlin, he was even faster for both halves of the race (9.92 sec - 9.27 sec).

The strength of the previous world record holder, Michael Johnson, who ran 19.32 sec, was the second half of the race (10.13 sec – 9.19 sec).

Of the three finalists who were slower than in their semi-final races (Clark (USA), Guliyev (AZE) and Alerte FRA), it can be said that the main difference for them was in the second half of the race (Clark 9.83 sec - 10.01 sec; Alerte 9.85 sec - 10.03 sec) while Guliyev ran the first 100m 0.34 sec slower than in the semi-final.
Table 17: Split times (sec) of the men’s 200m sections in the 200m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Result</th>
<th>0-100m</th>
<th>Diff.</th>
<th>100-200m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt</td>
<td>19.19</td>
<td>9.92</td>
<td>0.65</td>
</tr>
<tr>
<td>Edward</td>
<td>19.81</td>
<td>10.37</td>
<td>0.93</td>
</tr>
<tr>
<td>Spearmon</td>
<td>19.85</td>
<td>10.42</td>
<td>0.99</td>
</tr>
<tr>
<td>Crawford</td>
<td>19.89</td>
<td>10.15</td>
<td>0.41</td>
</tr>
<tr>
<td>Mullings</td>
<td>19.98</td>
<td>10.20</td>
<td>0.42</td>
</tr>
<tr>
<td>Clark</td>
<td>20.27</td>
<td>10.44</td>
<td>0.61</td>
</tr>
<tr>
<td>Guliyev</td>
<td>20.28</td>
<td>10.43</td>
<td>0.58</td>
</tr>
<tr>
<td>Alerte</td>
<td>20.45</td>
<td>10.60</td>
<td>0.75</td>
</tr>
</tbody>
</table>

The performance of the first two of these athletes strengthens the common belief among experts that success in a major event final can be realised only if there is a constant improvement of performance from round to round.

The most important information provided by the velocity analysis is that Bolt was able to run two 50m sections at an average velocity of more than 11m/sec (50-150m: 11.31 m/sec), and that besides Bolt only Crawford with (11.03 m/sec) could do this for the same sec-
Table 19: Mean velocity (m/sec) of the 50m sections in the men’s 200m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th></th>
<th>0-50m</th>
<th>50-100m</th>
<th>100-150m</th>
<th>150-200m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt</td>
<td>8.93</td>
<td>11.57</td>
<td>11.06</td>
<td>10.53</td>
</tr>
<tr>
<td>Edward</td>
<td>8.50</td>
<td>11.14</td>
<td>10.80</td>
<td>10.40</td>
</tr>
<tr>
<td>Spearmon</td>
<td>8.49</td>
<td>11.04</td>
<td>10.78</td>
<td>10.44</td>
</tr>
<tr>
<td>Crawford</td>
<td>8.73</td>
<td>11.31</td>
<td>10.75</td>
<td>9.82</td>
</tr>
<tr>
<td>Mullings</td>
<td>8.77</td>
<td>11.11</td>
<td>10.57</td>
<td>9.90</td>
</tr>
<tr>
<td>Clark</td>
<td>8.56</td>
<td>10.87</td>
<td>10.50</td>
<td>9.86</td>
</tr>
<tr>
<td>Guliyev</td>
<td>8.55</td>
<td>10.92</td>
<td>10.46</td>
<td>9.86</td>
</tr>
<tr>
<td>Alerte</td>
<td>8.42</td>
<td>10.73</td>
<td>10.42</td>
<td>9.90</td>
</tr>
</tbody>
</table>

Table 20: Stride analysis for Usain Bolt in the 100m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th></th>
<th>0-50m</th>
<th>50-100m</th>
<th>100-150m</th>
<th>150-200m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt</td>
<td>79.88</td>
<td>2.14</td>
<td>4.17</td>
<td>2.61</td>
</tr>
<tr>
<td>Edward</td>
<td>8.50</td>
<td>11.14</td>
<td>10.80</td>
<td>10.40</td>
</tr>
<tr>
<td>Spearmon</td>
<td>8.49</td>
<td>11.04</td>
<td>10.78</td>
<td>10.44</td>
</tr>
<tr>
<td>Crawford</td>
<td>8.73</td>
<td>11.31</td>
<td>10.75</td>
<td>9.82</td>
</tr>
<tr>
<td>Mullings</td>
<td>8.77</td>
<td>11.11</td>
<td>10.57</td>
<td>9.90</td>
</tr>
<tr>
<td>Clark</td>
<td>8.56</td>
<td>10.87</td>
<td>10.50</td>
<td>9.86</td>
</tr>
<tr>
<td>Guliyev</td>
<td>8.55</td>
<td>10.92</td>
<td>10.46</td>
<td>9.86</td>
</tr>
<tr>
<td>Alerte</td>
<td>8.42</td>
<td>10.73</td>
<td>10.42</td>
<td>9.90</td>
</tr>
</tbody>
</table>

The comparison of the stride analysis of Bolt’s 100m and 200m races (Table 5 and Table 20) leads to the assumption that he deliberately started the 200m race in a more conservative way than he did in the 100m. The stride lengths in the first part of the 200m are in the area of 91-95% of the maximal value of the 100m race, which tends to disprove the assumed submaximal character of the 200m race. It seems that in the 200m, Bolt aimed to achieve an even stride length pattern. The significant difference of the mean velocity between the second and the fourth 50m sections (decrease of approximately 9%) can be understood on the basis of the change of the stride frequency.
Results and Comments – Women

The performances in the women's 200m final in Berlin were not of an exceptional character. Although the time of 22.02 sec for the winner Allyson Felix (USA) and the mean time of 22.26 sec for the medal winners were of a comparatively high level, the 22.59 sec mean time of all the finalists was only moderate (see Table 21).

With the exception of Felix, the performances of all the finalists were worse than what they were able to do in the semi-finals. That is why our analysis and comments here is largely based on the seven better semi-final performances. Interestingly, only two of the Berlin women's 100m finalists made it to the 200m final (Campbell-Brown (JAM) and Ferguson-McKenzie (BAH)). This might suggest that the entire competition was too great a burden for most of the participants. However, it is not entirely plausible, because, contrary to earlier competitions and compared with the men's competition, there were only three rounds. Moreover, the semi-finals and final were held on separate days. Except for Felix, whose performance is not discussed here, and Campbell-Brown, all other finalists demonstrated worse performances for both of the two 100m sections in the final compared to what they did in the semi-finals. Since there are relatively small differences between the first and second 100m split times (see Table 22), it is the general level of speed endurance that deserves a critical comment, particularly as far as its repeatability in multiple runs within a major event is concerned.

Looking at the 50m interval times in Table 23, we see that times below 5.00 sec in the second section (50-100m) are conspicuous with three athletes. The winner, Felix, reached a velocity of 10.18 m/sec in the final. In the 50-150m section, she also reached a partial time of 10.12 sec, which in a 4x100m relay race would constitute an outstanding leg. By comparison, in the relay analysis, times below 10.00 sec and 10.12 sec could only be measured for the 100m final runners Ferguson-McKenzie and Stewart, while the partial times for the other two flying distances remained clearly behind the aforementioned value of Felix. This is also due to the baton exchanges taking place in these sections. Felix’s performance is all the more remarkable because she tends to the 400m rather than the 100m (she was not even a member of the US 4x100m relay team). This orientation is also certainly a reason for her dominance in the fourth 50m interval.

Table 21: Results of the women's 200m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>200 Metres - Women’s Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 August 2009 – 21:40 Wind: -0.1 m/sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Allyson Felix (USA)</td>
<td>22.02</td>
<td>0.173</td>
<td>6</td>
</tr>
<tr>
<td>2 Veronica Campbell-Brown (JAM)</td>
<td>22.35</td>
<td>0.184</td>
<td>5</td>
</tr>
<tr>
<td>3 Debbie Ferguson-McKenzie (BAH)</td>
<td>22.41</td>
<td>0.171</td>
<td>4</td>
</tr>
<tr>
<td>4 Muna Lee (USA)</td>
<td>22.48</td>
<td>0.174</td>
<td>3</td>
</tr>
<tr>
<td>5 Anneisha McLaughlin (JAM)</td>
<td>22.62</td>
<td>0.178</td>
<td>8</td>
</tr>
<tr>
<td>6 Simone Facey (JAM)</td>
<td>22.80</td>
<td>0.163</td>
<td>7</td>
</tr>
<tr>
<td>7 Emily Freeman (GBR)</td>
<td>22.98</td>
<td>0.141</td>
<td>2</td>
</tr>
<tr>
<td>8 Eleni Artymata (CYP)</td>
<td>23.05</td>
<td>0.176</td>
<td>1</td>
</tr>
</tbody>
</table>
### Table 22: Comparison of the 100m intervals between the final and semi-finals in the women’s 200m at the 2009 IAAF World Championships in Athletics (SF = semi-final)

<table>
<thead>
<tr>
<th>Round</th>
<th>Wind [m/sec]</th>
<th>Result [sec]</th>
<th>0-100m [sec]</th>
<th>Difference [sec]</th>
<th>100-200m [sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Felix</td>
<td>Final</td>
<td>-0.1</td>
<td>22.02</td>
<td>11.16</td>
<td>-0.30</td>
</tr>
<tr>
<td></td>
<td>SF 2</td>
<td>0.3</td>
<td>22.44</td>
<td>11.34</td>
<td>-0.24</td>
</tr>
<tr>
<td>Campbell-Brown</td>
<td>Final</td>
<td>-0.1</td>
<td>22.35</td>
<td>11.14</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>SF 1</td>
<td>0.5</td>
<td>22.29</td>
<td>11.23</td>
<td>-0.17</td>
</tr>
<tr>
<td>Ferguson-McKenzie</td>
<td>Final</td>
<td>-0.1</td>
<td>22.41</td>
<td>11.29</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>SF 1</td>
<td>0.5</td>
<td>22.24</td>
<td>11.21</td>
<td>-0.18</td>
</tr>
<tr>
<td>Lee</td>
<td>Final</td>
<td>-0.1</td>
<td>22.48</td>
<td>11.25</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>SF 3</td>
<td>0.5</td>
<td>22.30</td>
<td>11.23</td>
<td>-0.16</td>
</tr>
<tr>
<td>McLaughlin</td>
<td>Final</td>
<td>-0.1</td>
<td>22.62</td>
<td>11.43</td>
<td>-0.24</td>
</tr>
<tr>
<td></td>
<td>SF 2</td>
<td>0.3</td>
<td>22.55</td>
<td>11.39</td>
<td>-0.23</td>
</tr>
<tr>
<td>Facey</td>
<td>Final</td>
<td>-0.1</td>
<td>22.80</td>
<td>11.39</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>SF 3</td>
<td>0.5</td>
<td>22.58</td>
<td>11.39</td>
<td>-0.20</td>
</tr>
<tr>
<td>Freeman</td>
<td>Final</td>
<td>-0.1</td>
<td>22.98</td>
<td>11.47</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>SF 1</td>
<td>0.5</td>
<td>22.64</td>
<td>11.40</td>
<td>-0.16</td>
</tr>
<tr>
<td>Artymata</td>
<td>Final</td>
<td>-0.1</td>
<td>23.01</td>
<td>11.70</td>
<td>-0.39</td>
</tr>
<tr>
<td></td>
<td>SF 1</td>
<td>0.5</td>
<td>22.64</td>
<td>11.57</td>
<td>-0.50</td>
</tr>
</tbody>
</table>

*Individual better time*

### Table 23: 50m interval times (sec) for the best runs of the finalists in the women’s 200m at the 2009 IAAF World Championships in Athletics (SF = data from semi-final)

<table>
<thead>
<tr>
<th>Result</th>
<th>0-50m</th>
<th>50-100m</th>
<th>100-150m</th>
<th>150-200m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Felix</td>
<td>22.02</td>
<td>6.25</td>
<td>4.91</td>
<td>5.22</td>
</tr>
<tr>
<td>Campbell-Brown (SF)</td>
<td>22.29</td>
<td>6.25</td>
<td>4.98</td>
<td>5.29</td>
</tr>
<tr>
<td>Ferguson-McKenzie (SF)</td>
<td>22.24</td>
<td>6.19</td>
<td>5.02</td>
<td>5.33</td>
</tr>
<tr>
<td>Lee (SF)</td>
<td>22.30</td>
<td>6.26</td>
<td>4.97</td>
<td>5.30</td>
</tr>
<tr>
<td>McLaughlin (SF)</td>
<td>22.55</td>
<td>6.38</td>
<td>5.01</td>
<td>5.30</td>
</tr>
<tr>
<td>Facey (SF)</td>
<td>22.58</td>
<td>6.31</td>
<td>5.08</td>
<td>5.39</td>
</tr>
<tr>
<td>Freeman (SF)</td>
<td>22.64</td>
<td>6.29</td>
<td>5.11</td>
<td>5.39</td>
</tr>
<tr>
<td>Artymata (SF)</td>
<td>22.64</td>
<td>6.46</td>
<td>5.11</td>
<td>5.35</td>
</tr>
</tbody>
</table>
Table 24: Mean velocities (m/sec) for the 50m intervals in the best runs of the finalists in the women’s 200m at the 2009 IAAF World Championships in Athletics (SF = semi-final)

<table>
<thead>
<tr>
<th></th>
<th>0-50m</th>
<th>50-100m</th>
<th>100-150m</th>
<th>150-200m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Felix</td>
<td>8.00</td>
<td>10.18</td>
<td>9.60</td>
<td>8.85</td>
</tr>
<tr>
<td>Campbell-Brown (SF)</td>
<td>8.00</td>
<td>10.04</td>
<td>9.45</td>
<td>8.67</td>
</tr>
<tr>
<td>Ferguson-McKenzie (SF)</td>
<td>8.08</td>
<td>9.96</td>
<td>9.38</td>
<td>8.77</td>
</tr>
<tr>
<td>Lee (SF)</td>
<td>7.99</td>
<td>10.06</td>
<td>9.43</td>
<td>8.67</td>
</tr>
<tr>
<td>McLaughlin (SF)</td>
<td>7.84</td>
<td>9.98</td>
<td>9.43</td>
<td>8.53</td>
</tr>
<tr>
<td>Facey (SF)</td>
<td>7.92</td>
<td>9.84</td>
<td>9.28</td>
<td>8.62</td>
</tr>
<tr>
<td>Freeman (SF)</td>
<td>7.95</td>
<td>9.78</td>
<td>9.28</td>
<td>8.55</td>
</tr>
<tr>
<td>Artymata</td>
<td>7.74</td>
<td>9.78</td>
<td>9.35</td>
<td>8.74</td>
</tr>
</tbody>
</table>

The 400 Metres

Methods and Procedures

The analysis of the 400m races was conducted as a split-time measurement with three video cameras and two recording systems. Camera no. 11 was used to record the outer four lanes and the 250m (no. 1), 300m (no. 3), and 350m (no. 6) measuring points on one system while camera no. 12 was used to record lanes 1-4 independently on a second system. Thus, it was possible to break down the performance into four identical intervals of 100m each. In addition, if required, an analysis of the 50m intervals could be conducted.

However, this option was used only in selected cases, since the lane markings at 50m and 150m were barely visible for the evaluation in the video footage, which, as far as the split times determined at these measuring points, requires the assumption of an error tolerance of 0.04 sec.

Results and Comments – Men

Compared to other major events in the last decade, the performances in the men’s 400m final were generally poor (Table 25). Although winner LaShawn Merritt’s (USA) 44.06 sec performance was at a very high level and the world leading time for the year, only second placed Jeremy Wariner (USA) was also below 45.00 sec, which has not been the case in any recent comparable competition. The 44.56 sec average time of the three medallists is fairly good because of Merritt’s respectable performance but the average time of all the finalists, 45.19 sec, is the slowest in the reference period.

However, this does not accurately reflect the quality of the finalists, since some of the athletes in places 3-8 achieved significantly better performances in the semi-finals. Therefore, the comments made with regard to the women’s 200m competition could be repeated here. Therefore, analysis of the better performances in the semi-finals by the athletes placed 3-8 are also taken into account here.

Table 26 demonstrates that, with the exception of Merritt and Wariner, the finalists hit their performance peaks in the semi-finals while achieving the qualification for the final. Consideration of the performances in Round 1 also leads to a result hardly expected and strengthens the semi-final peak thesis: only two of the six runners placed 3-8 in the final show an improvement between the Round 1 result and the final, while the other four in some cases show a marked deterioration.

Table 27 provides an interesting insight into the course of the final and shows the very different individual realisation of the race. It is clear that the winner, Merritt, dominated the second half of the race. However, during the first two sections he was only slightly behind the leaders. One can also notice that Brown (BAH) ran the first 200m much too fast (in his faster semi-final he was 21.72 sec), which in turn had a significantly negative impact on the final 100m, where he lost third place, which he had occupied until then, to Quow (TFL). Quow in turn started the race atypically slow for a 400m runner. He ran almost identical halves, which resulted in him being the fastest over the last 100m. The silver medallist, Wariner, de
Table 25: Results of the men’s 400m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>LaShawn Merritt (USA)</td>
<td>44.06 WL</td>
<td>0.161</td>
<td>4</td>
</tr>
<tr>
<td>Jeremy Wariner (USA)</td>
<td>44.60 SB</td>
<td>0.162</td>
<td>6</td>
</tr>
<tr>
<td>Renny Quow (TRI)</td>
<td>45.02</td>
<td>0.195</td>
<td>3</td>
</tr>
<tr>
<td>Tabarie Henry (ISV)</td>
<td>45.42</td>
<td>0.162</td>
<td>7</td>
</tr>
<tr>
<td>Chris Brown (BAH)</td>
<td>45.47</td>
<td>0.161</td>
<td>5</td>
</tr>
<tr>
<td>David Gillick (IRL)</td>
<td>45.53</td>
<td>0.148</td>
<td>2</td>
</tr>
<tr>
<td>Michael Bingham (GBR)</td>
<td>45.56</td>
<td>0.172</td>
<td>8</td>
</tr>
<tr>
<td>Leslie Djhone (FRA)</td>
<td>45.90</td>
<td>0.151</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 26: Comparison (sec) of the three competition rounds of the men’s 400m at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete</th>
<th>Round 1</th>
<th>Diff.</th>
<th>Semi-final</th>
<th>Diff.</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merritt</td>
<td>45.23</td>
<td>0.86</td>
<td>44.37</td>
<td>0.31</td>
<td>44.06</td>
</tr>
<tr>
<td>Wariner</td>
<td>45.54</td>
<td>0.85</td>
<td>44.69</td>
<td>0.09</td>
<td>44.60</td>
</tr>
<tr>
<td>Quow</td>
<td>45.21</td>
<td>0.68</td>
<td>44.53</td>
<td>-0.49</td>
<td>45.02</td>
</tr>
<tr>
<td>Henry</td>
<td>45.14</td>
<td>0.17</td>
<td>44.97</td>
<td>-0.45</td>
<td>45.42</td>
</tr>
<tr>
<td>Brown</td>
<td>45.53</td>
<td>0.58</td>
<td>44.95</td>
<td>-0.52</td>
<td>45.47</td>
</tr>
<tr>
<td>Gillick</td>
<td>45.54</td>
<td>0.80</td>
<td>44.74</td>
<td>-0.82</td>
<td>45.56</td>
</tr>
<tr>
<td>Bingham</td>
<td>45.54</td>
<td>0.40</td>
<td>44.80</td>
<td>-1.10</td>
<td>45.90</td>
</tr>
<tr>
<td>Djhone</td>
<td>45.20</td>
<td></td>
<td>44.80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Individual best

Table 27: Split times, interval times and rankings in the men’s 400m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete</th>
<th>100m Time / Rank [sec]</th>
<th>200m Time / Rank [sec]</th>
<th>300m Time / Rank [sec]</th>
<th>400m Time / Rank [sec]</th>
<th>100-200m Time / Rank [sec]</th>
<th>200-300m Time / Rank [sec]</th>
<th>300-400m Time / Rank [sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merritt</td>
<td>11.14 3</td>
<td>21.49 3</td>
<td>32.30 1</td>
<td>44.06 1</td>
<td>10.35 2</td>
<td>10.81 1</td>
<td>11.76 2</td>
</tr>
<tr>
<td>Wariner</td>
<td>10.98 1</td>
<td>21.41 2</td>
<td>32.34 2</td>
<td>44.60 2</td>
<td>10.43 3</td>
<td>10.93 3</td>
<td>12.26 4</td>
</tr>
<tr>
<td>Quow</td>
<td>11.70 8</td>
<td>22.43 8</td>
<td>33.32 7</td>
<td>45.02 3</td>
<td>10.73 8</td>
<td>10.89 2</td>
<td>11.70 1</td>
</tr>
<tr>
<td>Henry</td>
<td>11.18 4</td>
<td>21.83 4</td>
<td>33.17 5</td>
<td>45.42 4</td>
<td>10.65 5</td>
<td>11.34 6</td>
<td>12.25 3</td>
</tr>
<tr>
<td>Brown</td>
<td>10.98 1</td>
<td>21.31 1</td>
<td>32.53 3</td>
<td>45.47 5</td>
<td>10.33 1</td>
<td>11.22 5</td>
<td>12.94 8</td>
</tr>
<tr>
<td>Gillick</td>
<td>11.24 6</td>
<td>21.83 4</td>
<td>33.18 6</td>
<td>45.53 6</td>
<td>10.59 4</td>
<td>11.35 7</td>
<td>12.35 5</td>
</tr>
<tr>
<td>Bingham</td>
<td>11.19 5</td>
<td>21.84 6</td>
<td>33.02 4</td>
<td>45.56 7</td>
<td>10.65 6</td>
<td>11.18 4</td>
<td>12.54 7</td>
</tr>
<tr>
<td>Djhone</td>
<td>11.34 7</td>
<td>22.04 7</td>
<td>33.46 8</td>
<td>45.90 8</td>
<td>10.70 7</td>
<td>11.42 8</td>
<td>12.44 6</td>
</tr>
</tbody>
</table>

Individual best
Figure 7: Example analysis from the 400m finals at the 2009 IAAF World Championships in Athletics

Figure 8: Velocity course of the medallists’ best runs in the men’s 400m at the 2009 IAAF World Championships in Athletics
Biomechanical Analysis of the Sprint and Hurdles Events at the 2009 IAAF World Championships in Athletics

Table 28: Comparison of the first and second half times (sec) of the best races for the top 10 men in the 400m at the 2009 IAAF World Championships in Athletics (SF = semi-final)

<table>
<thead>
<tr>
<th></th>
<th>400m</th>
<th>1st 200m</th>
<th>Diff.</th>
<th>2nd 200m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merrit</td>
<td>44.06</td>
<td>21.49</td>
<td>1.08</td>
<td>22.57</td>
</tr>
<tr>
<td>Wariner</td>
<td>44.60</td>
<td>21.41</td>
<td>1.78</td>
<td>23.19</td>
</tr>
<tr>
<td>Quow (SF)</td>
<td>44.53</td>
<td>22.09</td>
<td>0.35</td>
<td>22.44</td>
</tr>
<tr>
<td>Henry (SF)</td>
<td>44.97</td>
<td>21.91</td>
<td>1.15</td>
<td>23.06</td>
</tr>
<tr>
<td>Brown (SF)</td>
<td>44.95</td>
<td>21.72</td>
<td>1.51</td>
<td>23.23</td>
</tr>
<tr>
<td>Gillick (SF)</td>
<td>44.88</td>
<td>21.80</td>
<td>1.28</td>
<td>23.08</td>
</tr>
<tr>
<td>Bingham (SF)</td>
<td>44.74</td>
<td>21.84</td>
<td>1.06</td>
<td>23.90</td>
</tr>
<tr>
<td>Djhone (SF)</td>
<td>44.80</td>
<td>21.87</td>
<td>1.06</td>
<td>22.93</td>
</tr>
<tr>
<td>Collazo (SF)</td>
<td>44.93</td>
<td>21.56</td>
<td>1.81</td>
<td>23.37</td>
</tr>
<tr>
<td>Miller (SF)</td>
<td>44.99</td>
<td>21.99</td>
<td>1.01</td>
<td>23.00</td>
</tr>
</tbody>
</table>

Table 29: Mean velocities (m/sec) of the 50m sections of the medallists’ best runs in the men’s 400m at the 2009 IAAF World Championships in Athletics (SF = semi-final)

<table>
<thead>
<tr>
<th></th>
<th>0-50m</th>
<th>50-100m</th>
<th>100-150m</th>
<th>150-200m</th>
<th>200-250m</th>
<th>250-300m</th>
<th>300-350m</th>
<th>350-400m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merritt - 44.06</td>
<td>8.22</td>
<td>9.88</td>
<td>9.78</td>
<td>9.54</td>
<td>9.26</td>
<td>9.24</td>
<td>8.80</td>
<td>8.22</td>
</tr>
<tr>
<td>Wariner - 44.60</td>
<td>8.32</td>
<td>10.06</td>
<td>9.71</td>
<td>9.47</td>
<td>9.17</td>
<td>9.12</td>
<td>8.67</td>
<td>7.70</td>
</tr>
</tbody>
</table>

Livered almost identical races in the semi-final and final, but he demonstrated a perceptible weakness in the fourth section, where in the final he lost exactly half a second to Merritt.

When comparing the first and second 200m sections (see Table 28), the extreme values for the difference stand out (Wariner, Quow and Collazo). However, when Wariner’s performance is compared to his winning 2007 World Championship run in Osaka, where he achieved a significantly better end-time (43.45 sec), a marked deterioration is noticeable in both halves (20.91 sec – 22.54 sec; difference: 1.63 sec). Figure 8 again illustrates that Wariner slowed down dramatically during the last 50m, while Quow caught up significantly from approximately 270m on.

The 50m section data (Table 29) supports some statements about the velocity course of the medalists. In the second interval Wariner was the only one of the three who ran faster than 10 m/sec (Brown was the only other finalist to do so 50-100m: 10.08 m/sec, 100-150m: 9.90 m/sec, 150-200m: 9.47 m/sec) and he shows the largest variation in velocity among runners considered here: 2.36 m/sec. If one ignores the first section, Quow shows a velocity fluctuation of only 1.20 m/sec, while with Merritt it is 1.66 m/sec.

Results and Comments – Women

The 10-year comparison of the women’s 400m final in Berlin is quite different than with the men. Because of Richards’ top-level winning performance of 49.00 sec, three additional results below 50.00 sec and place 8 with 50.65 sec, best values are achieved with regard to both the mean time of the medal winners, 49.34 sec, and of the entire final field, 49.94 (see Table 30).

In Table 31 we see that half the athletes repeated or improved their semi-final performances in the final and of the four with slower final performances, three had semi-final performances below 50.00 sec (Kirivoshapka (RUS): 49.67 sec -> 49.71 sec; Dunn (USA): 49.95 sec -> 50.35 sec; Montsho (BOT): 49.89 sec -> 50.65 sec). This underlines the overall strength of the competition.
Biomechanical Analysis of the Sprint and Hurdles Events at the 2009 IAAF World Championships in Athletics

It is striking that a number of runners approached the first 200m in the final much more slowly than in the semi-final, which is the primary reason for the deterioration of the time in the final as compared to the semi-final for four athletes. For clarification, the smaller comparative differences in the respective second halves and the much smaller differences between the first and second half of the race in the final can be pointed out (Montsho, Kapachinskaya).

A comparison is made between the semi-finals and the final in terms of split times in Table 32. We can see that in both races the eventual winner, Richards, led from start to finish: she was the only one who ran the first 100m below 12.00 sec and in the final she was the first to reach all the other measuring points. In fact, she got away from her opponents in the first and third 100m sections, while in both races presented, the second 100m sections were dominated by Krivoshapka. Among the other participants, there were only slight shifts in place, which are without any informative value. One positive aspect that can be ascribed to the winner on the basis of her superiority in the fourth section: she finished the semi-final restraining herself (13.80 sec – 13.38 sec) and this way certainly saved power for the final.

It is striking that a number of runners approached the first 200m in the final much more slowly than in the semi-final, which is the primary reason for the deterioration of the time in the final as compared to the semi-final for four athletes. For clarification, the smaller comparative differences in the respective second halves and the much smaller differences between the first and second half of the race in the final can be pointed out (Montsho, Kapachinskaya).

Once more, the analysis of the velocity courses in Table 33 proves in detail the statements that have been made previously. Outstanding are the values for the second 50m sections of Richards and Williams, both of whom ran at a mean velocity of more than 9 m/sec. It is illustrated once again that Richards has her greatest

### Table 30: Results of the women’s 400m final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanya Richards (USA)</td>
<td>49.00 WL</td>
<td>0.164</td>
<td>3</td>
</tr>
<tr>
<td>Sherika Williams (JAM)</td>
<td>49.32 PB</td>
<td>0.194</td>
<td>4</td>
</tr>
<tr>
<td>Antonia Krivoshapka (RUS)</td>
<td>49.71</td>
<td>0.187</td>
<td>5</td>
</tr>
<tr>
<td>Novlene Williams-Mills (JAM)</td>
<td>49.77 SB</td>
<td>0.214</td>
<td>6</td>
</tr>
<tr>
<td>Christine Ohuruogu (GBR)</td>
<td>50.21 SB</td>
<td>0.231</td>
<td>7</td>
</tr>
<tr>
<td>Debbie Dunn (USA)</td>
<td>50.35</td>
<td>0.275</td>
<td>1</td>
</tr>
<tr>
<td>Anastaslya Kapachinskaya (RUS)</td>
<td>50.53</td>
<td>0.220</td>
<td>2</td>
</tr>
<tr>
<td>Amantle Monsho (BOT)</td>
<td>50.65</td>
<td>0.212</td>
<td>8</td>
</tr>
</tbody>
</table>

### Table 31: Comparison (sec) of the three competition rounds of the women’s 400m at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Round 1</th>
<th>Diff.</th>
<th>Semi-final</th>
<th>Diff.</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richards</td>
<td>51.06</td>
<td>0.85</td>
<td>50.21</td>
<td>1.21</td>
</tr>
<tr>
<td>Williams</td>
<td>51.23</td>
<td>1.72</td>
<td>49.51</td>
<td>0.19</td>
</tr>
<tr>
<td>Krivoshapka</td>
<td>51.03</td>
<td>1.36</td>
<td>49.67</td>
<td>-0.04</td>
</tr>
<tr>
<td>Williams-Mills</td>
<td>51.55</td>
<td>1.67</td>
<td>49.88</td>
<td>0.11</td>
</tr>
<tr>
<td>Ohuruogu</td>
<td>51.30</td>
<td>0.95</td>
<td>50.35</td>
<td>0.14</td>
</tr>
<tr>
<td>Dunn</td>
<td>51.13</td>
<td>1.18</td>
<td>49.95</td>
<td>-0.40</td>
</tr>
<tr>
<td>Kapachinskaya</td>
<td>51.17</td>
<td>0.87</td>
<td>50.30</td>
<td>-0.23</td>
</tr>
<tr>
<td>Montsho</td>
<td>50.65</td>
<td>0.76</td>
<td>49.89</td>
<td>-0.76</td>
</tr>
</tbody>
</table>
advantage in the first 100m, while her other sections have approximately the level of the respective best section values of the finalists, without standing out particularly. The differences between the velocities in the slowest and fastest 50m intervals of all four runs analysed are within a narrow range of 0.21 m/sec (Richards 2.01 m/sec; Krivoshapka 1.80 m/sec), resulting in great similarities in the velocity courses of the four runners, which is illustrated in Figure 9.

Table 33: Mean velocities (m/sec) of the 50m sections of the four best runs in the women’s 400m at the 2009 IAAF World Championships in Athletics (sf = semi final)
The 100 Metres and 110 Metres Hurdles

Methods and Procedures

The analysis of the women's 100m hurdles and the men's 110m hurdles were based on video recordings with a pan video camera (no. 13), which were made on a system similar to the one used for the other events. The analysis included an evaluation of the hurdle split times (from touchdown to touchdown behind the hurdle) and the hurdle flight times for the medallists and a calculation of the average speeds for the hurdle intervals. Unfortunately, the present video recordings cannot be used to make statements about the take-off and landing distances. Neither can they be used for technique analysis.

Results and Comments - Men

Compared to the finals of major athletics events from the year 2000, performances in the men's 110m hurdle final in Berlin were of a rather average level (see Table 34). This applies equally to the winner Brathwaite's (BAR) time of 13.14 sec (the slowest of all recent finals), the average time of the medallists (13.14 sec) and average time of the finalists (13.32 sec). It is true that two of the most powerful athletes in previous years were not present due to injury, having dropped out in the preliminary round - Robles (CUB) - or not starting at all - Liu (CHN). Because of the performance level, this analysis is limited mainly to the three medallists, whose performances were barely distinguishable.

In Table 35 we can see that although the eventual winner, Brathwaite, was with the leading runners from the first hurdle and alone at the front from hurdle 5. In dominating the first half of the race his velocity course was characterised by an almost perfect continuity, even though he had a contact at the first hurdle. He was also the only runner in the final who went below 1.00 sec in two sections. However, he could not achieve a significant lead. In the run-in to the finish line, Trammel (USA) and Payne (USA) were able to catch up to within a hundredth of a second. They were helped by the fact that Brathwaite contacted hurdle 7 and had rhythm difficulties in the following interval, which can be seen from the long flight time over hurdle 8.

When watching the video, Payne's run gives the overall impression of being rounded and harmonious with only a slight contact at hurdle 7.

However, the velocity curve gives a slightly different impression. Trammell, managed to maintain an almost unchanged duration of hurdle clearance (from the take-off before to the touchdown after the hurdle) throughout the race and a similar velocity to the other medallists (Figure 11 and Figure 12) despite five,
sometimes violent hurdle contacts during the second half of the race (Table 36).

The remaining finalists did not exhibit any marked peculiarities. Those in places 4-6 – Sharman (GBR), Wignall (JAM), Svoboda (CZE) – basically repeated their semi-final performances in the final. In particular, Sharman’s run was technically sound without any hurdle contacts, while Svoboda only managed to clear the eighth hurdle without contact and conveys a technically inconsistent impression. The runners placed 7-8 could not match their semi-final performances.

Because of the small margins between the final times of the three medallists, it is necessary to look at the start and the reaction times. We can see that Payne achieved a very good reaction time, but Trammell’s relatively slow reaction suggest that he would have had a chance to win had he been able to match Payne.

It must be mentioned that reaction time is primarily a parameter of the timing system with the aim of detecting a false start (false start control apparatus according to rule 161.2). For this purpose a threshold value pressure switch in the rail of the starting block is used that is triggered in

**Table 34: Results of the men’s 110m hurdles final at the 2009 IAAF World Championships in Athletics**

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ryan Brathwaite (BAR)</td>
<td>13.14 NR</td>
<td>0.157</td>
<td>4</td>
</tr>
<tr>
<td>2 Terrence Trammell (USA)</td>
<td>13.15</td>
<td>0.141</td>
<td>5</td>
</tr>
<tr>
<td>3 David Payne (USA)</td>
<td>13.15 PB</td>
<td>0.122</td>
<td>3</td>
</tr>
<tr>
<td>4 William Sharman (GBR)</td>
<td>13.30 SB</td>
<td>0.125</td>
<td>6</td>
</tr>
<tr>
<td>5 Maurice Wignall (JAM)</td>
<td>13.31</td>
<td>0.155</td>
<td>8</td>
</tr>
<tr>
<td>6 Petr Svoboda (CZE)</td>
<td>13.38</td>
<td>0.144</td>
<td>7</td>
</tr>
<tr>
<td>7 Dwight Thomas (JAM)</td>
<td>13.56</td>
<td>0.145</td>
<td>2</td>
</tr>
<tr>
<td>8 Wei Ji (CHN)</td>
<td>13.57</td>
<td>0.144</td>
<td>1</td>
</tr>
</tbody>
</table>

**Figure 10: Examples for the hurdles analysis (100m hurdles/110m hurdles)**
### Table 35: Hurdle split-times and intervals (sec) in the men's 110m hurdles final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>RT</th>
<th>H1</th>
<th>H2</th>
<th>H3</th>
<th>H4</th>
<th>H5</th>
<th>H6</th>
<th>H7</th>
<th>H8</th>
<th>H9</th>
<th>H10</th>
<th>110m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brathwaite</td>
<td>0.157</td>
<td>2.54</td>
<td>3.60</td>
<td>4.61</td>
<td>5.60</td>
<td>6.59</td>
<td>7.60</td>
<td>8.62</td>
<td>9.65</td>
<td>10.70</td>
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</tr>
<tr>
<td></td>
<td>1.06</td>
<td>1.01</td>
<td>0.99</td>
<td>0.99</td>
<td>1.01</td>
<td>1.02</td>
<td>1.03</td>
<td>1.05</td>
<td>1.04</td>
<td>1.40</td>
<td></td>
</tr>
<tr>
<td>Trammell</td>
<td>0.141</td>
<td>2.56</td>
<td>3.60</td>
<td>4.61</td>
<td>5.60</td>
<td>6.60</td>
<td>7.62</td>
<td>8.63</td>
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<td>10.71</td>
<td>11.77</td>
</tr>
<tr>
<td></td>
<td>1.04</td>
<td>1.01</td>
<td>0.99</td>
<td>1.00</td>
<td>1.02</td>
<td>1.01</td>
<td>1.03</td>
<td>1.05</td>
<td>1.06</td>
<td>1.38</td>
<td></td>
</tr>
<tr>
<td>Payne</td>
<td>0.122</td>
<td>2.54</td>
<td>3.58</td>
<td>4.61</td>
<td>5.61</td>
<td>6.62</td>
<td>7.64</td>
<td>8.66</td>
<td>9.69</td>
<td>10.74</td>
<td>11.78</td>
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<tr>
<td></td>
<td>1.04</td>
<td>1.03</td>
<td>1.00</td>
<td>1.01</td>
<td>1.02</td>
<td>1.02</td>
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<td>1.05</td>
<td>1.04</td>
<td>1.37</td>
<td></td>
</tr>
<tr>
<td>Sharman</td>
<td>0.150</td>
<td>2.54</td>
<td>3.60</td>
<td>4.62</td>
<td>5.64</td>
<td>6.65</td>
<td>7.68</td>
<td>8.73</td>
<td>9.78</td>
<td>10.84</td>
<td>11.91</td>
</tr>
<tr>
<td></td>
<td>1.06</td>
<td>1.02</td>
<td>1.02</td>
<td>1.01</td>
<td>1.03</td>
<td>1.05</td>
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<td>1.06</td>
<td>1.07</td>
<td>1.39</td>
<td></td>
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<tr>
<td>Wignall</td>
<td>0.151</td>
<td>2.61</td>
<td>3.66</td>
<td>4.70</td>
<td>5.72</td>
<td>6.75</td>
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<td>1.05</td>
<td>1.08</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>Svoboda</td>
<td>0.144</td>
<td>2.58</td>
<td>3.62</td>
<td>4.64</td>
<td>5.66</td>
<td>6.69</td>
<td>7.74</td>
<td>8.77</td>
<td>9.82</td>
<td>10.87</td>
<td>11.94</td>
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<td>1.06</td>
<td>1.07</td>
<td>1.44</td>
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<tr>
<td>Dwight</td>
<td>0.145</td>
<td>2.66</td>
<td>3.73</td>
<td>4.77</td>
<td>5.80</td>
<td>6.84</td>
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<td>1.05</td>
<td>1.05</td>
<td>1.14</td>
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<tr>
<td>Ji0.144</td>
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<td>3.77</td>
<td>4.80</td>
<td>5.84</td>
<td>6.86</td>
<td>7.92</td>
<td>8.96</td>
<td>10.02</td>
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<td>1.04</td>
<td>1.07</td>
<td>1.08</td>
<td>1.08</td>
<td>1.40</td>
<td></td>
</tr>
</tbody>
</table>

*Bold = Leader*

### Table 36: Hurdle flight times (sec) of the medallists in the men's 110m hurdles final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>RT</th>
<th>H1</th>
<th>H2</th>
<th>H3</th>
<th>H4</th>
<th>H5</th>
<th>H6</th>
<th>H7</th>
<th>H8</th>
<th>H9</th>
<th>H10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brathwaite</td>
<td>0.32</td>
<td>0.33</td>
<td>0.35</td>
<td>0.33</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
<td>0.42</td>
<td>0.33</td>
<td>0.32</td>
</tr>
<tr>
<td>Trammell</td>
<td>0.38</td>
<td>0.37</td>
<td>0.37</td>
<td>0.35</td>
<td>0.34</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>Payne</td>
<td>0.35</td>
<td>0.35</td>
<td>0.36</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.36</td>
<td>0.36</td>
</tr>
</tbody>
</table>

*Bold = Contact with hurdle*
the case of horizontal forces acting against the running direction. This threshold value is normally set by the timing system providers to >= 300N, so that the athlete cannot trigger the false start function unintentionally by his or her pre-tension in the “ready” position. This implies that, in theory, a reaction before the time threshold value of 0.1 sec, which is not registered by the system, can occur at force levels below 300N. This is why visual impression continues to be important for starters. The pressure switch threshold value can also be used to describe why very fast reaction times (<200 ms) can occur, especially in the 400m and 400m hurdles: these athletes usually demonstrate a less dynamic force development at the starting block than 100m or 100/110m hurdle runners, so that they reach 300N later, even though they might well react in normal time.
Results and Comments - Women

Unlike for the men’s race, the result of the women’s 100m hurdles final can be categorised as thoroughly positive when compared to the major events since 2000. The 12.51 sec winning performance by Foster-Hylton (JAM), the average time of the medallists (12.53 sec), and the average time for the first seven (12.65 sec) all indicate a high level of performance (see Table 37).

This evaluation is based on the final result plus in two cases on the semi-final performance. One reason for this is because Harper (USA), who only placed seventh in the final after striking the second hurdle, ran the absolute best time of the competition in the semi-final. The second reason is that Felicien (CAN), one of the fastest qualifiers for the final, stumbled slightly after the first hurdle and finished the race only at a slow pace (possibly because of an injury).

As far as Foster-Hylton is concerned, one can notice in Table 38 that she accelerated a little slower than most of the other finalists. On the other hand, with two intervals of 0.95 sec (mean velocity: 8.95 m/sec) she achieved the highest speed of the race. Importantly, she reached the fastest time intervals for each of the last five hurdles in the final. Ennis-London (JAM), Lopez-Schliep (CAN) and Felicien reached slightly slower best interval times of 0.96 sec and exhibited more uniform velocity profiles over the course of the race.

The assessment of the winner applies equally to Harper’s semi-final run, which was characterised by a high degree of perfection and she even had the chance to achieve a better time. She did not run at 100% effort from the 8th hurdle to the finish line, because it was clear that she had reached the final. The visual impression when viewing the video corroborates this statement. We estimate that a time of 12.45 sec would have been possible with a full effort.

In the five best runs covered in this analysis, the hurdle clearance times (Table 39) for Harper and Foster-Hylton are somewhat similar, and they are in the range of previous analyses. The other three runners tend to have longer flight times. There were no hurdle contacts. Of the remaining participants, only McLellan (AUS) and Powell (USA) had problems clearing the hurdles without contact. Apparently the spaces between the last three hurdles become too large due to their declining performance capacity.

Table 37: Results of the women’s 100m hurdles final at the 2009 IAAF World Championships in Athletics

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brigitte Foster-Hylton (JAM)</td>
<td>12.51 SB</td>
<td>0.157</td>
<td>4</td>
</tr>
<tr>
<td>Priscilla Lopes-Schliep (CAN)</td>
<td>12.54</td>
<td>0.128</td>
<td>6</td>
</tr>
<tr>
<td>Delloreen Ennis-London (JAM)</td>
<td>12.55 SB</td>
<td>0.142</td>
<td>8</td>
</tr>
<tr>
<td>Derval O’Rourke (IRL)</td>
<td>12.67 NR</td>
<td>0.128</td>
<td>1</td>
</tr>
<tr>
<td>Sally McLellan (AUS)</td>
<td>12.70</td>
<td>0.139</td>
<td>7</td>
</tr>
<tr>
<td>Ginnie Powell (USA)</td>
<td>12.78</td>
<td>0.146</td>
<td>2</td>
</tr>
<tr>
<td>Dawn Harper (USA)</td>
<td>12.81</td>
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Table 38: Hurdle split-times and intervals (sec) in the women’s 110m hurdles at the 2009 IAAF World Championships in Athletics

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Semi-final performances

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Table 39: Hurdle flight times (sec) for selected finalists in the women’s 110m hurdles at the 2009 IAAF World Championships in Athletics (SF = semi-final)

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<td>Lopes-Schliep</td>
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<tr>
<td>Ennis-London</td>
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<td>0.30</td>
<td>0.31</td>
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<td>Felicien (SF)</td>
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<tr>
<td>Bold = Contact with hurdle</td>
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Biomechanical Analysis of the Sprint and Hurdles Events at the 2009 IAAF World Championships in Athletics

The 400 Metres Hurdles

Methods and Procedures

The analysis of the 400m races was conducted as a split-time measurement with three video cameras and two recording systems. Camera no. 11 was used to record the outer four lanes and the 250m (no. 1), 300m (no. 3) and 350m (no. 6) measuring points on one system while camera no. 12 was used to record lanes 1-4 independently on a second system. The data extracted from the video recordings included the determination of the hurdle interval times (from touchdown to touchdown after the hurdle) and the hurdle rhythm (number of intermediate hurdle steps). Based on these measurements, the average velocities for the hurdle intervals were calculated.

Results and Comments - Men

Compared to the results from other major events over the last 10 years, the men’s 400m hurdles final in Berlin can be regarded as fairly good, as seven participants achieved a time below 49.00 sec (see Table 39). The average time for the medallists was 48.07 sec and for the top seven was 48.32 sec. The 8th participant (Sanchez (PUR) the World Champion in 2001 and 2003) finished the race after stumbling at the first hurdle (the distance before the hurdle was too long) with a time not worth talking about. For this reason, his semi-final run, where he achieved a performance that was worth a medal, was used for the analysis.
In Table 40 we can see that although the eventual winner, Clement, dominated the race nearly throughout, the runner-up, Culson (PUR), and the fourth-placed runner, Gordon (TRI), were always only a short distance behind. The ex-World Champion, Jackson (USA), had a significant lead already at the first hurdle, but immediately thereafter he reduced his tempo, which had possibly been too fast for him. At times he was three-quarters of a second behind the leaders, but then he significantly caught up from the 6th hurdle to place third. When approaching the finish line, both the winner and the second-placed runner also managed to increase their velocity.

When considering the hurdle rhythms, Clement stands out, because he completed all intervals using a 13-stride rhythm (Tables 41, 42). All other athletes present a very varied picture. Besides Jackson and Green (GBR) who both started with a 14-stride rhythm, all participants started with a 13-stride rhythm and changed to a 14-stride rhythm and sometimes even to a 15-stride rhythm at different hurdles. In these switches no noticeable changes of the hurdle interval times are evident, so that it can be said that all the finalists have such good hurdle technique with both legs that no significant effects on the speed course could be registered. Sanchez achieved the highest velocity in a hurdle interval (9.59 m/sec) during his semi-final.

**Table 40: Results of the men’s 400m hurdles final at the 2009 IAAF World Championships in Athletics**

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
</thead>
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<td>1. Kerron Clement (USA)</td>
<td>47.91 WL</td>
<td>0.176</td>
<td>3</td>
</tr>
<tr>
<td>2. Javier Culson (PUR)</td>
<td>48.09 NR</td>
<td>0.187</td>
<td>8</td>
</tr>
<tr>
<td>3. Bershawn Jackson (USA)</td>
<td>48.23</td>
<td>0.141</td>
<td>5</td>
</tr>
<tr>
<td>4. Jehue Gordon (TRI)</td>
<td>48.26 NR</td>
<td>0.172</td>
<td>2</td>
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<tr>
<td>5. Periklis Iakovakis (GRE)</td>
<td>48.42 SB</td>
<td>0.189</td>
<td>7</td>
</tr>
<tr>
<td>6. Danny McFarlane (JAM)</td>
<td>48.65</td>
<td>0.162</td>
<td>1</td>
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<tr>
<td>7. David Green (GBR)</td>
<td>48.68</td>
<td>0.148</td>
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</tr>
<tr>
<td>8. Felix Sanchez (PUR)</td>
<td>59.11</td>
<td>0.171</td>
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<p>| Figure 15: Velocity course for the finalists in the men’s 400m hurdles at the 2009 IAAF World Championships in Athletics (Semi-final data for Sanchez) |</p>
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**Bold = Leading position**
Table 42: Hurdle rhythms (strides) for the men’s 400m hurdles at the 2009 IAAF World Championships in Athletics (SF = semi-final performance)

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Table 43: Results of the women’s 400m hurdles final at the 2009 IAAF World Championships in Athletics

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<th>Athlete (Country)</th>
<th>Mark [sec]</th>
<th>Reaction Time [sec]</th>
<th>Lane</th>
</tr>
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<tbody>
<tr>
<td>1 Melaine Walker (JAM)</td>
<td>52.42 CR</td>
<td>0.142</td>
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<td>2 Lashinda Demus (USA)</td>
<td>52.96</td>
<td>0.159</td>
<td>5</td>
</tr>
<tr>
<td>3 Josanne Lucas (TRI)</td>
<td>53.20 NR</td>
<td>0.186</td>
<td>3</td>
</tr>
<tr>
<td>4 Kalise Spencer (JAM)</td>
<td>53.56 PB</td>
<td>0.186</td>
<td>6</td>
</tr>
<tr>
<td>5 Tiffany Williams (USA)</td>
<td>53.83 SB</td>
<td>0.161</td>
<td>2</td>
</tr>
<tr>
<td>6 Natalya Atyukh (RUS)</td>
<td>54.11 SB</td>
<td>0.205</td>
<td>7</td>
</tr>
<tr>
<td>7 Anastasiya Rabchenyuk (UKR)</td>
<td>54.78 SB</td>
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<tr>
<td>8 Angela Morosanu (ROU)</td>
<td>55.04</td>
<td>0.183</td>
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Figure 16: Velocity course for the finalists in the women’s 400m hurdles at the 2009 IAAF World Championships in Athletics
Table 44: Hurdle split and interval times (sec) for the women’s 400m hurdles final at the 2009 IAAF World Championships in Athletics

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<tr>
<th>RT</th>
<th>H1</th>
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<tr>
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<td>0.142</td>
<td>6.23</td>
<td>10.15</td>
<td>14.32</td>
<td>18.58</td>
<td>22.98</td>
<td><strong>27.45</strong></td>
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<td>36.81</td>
<td><strong>41.58</strong></td>
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<tr>
<td>Demus</td>
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<td>6.16</td>
<td>10.11</td>
<td><strong>14.23</strong></td>
<td>18.59</td>
<td>23.05</td>
<td>27.51</td>
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<td>14.30</td>
<td>18.50</td>
<td><strong>22.90</strong></td>
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<td>18.93</td>
<td>23.31</td>
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<tr>
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<td>22.96</td>
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<tr>
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<td>10.63</td>
<td>14.67</td>
<td>18.86</td>
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<td>37.07</td>
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<td>32.63</td>
<td>37.70</td>
<td>43.08</td>
<td>48.71</td>
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**Bold** = Leading position

Table 45: Hurdle rhythms strides for the women’s 400m hurdles final at the 2009 IAAF World Championships in Athletics

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</table>
Results and Comments - Women

When comparing the rhythm pattern of all finalists (Table 45), one must surmise that Demus was the only runner who was not able to clear the hurdles leading with both legs. The same weakness could be observed in the semi-final. In other runners, sometimes up to three rhythm changes (Rabchenyuk (UKR)) could be observed.

Please send all correspondence to:
Rolf Graubner
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Eberhard Nixdorf
enixdorf@lsbh.de

REFERENCE

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REFERENCE
The Bolt Phenomenon

By Mike Rowbottom

ABSTRACT

Usain Bolt is the world’s highest profile athlete, an internationally known figure on the scale of any football player or movie star. Through his success in athletics’ most popular events, he has almost single-handedly brought the sport to a new generation wherever it is followed, as well as some places where it was not previously strong. His star power has been confirmed with the signing of the largest ever sponsorship deal for a track and field athlete. This article traces Bolt’s development, from his birth through to the end of the 2010 season. It chronicles his early career, his decision to become a professional athlete, his lifestyle adjustments and health problems, his emergence in the global sporting consciousness with a world record in the 100m in early 2008, and his phenomenal performances in the 2008 Olympic Games and 2009 IAAF World Championships in Athletics. Along the way the social and sporting background to the strength of Jamaica’s sprinters, the role of Bolt’s coach and support team and his impact on the whole sport of athletics are covered. The article concludes that Bolt is not bigger than athletics, but he is undeniably the biggest thing in the sport.

AUTHOR

Mike Rowbottom is the chief feature writer for insidethegames.com. He has covered the last five summer and four winter Olympic Games for the British newspaper The Independent and has previously worked for other British papers including The Daily Mail, The Times, The Observer, the Sunday Correspondent and The Guardian.

Introduction

Usain Bolt is a phenomenon. He is the world’s highest profile athlete and has transcended his sport to become, for young people especially, an internationally known figure on the scale of any football player or movie star.

Part of the story is that he makes it look so easy – crushing the sport’s toughest opposition without losing his cool or his sense of fun. But it is not quite as simple as it seems. Make no mistake, Bolt has worked hard and overcome difficulties to reach his current status.

In this article I will trace the steps of the emergence of this charming giant as an athlete, from his young days in the sprinting powerhouse of Jamaica to the peak of sporting fame and through the 2010 season. Along the way I will also discuss some of the impact he has had on his sport, both on and off the track.
2008 -Taking Centre Stage

For the majority of those now aware of Bolt, he appeared to arrive on the scene as a peerless sprinter in 2008. On a rainswept May evening at New York’s Icahn Stadium, the 21 year-old shocked the home favourite Tyson Gay, the 2007 world 100 and 200m champion, to set a world 100m record of 9.72 sec in what was only his fifth serious race at the distance.

Later that summer, of course, the world became properly acquainted with Bolt as he lowered his record to 9.69, while simultaneously earning himself the Olympic title and beating his fist against his chest in excitement. The packed crowd in Beijing’s Bird’s Nest Stadium, huge television audiences around the world, and surely athletics’ greatest YouTube following did not need to be told that something quite unusual had taken place. They could see the daylight he had opened up on the rest of the world’s top sprinters, seemingly without a full effort.

Bolt followed up by beating the legendary world 200m record of 19.32, which many believed Michael Johnson had set for a generation in winning the 1996 Olympics, This time there was no showboating at the line as Bolt drove through, long legs working, arms pumping past his ears, intent on making an indelible mark in the event which has always appeared to be his speciality, the event where his lauded fellow countrymen, Don Quarrie, had earned a gold medal for Jamaica at the 1976 Olympics. This time the clock stopped at 19.30.

And at the stroke of midnight, Bolt turned 22.

As after the 100m, Bolt’s competitors in the Beijing final were left straining for words. “It’s mind-blowing,” said Christian Malcolm of Great Britain, whose seventh place turned into fifth once the disqualifications were announced. “I hear he looked impressive, but I didn’t really get to see.”

“We thought the 100 record could possibly go to 9.6, but we never thought the 200 record could be broken,” said another of his opponents, the 2003 world 100m champion Kim Collins of St Kitts and Nevis. “I didn’t think it would happen while I was still running. How fast can a human being run before there is no more going fast?”

“Everything came together tonight,” Bolt said at the post-race press conference, at which, characteristically, he appeared laid-back, almost childlike. “I just blew my mind. And I blew the world’s mind.”

The world certainly was agog at his demonstrations of superiority. But most of all, it was agog over the 6ft 5in showman who had energised his sport with a startling display of athleticism, and inimitable showmanship.

Before and after his triumphs, Bolt assumed the pose with which he is now synonymous – left arm raised with a forefinger pointing to the sky, right arm cocked back as if holding the string of a bow.

And as he celebrated his successive triumphs, the pose was supplemented with impromptu dancing – moves drawn from the Jamaican dancehall scene, which Bolt has embraced. Four years earlier, Hicham El Guerrouj had capered in joy after finally capturing the Olympic 1500m title at the third time of asking. But Bolt’s moves were not the overflowing of emotion so much as a jubilant expression of personality.

Bolt capped his efforts in Beijing by claiming a third Olympic gold as he ran the third leg in the sprint relay, handing over to the fellow Jamaican from whom he had taken away the distinction of being world record holder – Asafa Powell. The 2006 Commonwealth champion brought Jamaica home in a world record of 37.10 and added another gold to what was Jamaica’s richest haul of medals at any Olympics.

With six golds, three silvers and two bronzes, this nation of less than three million inhabitants finished 13th out of the 200 competing countries. In terms of sprinting, however, it finished as far and away the dominant force of the Games,
with Shelly-Ann Fraser and Veronica Campbell-Brown taking the women's 100m and 200m respectively, and Melanie Walker adding gold in the 400m hurdles. Had it not been for a dropped baton in the women's sprint relay, the domination in the sprints would probably have been complete.

The Back Story

Beijing was where the world took full notice of Bolt. And yet, as Bert Cameron, the Jamaican coach who won the first ever world 400m title in 1983, remarked in the wake of Bolt's opening flourish at the Games: “We knew what was coming”.

Bolt may have flashed onto the world’s consciousness like lightning but, any Jamaican could have told you, he was no bolt from the blue. From the first moment he became an athlete, it was clear that he could do something special. Jamaica had been awaiting his overnight success for almost a decade.

After the impact Bolt and his fellow Jamaicans had made in Beijing, the sporting world was asking the question: how do they all, and how does Bolt in particular, run so fast?

A large part of the answer lies in Jamaica’s unique competitive structure and heritage. To fully understand how an island with a population of less than three million people can match and beat a nation such as the United States, with a population one hundred times larger and a far greater advantage in terms of economic resources, you have to see how this great sporting tradition has evolved.

In his book entitled Jamaican Athletics, A model for 2012 and the world (BlackAmber 2007) Patrick Robinson points out that runners from the island have benefited down the years not just from the competitions established, but a legacy of inspiration from successive generations, starting with a sprinter who ended up as the nation’s Premier from 1955 to 1962, Norman Manley.

As a member of Jamaica College, Manley ran the 100 yards in 10.0 (when the world record was 9.7) and the 220 yards in 23 seconds. The latter time would have earned him a place in the finals of both the 1908 and the 1912 Olympics.

The testing ground for Manley, as for so many other great Jamaican athletes who would follow him including Quarrie, Powell and Bolt, was a competition that emerged at the same time as he did, and in 2010 celebrated its centenary. Officially, it is the Boys and Girls High School Championships. But everyone who has ever been involved in this energising event knows it simply as Champs.

When Champs started, in 1910, there were six secondary schools and around 70 athletes taking part.

Nowadays, this four-day event held at the National Stadium brings traffic in Kingston to a halt. More than 2,000 young athletes take part in front of capacity crowds of 30,000.

And when he attends, Bolt is the ultimate role model, besieged by young athletes who ask to know how to run as fast as he does – “Work hard” they are told – or just want to get him to do “The Pose”.

“This then – a rich athletic history and tradition, supported by the assertiveness, the combative- ness, the self-belief and resilience that are native to the Jamaican persona – is the first explanation of Jamaica’s success,” Robinson writes.

Not only has Jamaica provided world-class sprinters down the years, to the point where they now dominate world sprinting in both male and female events, but many of the world’s finest sprinters who have not competed for Jamaica have been Jamaican either by birth or descent, including Olympic 100m champions Donovan Bailey (Canada) and Linford Christie (GB), world 200m champion Ato Boldon (Trinidad and Tobago), world 400m champion Sanya Richards (US), double 2004 Olympic champion Kelly Holmes (GB) and former world 100m hurdles champion and record holder Colin Jackson (GB).
Interview with Usain Bolt

NSA How are you? How did your recovery from the 2010 season go?

Bolt: Recovery went fairly well with rest and visits to the doctor. I am back in training since the first week in October and things are going great so far.

NSA You train mostly in Jamaica. Why do you prefer that rather than for example in the US or Europe?

Bolt: I like being at home and as our facilities improve in Jamaica it makes training even more comfortable. I also get an opportunity to train with my teammates.

NSA In a training period do you see Glen every day? Do you feel a training session without coach is less effective?

Bolt: The coach has specific programmes for all his athletes and if he is not there, he has a capable technical team to assist all the athletes in the club.

NSA How often do you actually train in a week?

Bolt: I try to train five to six days per week now.

NSA What’s your favorite training content?

Bolt: The early days are challenging, but training gets better once there is competition. I am a very competitive athlete plus we get an opportunity to see the progress we have made.

NSA Is there any type of training you don’t like?

Bolt: No one likes the multiple runs of 300/400 metres.

NSA How much of your success would you put down to mental and psychological strength and how much to physical abilities?

Bolt: I have been blessed with a great deal of talent but as I grow I have become stronger, mentally and psychologically. Also, my opponents are very strong so that helps to make me stronger. I take no one for granted.

NSA There is one thing that makes you very special: your ability to switch from being very relaxed to highly focused. Where do you think you get this skill and do you do anything to develop it?

Bolt: When I am on the track, there is only one thing I am aiming to do and that is win and once that is over I enjoy myself. I have realized that apart from competing well, people watch track and field for entertainment, so I do both.

NSA Most people associate Jamaicans, even top athletes, with a more relaxed attitude about life in general. How do you square this with the hard work and dedication it takes to reach your level of performance?

Bolt: We have a rich history of sport in Jamaica. While the laid back attitude is there, people expect the athletes to do well. Plus we have a rich tradition to follow.
How do you usually warm up? Is your competition warm-up different from training?

Bolt: The basic warm up is important and I do a few stretches for my back. I listen to music too.

What do you do to promote recovery after an intense training session?

Bolt: Athletes must remember to keep hydrated and get as much rest as possible. Those things are very important.

Does it happen that you are not motivated for a training session? What do you do when it happens?

Bolt: Coach is very quick to determine when I am not in the mood, but he always has an alternative, so we are not allowed to get away. I am motivated because I set goals for myself.

What kind of scientific and medical support do you have? In other words, do you work regularly with any sport medicine doctors, biomechanists or psychologists?

Bolt: Our technical team has a masseur and I have access to sport medicine doctors. I also visit Dr. Wolfhart in Germany for special treatment. Racers Track Club has meetings to discuss other aspects of training, so we work with several professionals from time to time.

If you look back, when did you realise that you really would become an elite athlete? What made you see it?

Bolt: I always knew I had the potential...had a bad rap in 2004, but changed coach and recovered since the 2007 World Championships.

Have you already recognized a Usain II in Jamaica yet?

Bolt: Jamaica has a good set of athletes. My club Racers also has a talented bunch of athletes.

Interview by Bill Glad
The innate sprinting ability of so many Jamaicans is something that Robinson acknowledges has prompted speculation regarding hereditary factors.

“It has long been claimed that black people of the West African diaspora (to which the vast majority of Jamaicans belong) are genetically predisposed to excellence in sports that call for explosive talent,” Robinson says. “A Jamaican journalist, Patrick Cooper, in his book The Black Superman, advances the thesis that there is a scientific basis for the dominance of blacks of West African decent, sports such as athletics, basketball, baseball, football, American football, boxing and cricket.

“To his credit, Cooper anticipates the objection that his thesis feeds into the stereotype of blacks as people with brawn and no brains; he, therefore, takes care to highlight the many achievements of blacks in areas outside the field of sports, and identifies the social and political factors explaining their relative underachievement in those areas.”

**Growing Up and Finding His Sport**

Bolt himself has no difficulty in embracing this idea of African influence, and has credited the African influx and its strong genes for the Jamaican success, along with the country’s warm climate and increasingly good coaching.

But part of Bolt’s athletic accomplishment may be down to an even more local accident of birth – over the years his home town of Trelawny has provided an above average number of outstanding sprinters, including Olympic and world champion Veronica Campbell-Brown, Olympians Michael Green and Michael Frater, and the infamous Ben Johnson, the naturalised Canadian who was stripped of the 1988 Olympic 100m title for doping.

Usain St Leo Bolt was born on August 21, 1986, and his starting blocks in life were firm – he comes from a close, grounded, loving and religious family.

Bolt’s father, Wellesley, and mother Jennifer ran the local grocery store in the rural district of Sherwood Content. Usain – who has a sister, Sherine, and a younger brother, Sadiki - was born two years after the couple met in 1984, and they married when he was 12.

As a child, Bolt played football, and lots of cricket, in the streets of Trelawny. But he began to show his athletic prowess while attending Waldensia Primary and All-age School, running in the annual national primary schools’ meeting for his parish. At 12, he was the fastest 100m runner in the school and he also ran 52 seconds for 400m on a grass track.

When he moved up to William Knibb Memorial High School – which had an impressive athletics tradition and had previously produced Olympic sprinters such as Michael Green – Bolt’s main interest was still cricket, where he was a fast bowler, but his coach noticed his general speed around the pitch and pointed him towards track and field.

Under the coaching of Dwayne Barrett and Pablo McNeil, a former Olympic 100m sprinter, Bolt was encouraged to concentrate his energies on running. McNeil had to work hard to keep his exuberant charge in line, particularly when he decided to start playing practical jokes. But he predicted that Bolt’s huge stride would take him to world record performances within the space of five or six years.

Champs, naturally, would be the big testing ground. In 2001, at age 14, Bolt won his first Champs medal when he took silver in the 200m with a time of 22.04.

**The Start of an International Career**

A few months after his first Champs success, Bolt performed for Jamaica in the CARIFTA Games, an annual international meeting that brings together the top talents from around the Caribbean, which took place that year in Bridgetown, Barbados. There he was second in both the under-17 200m and 400m, running
21.81 and a personal best of 48.28 respectively.

It was also in 2001 that Bolt made his first appearance in a global event when he competed at the IAAF World Youth Championships in Debrecen, Hungary. Racing against opponents who were two or three years older than he was, he failed to reach the final of the 200m, but lowered his personal best to 21.73.

At the 2002 CARIFTA Games, held at Nassau, Bahamas, Bolt set under-17 records in the 200m and 400m with 21.12 and 47.33 respectively. And within months he had improved those marks by running 20.61 and 47.12 at the Central American and Caribbean Junior Championships. The times were heading in one direction.

That summer the young prodigy earned his first major honour at the World Junior Championships, which were held in his native Kingston. On the evening of July 19, at the age of 15 years, 332 days, Bolt became the youngest male world junior champion after clocking a time of 20.61 for the 200m.

It was an exceptional result for an athlete who, though grown to his full height of 6ft 5in (1.82m), was still a relative novice in the sport, and racing against opponents who were two or three years older.

Dave Martin, who reported the event for the Press Association and the IAAF, remembers vividly the noise that crowd made – and the impact the emerging sprinter made upon the world of athletics.

“Covering the championships was a fantastic experience, but without a doubt the highlight was young Usain Bolt. When I first saw him I couldn’t believe he was only 15 years old. He stood head and shoulders above all the other runners in the 200 metres, He was already 6ft 5in. It was truly amazing.

“When it came to the final, what a night that was. I remember being in the press hotel before the race, and it was already Bolt-mania then. I was told by the hotel security to make sure I got onto the coach early and get into the stadium because the streets would be packed.

“And they were – they were jam-packed. There were buses, bicycles, people just walking in the streets, all dressed up in the yellow and green national colours. They were roaring “Jamaica, Jamaica”.

“In the stadium it was unbelievable. There were more than 25,000 there – there wasn’t a spare seat to be had. People were crowding the gangways, anywhere there was a space.

“The wall of the stadium was 30-feet (9m) high, and people were climbing up it, trying to get in, and the police were standing there on ladders and knocking them back down. It was just a total sell-out to see Bolt run that night.

“To win it in 20.61 was not exactly bad for a lad of 15. You knew as you were watching him run that you were watching someone who was going to be special.

“At the press conference he spoke quietly, but he was very confident. You could tell he was really serious about his sport. Even then he said he wanted one day to be the best in the world.

“When we got back to the press hotel that night it was well after midnight, and we couldn’t believe what we had just witnessed. We knew we had seen an athlete who had what it took to be a world-beater.”

**Becoming a Professional**

There was concern in Jamaica that Bolt might be tempted by one of the six offers he had already had to take up university sports scholarships in the United States. The situation prompted Howard Hamilton, who held the office of Public Defender in Jamaica’s government, to write to the Jamaica Observer urging the Jamaica Amateur Athletic Association to make sure Bolt’s future on and off the track was safeguarded.
The switch in location was starting to look like a bad idea.

“He almost lost himself,” McNeil recalled.

As world youth and world junior 200m champion, Bolt had the opportunity of trying for an unprecedented treble as he prepared for his first senior global event, the 2003 IAAF World Championships in Athletics in Paris.

A victory in the Pan-American juniors, a month before the Championships in the French capital, was achieved in a time of 20.13, equaling American Roy Martin’s world junior record set in 1985. Despite this show of good form, Bolt’s stated ambition was relatively conservative – he wanted to set a personal best, even if he didn’t make the Paris final.

But there was to be no 200m final, or personal best for Bolt there. The Jamaica Amateur Athletics Association took the controversial decision not to select him, even though he had beaten all the seniors in the 200 at the national trials. It cited his youth and inexperience, taking into account also the fact that his training schedule had been badly disrupted by conjunctivitis six weeks before the championships.

By this time, Bolt had a manager in Norman Peart, a former athlete whom he had met on the track where they both trained.

While his big future remained a topic for anxious discussion – and Puma signed him up on an initial sponsorship deal - Bolt was still producing outstanding performances. Everything looked bright for Bolt at that point.

But although his talent was never in question, circumstances and a succession of injuries were about to start hindering his progress.

In 2003 he won the 200m at the IAAF World Youth Championships in Sherbrooke, Canada, as well as earning another gold at the CARIFTA Games in Port of Spain, Trinidad, with a time of 20.43. Another 200 metres title soon followed - at the Pan-Am Junior Championships in Bridgetown, Barbados.

This was also the year when Bolt left his last mark on Champs as he altered the record books in the under-19 age group, recording an easy 45.3 in the 400m, a 0.87 improvement on the previous record, and 20.25 in the curved sprint, to lower the old mark by 0.57.

Peart told Bolt’s parents there was little point in him continuing to run for his high school, as he had run 20.25 there was no real local opposition. Instead it was planned for him to move to Kingston, where he would start training at the University of Technology on what was described as a five-year plan leading to Beijing.

But transferring the gifted 16-year-old away from home - and Coach McNeil - to the capital proved to be a challenge. The youngster began to succumb to off-the-track distractions - partying and night clubs - and to suffer criticism for his conduct. He also started to pick up injuries.

The Bolt Phenomenon

“It is the responsibility of the JAAA to ensure that this new-found treasure receives nurturing and protection,” Hamilton wrote. “Usain Bolt is the most phenomenal sprinter ever produced by this island and history will judge them harshly if they fail.”

Although a hamstring injury in May prevented him from defending his world junior title, he was still looking, at 17, like a genuine prospect for an Olympic medal at that summer’s Games in Athens. But, the problems with his leg, which mainly stemmed from a serious back condition – a curvature of the spine or scoliosis – persisted and prevented him from giving anything like full expression to his gifts and he was eliminated in the first round of the 200m.
A New Coach

Returning from Athens, Bolt began with a new coach – Glen Mills.

Mills had helped guide Kim Collins to unexpected 100m victories at the 2002 Commonwealth Games in Manchester and at the 2003 IAAF World Championships in Athletics. His previous Jamaican athletes included Raymond Stewart, who finished sixth in the 100m final at the 1984 Los Angeles Olympics, and the man to whom statues had been raised, after whom roads had been named, for whom songs had been composed – Don Quarrie.

Bolt’s partnership with Mills would produce riches even beyond the dreams of Quarrie - eventually. But before that could happen, several critical adjustments had to be made – not least to the Bolt work ethic.

By June 2005, Bolt was declaring himself ready to make a serious flourish at the World Championships due to be held two months later in Helsinki.

“I am working much harder now. I really want to make up for what happened in Athens,” Bolt said. “Hopefully everything will fall into place.”

He backed up his optimism the following month by smashing Ivan Garcia’s eight-year-old 200m championship record at the Central American and Caribbean Senior Championships in Nassau, Bahamas, recording 20.03, his fastest time since his world junior record of 19.93, despite effectively running the second half of the race on his own.

He dipped under 20 seconds once again in the London Grand Prix at Crystal Palace, recording 19.99.

But in August, having become the youngest Jamaican male to reach an IAAF World Championships sprint final – 10 days before his 19th birthday - he suffered another injury in the chill, rainy conditions that blighted so much of the...
championships, eventually trailing home last - in 26.27. His ambitions of making his mark in the world of senior sprinting continued to be frustrated.

And the injury problems came back again in 2006. In March, yet another hamstring injury forced Bolt to withdraw from the Commonwealth Games in Melbourne, where his friend Powell, by now established as the fastest man in the world, finally took possession of a major, if not global, title.

The general opinion in Jamaica had begun to shift a little as Bolt’s meteoric progress appeared to be over and he struggled to complete a full season of running. The 19-year-old, for all his brilliance at the world juniors in Kingston, was perceived as being in danger of becoming an athlete who might not deliver on all his huge promise.

The latest setback kept Bolt off the track for two months. But it had a silver lining – when he returned, he was given new training exercises to improve his flexibility and basic strength. And plans to move him up to the 400m were put on hold.

Interestingly, Coach Mills reported that his new charge was suffering from poor co-ordination, and that his scoliosis was affecting his hamstring. Which meant a new regime that consisted of not working so hard.

Bolt reflected: “From 2004 to 2006 I was pretty much injured every year because of my back - I have really bad scoliosis. I went through some rough times. I was wondering if I was really going to get to the level I wanted to run. But after joining up with Glen Mills we solved the problem, we really worked hard on exercises.

“I have to do a whole lot of work on my core and my abdominal muscles to make sure my back stays strong. As long as I keep doing that then I should stay away from injury. We don’t try to push my body too much now.”
When a long-awaited move to the European circuit arrived, the re-emphasis on the 200m – and the new approach to training – appeared to have paid off. On May 30, Bolt indicated his refocused state by winning the 200m in Ostrava with 20.28 in poor weather, breaking the meeting record of 20.30 set by Justin Gatlin in the year he won the Olympic 100m title. And intriguingly, Bolt was also keeping the idea of the 400m in play.

A month later, Bolt had achieved the target he might have managed in Ostrava but for the weather – another sub-20 second clocking. His time of 19.88, however, was only enough to give him third place in the Lausanne meeting as two US rivals broke through their own personal barriers ahead of him. Tyson Gay was second in a best of 19.70, but the race went to newcomer Xavier Carter in 19.63, a time only Michael Johnson had ever bettered.

In September, however, Bolt claimed his first major world medal at the IAAF World Athletics Final in Stuttgart, finishing third in 20.10. And before the year was out, he had another medal, this time silver, from the IAAF World Cup in Athens, where his time of 19.96 was bettered only by American Wallace Spearmon’s 19.87.

On the Right Track

Going into 2007, Bolt’s confidence was rising, as his body seemed finally to be becoming resistant to the injuries that had thwarted his progress.

Chris Turner of the IAAF Communications Department recalls a graphic illustration of Bolt’s evolving attitude to his sport. It came at the 2007 IAAF World Championships in Athletics in Osaka, where he ended up taking his first senior global medal, the 200m silver, with a time of 19.91 behind Gay’s 19.76.

Turner believes that, although Bolt’s progress had been undermined since his 2002 World Junior victory by a succession of injuries, there was a more profound reason for his failure to break through immediately.

“IT was not so much injuries, it was the way he was looking at his life,” Turner said. “He obviously had not trained as hard as he should have in the past.”

“When he got to Osaka, people were asking: ‘What’s happened to all his chains and his jewellery?’ He used to wear lots of it. He had all kinds of gold slinging around his neck.

“And this seemed like a visual sign that he had changed his attitude. It was as, if a transformational thing had happened in his head.

“His coach, Glen Mills, was the one who had told him what he could be if he did the training required. Usain also had support from his manager Norman Peart, whom he had known for years, and an agent in Ricky Simms – you couldn’t find a more stable and reliable agent if you tried.

“I remember meeting Ricky regularly over the years before Usain started to succeed at senior level, and he would always tell me ‘Don’t worry. Be patient. He’ll do it.’”

For his part, Dave Martin thinks Bolt’s injury problems may have been a blessing in disguise: “He would have got to where he is now a lot more quickly if he hadn’t had all the injuries. But in a way I think that helped him, because although it slowed him down, he could well have burnt out and been lost to the sport if he had carried straight on.”

Taking over the 100 metres

With Bolt’s increased confidence came an increased sense of which events he wanted to be running. For all of Mills’s desire to make him a 200/400 runner, Bolt was set on something a little less strenuous – 100/200. As for new events – he has said repeatedly that when he has finished with sprinting, he fancies having a go at long jumping. World record holder Mike Powell has offered, only half jokingly, to help him better the mark he set at the 1991 World Championships if he does take to the sandpit.
But the question of whether Bolt should run the short sprint led to a deal being made in early 2007 which was to re-shape athletics. Mills told Bolt that he could have his wish of running a serious 100m – but only if he broke Don Quarrie’s 36-year-old national 200m record at the Jamaican Championships.

Bolt accepted the challenge, running 19.75 – 0.11 inside the mark set by his long-time idol.

Mills kept up his side of the bargain, entering Bolt for the 100m at the 23rd Vardinoyiannia meeting in Rethymno, Crete. Bolt won in 10.03. And as we know by now, the following year all that promise in the 100m came good – first in New York, then Beijing. Bolt was established as the highest profile performer in his sport.

With the successes of 2008, new pressure was on for the following year’s World Championships in Berlin. How Bolt dealt with that pressure is now part of sporting history: he lowered his world 100m record to 9.58.

“I keep telling you guys, my main aim is to become a legend, that’s what I’m working on,” he shrugged as he addressed the assembled media. “It’s a great feat for me to have broken my world record. I didn’t know I was going to break it.”

Then he lowered his 200m world record to 19.19 and ran on Jamaica’s winning relay team. By the time the 12th IAAF World Championships had come to a close, Bolt had taken three more giant strides towards the legendary status of the sprinter who achieved his finest hour in the same stadium at the Olympic Games of 1936 – Jesse Owens.

2010 – An “off year”

Inevitably, Bolt was not able to remain at the same pitch of achievement in 2010, although he did produce some outstanding performances, notably a 19.56 win over 200m in Kingston on May 1, which remained the fastest performance of the year, and a 30.97 300m on May 27, which was the second fastest ever.

Unfortunately the latter achievement, in heavy rain in Ostrava, exacerbated an Achilles tendon problem, forcing him out of action for six weeks.

His return to the track, at the Lausanne Diamond League meeting on July 8, saw him win the 100m in 9.82, which equalled the season’s fastest time set by Powell. On July 16 he beat Powell in the Paris Diamond League meeting in San Denis, winning the 100m in 9.84.

But on August 6 Bolt suffered his first defeat over 100m in two years at the Stockholm Diamond League meeting, where a keenly anticipated showdown with Gay ended with the American clocking 9.84 and Bolt a disconsolate but philosophical second in 9.97. It was only the third meeting between the two men over 100m – on both previous occasions, in New York and Berlin, Bolt had set a world record.

“Just one of those days,” Bolt said. “I told you I’m not unbeatable. I did not train as hard as in past years, so I can’t complain. And it was Tyson Gay. My congratulations to him. I’m not in my best shape and he is in great shape.”

Four days later, Bolt called his season to an early close in order not to exacerbate the long-standing problem with his lower back.

He is already targeting the 2011 IAAF World Championships in Daegu, and the Olympics a year beyond them. After that, he has hinted he might retire and put his feet up. But it is too early to tell what course he will take post 2012.

Conclusion - The phenomenon is still growing

If his track activity had come to an early end in 2010, Bolt’s activity off the track began in earnest and his phenomenon kept growing. On August 24 he signed new deal with sports manufacturers Puma, billed as ‘by far the largest ever given to a track and field athlete’ and thought to be worth £10m over three years.

The Bolt Phenomenon
The following month he embarked on tours of the United Kingdom and Australia promoting his new book “Usain Bolt: 9.58 My Story (Harper Sport).

Wherever he appears, the marketing goes with him. Puma supply “Bolt hands” – set in his trademark stance. Tiny Jamaican flags also appear at trackside when he races.

And, as a thoroughly modern star, Bolt has thousands of followers on his official Facebook site.

At a recent appearance in Britain to open the Kip Keino Stadium at Filton College, in north Bristol, which will be the venue where Kenyan Olympic competitors train before the 2012 Games in London, Keino himself spent much time talking to young athletes who were competing on the day, and awarding them prizes.

As he approached one school group, several exuberant “Bolt signs” from the boys in the group greeted the double Olympic champion of 1968 and 1972. He smiled, acknowledging the gesture.

Bolt and everything about Bolt have become instantly recognisable.

The world 100m and 200m record holder is not bigger than his sport. But he is undeniably the biggest in his sport.

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Modelling a Sub-10 Second 100m Sprinter Using Newton’s Equations of Motion

By Jeremy Richmond

ABSTRACT

After the exploits of Usain Bolt in 2008 and 2009, many have asked: how is it possible that a human could run so fast? For rivals seeking to close the gap, strength training, the central element of the modern training paradigm for sprinters, offers only limited proven benefits for increasing maximal running velocity, which is the apparent key to Bolt’s domination. This paper discusses alternate training strategies. A model of forces generated in a sub-10 sec 100m was created based on Newton’s equations of motions and data from world-class sprint performances. It shows that after 30m, force in the horizontal direction is quite small, little more than body weight. At such a low level, the influence of maximum strength diminishes and the rate of force development becomes the predominant factor. Improvement of a sprinter’s maximal velocity requires more force production within the same ground contact times. This calls for greater training specificity, with more emphasis on increasing movement velocity and less on force production. The author suggests that better results may be achieved through explosive strength training such as plyometric exercises with a horizontal emphasis carried out with less force, reduced ground contact time and greater joint velocity.

AUTHOR

Jeremy Richmond is an Exercise Physiologist and Personal Trainer in Australia. He holds a Bachelor’s degree in Applied Science-Physics and a Master’s degree in Exercise and Sports Science.

Introduction

After the exploits of Usain Bolt (JAM) at the 2008 Olympic Games in Beijing, many in the audience will have asked: how is it possible that a human could run so fast? Four seconds (34m) into the final of the 100m, the other competitors seemed to be a match for Bolt, which would suggest they possess similar starting and acceleration qualities. This changed shortly thereafter as Bolt’s superior top-end velocity became evident to all. At 6.2 sec into the race the distance between him and silver medallist Richard Thompson (TRI) was 0.7m but barely a second later (at 7.3 sec), when Bolt was 73.3m down the track, the difference had lengthened to 1.2m.

It appeared that for the first third of the distance there was little difference between the finalists, but from that point onwards Bolt clearly distinguished himself as the “fastest man on earth” by pulling away from the field and setting a world record of 9.69 sec (see Figure 1).
The fact that the above training methods provide little significant benefit to sprint performance will disappoint those chasing Bolt and trying to bridge the large gap that exists. But perhaps their exercise methods need more specificity in order to provide better transfer of strength gains to sprinting. More specificity of movement in training makes sense because even when different exercises involve identical muscle groups the specific movement pattern used in training is where most of the strength improvement occurs. Therefore, useful improvements in strength for sprinters must be initiated in the muscles that generate the forces with the same pattern observed during sprinting. Moreover, we know that the greatest strength gains will occur at or near the training velocity. It seems that only through training with the same pattern and velocity will the coordination of agonist and synergist muscles improve effectively.

Therefore, what must be addressed in the design of training programmes for elite sprinters is whether and how well the forces in training mimic the requirements of sprinting.

Some researchers believe that greater top-end running velocity is achieved with greater vertical ground forces. Others have shown that horizontal thrust is necessary for for...
ward movement\textsuperscript{23,24} and that maximal velocity is more dependent on horizontal forces than vertical forces\textsuperscript{25}. It would be great if we could examine these forces throughout the race, especially at the world-class level, to allay any doubts between the theories. But for now we can say that sprinting is characterised by short force production times. In a study of the relationship between strength measures and sprinting performance, the best predictor of 2.5m starting performance was found to be the peak force generated during the concentric contraction of a jump (\(r=0.86\)) from a similar biomechanical position to that held in the starting blocks\textsuperscript{27}. The same study also found that the concentric force applied at 100 ms from the start of a loaded jumping action correlated with maximum sprinting speed (\(r=0.80\)). In addition, strong correlations were found with the countermovement jump (\(r=-0.79\)) and maximum force during a jump take-off (\(r=-0.79\)) and maximal running velocity. These results show that sprint performance is related to the rate of force production and may also be related to explosive movement.

The velocity of a runner at full speed relates directly to the backswing velocity of his/her leg\textsuperscript{28,29}. Very strong correlations have been observed between running velocity in male participants and the peak angular thigh pushing velocity (\(r=0.98\)) whilst peak angular velocity of the lower leg (\(r=0.96\)) was also found to correlate extremely well\textsuperscript{30}. Similarly in females, peak angular velocity of the lower leg was found to be a strong predictor of sprinting velocity (\(r=0.98\)). These results show that sprint performance correlates very strongly with velocity of movement in the propulsive limbs, at least when running at high velocities.

The question is whether improving force generation or velocity of movement is going to be enough to catch Bolt. In order to address this, we need first to understand the mechanisms by which Bolt may have an advantage over his competitors. Although a large amount of biomechanical research on the sprints has been carried out the context of IAAF projects at the Olympic Games and World Championships in Athletics, there remains a dearth of information that allows us to understand the mechanisms related to how world-class sprinters run faster than everyone else. Therefore, we have to use modelling to give us an insight into what might transpire in a world record sprint race. Such an insight might reveal some clues as to where improvements can be gained.

This paper, therefore, intends to approximate the mechanisms that propel world-class sprinters to their speeds by using Newton's equations of motion.

**Newtonian Modelling**

**Force and Velocity**

To move forward, any runner must produce horizontal force against the ground. The sprinter must produce vertical force but this need only be enough to allow him/her to reposition the legs for the following step and horizontal force generation. If the sprinter chooses to generate more vertical force this may allow more time in which to create backward movement of the repositioned leg in order to generate horizontal force. In the absence of data on force production for world-class sprinters, we will approximate the forces using equations of physics.

In 1686 Sir Isaac Newton (1642-1727) stated three natural laws relating force and motion. These laws provide us with equations of motion that relate force production with ensuing velocity. The equation of impulse governs the velocity:

\[
Ft = m(u-v)
\]

where \(u-v\) represents the change in velocity (\(u\) is initial velocity and \(v\) is the final velocity), \(t\) is the change in time between each step and \(m\) is the mass of the sprinter. The impulse that results in the forward motion of the sprinter is only applied when the foot of the sprinter is in contact periodically with the ground. Therefore, the equation for impulse is:

\[
F_{\text{total}} \times t_{\text{ground contact time}} = m(u-v)
\]
**Method**

To develop a model of a sub-10 sec 100m sprinter, data from numerous papers were combined\(^{35,36,37}\). When reaction time is neglected, the average times of the sprinters in each study compare well, such that the greatest differential is 1.75% over the first 10m with the average difference in times at each interval up to 60m being 0.65% (see Table 1). From this we equated the average number of steps taken and the average ground contact time with that of the instantaneous velocity (Table 2). Both studies used video analysis for each 10m interval. In addition, laser guns (LAVEG Sport, Germany) were used to determine the instantaneous velocity of former world record holder Maurice Greene (USA) on his way to a 9.86 sec 100m\(^{37}\). The methods of analysis were justified in each paper. Lastly, the mass of Greene was quoted at 75kg\(^{35}\).

It can be seen from the stride model of a sub-10 sec sprinter (Figure 2) that horizontal force production diminishes rapidly from the start of the race until about 30m, at which point it continues to diminish but at a markedly slower rate. Likewise it can be seen that ground contact time behaves in a similar fashion with both relationships tending towards a plateau. If Bolt’s competitors fall behind from 30m onwards it seems that they only need to produce more horizontal force or increase ground

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**Table 1: Calculation of differentials between the sprint times from published papers on world-class 100m races (data from BRÜGGEMAN & GLaD\(^{36}\) and KERSTING\(^{37}\))**

<table>
<thead>
<tr>
<th>Distance</th>
<th>Time averaged for two sprinters in each 10m section of the 1988 Olympic 100m [sec]</th>
<th>Time for Maurice Greene in each 10m section of a 9.86 sec 100m [sec]</th>
<th>Differential [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10m</td>
<td>1.74</td>
<td>1.71</td>
<td>1.75</td>
</tr>
<tr>
<td>20m</td>
<td>2.76</td>
<td>2.75</td>
<td>0.36</td>
</tr>
<tr>
<td>30m</td>
<td>3.70</td>
<td>3.67</td>
<td>0.82</td>
</tr>
<tr>
<td>40m</td>
<td>4.57</td>
<td>4.55</td>
<td>0.44</td>
</tr>
<tr>
<td>50m</td>
<td>5.43</td>
<td>5.42</td>
<td>0.18</td>
</tr>
<tr>
<td>60m</td>
<td>6.29</td>
<td>6.27</td>
<td>0.32</td>
</tr>
<tr>
<td>Avg. difference</td>
<td></td>
<td></td>
<td>0.65</td>
</tr>
</tbody>
</table>
Table 2: Number of steps and averaged ground contact times\textsuperscript{36} for male Olympic 100m Finalists equated with instantaneous velocity of Maurice Greene in 9.83 sec 100m sprint (data from BRÜGGEMAN & GLAD\textsuperscript{36} and KERSTING\textsuperscript{37})

<table>
<thead>
<tr>
<th>Distance</th>
<th>Averaged steps per 10m section for sprinters in the 1988 Olympic 100m</th>
<th>Average ground contact time for the last step in each 10m section</th>
<th>Instantaneous velocity of Maurice Greene in each 10m section of a 9.86 sec 100m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[n]</td>
<td>[m/sec]</td>
<td>[m/sec]</td>
</tr>
<tr>
<td>10m</td>
<td>7</td>
<td>124.5</td>
<td>8.71</td>
</tr>
<tr>
<td>20m</td>
<td>5</td>
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</tr>
<tr>
<td>30m</td>
<td>5</td>
<td>86.0</td>
<td>11.14</td>
</tr>
<tr>
<td>40m</td>
<td>4</td>
<td>83.75*</td>
<td>11.50</td>
</tr>
<tr>
<td>50m</td>
<td>4</td>
<td>81.5</td>
<td>11.67</td>
</tr>
<tr>
<td>60m</td>
<td>4</td>
<td>81.0</td>
<td>11.80</td>
</tr>
</tbody>
</table>

*Data smoothed from 86 to 83.75 (i.e. (86-81.5)/2)

Results and Discussion

Figure 2: Stride model for a sub-10 sec 100m sprinter: comparison of horizontal force approximated per step per 10m interval and ground contact time at the end of each 10m interval for the first 60m

contact time in order to increase their velocity according to Newton’s equation of motion; \(Ft=m(u-v)\). However, we may be limited in ground contact time by the velocity at which they are running. If the legs are to be considered as being of fixed length, then the faster a sprinter runs must mean that less time is available to be in contact with the ground. Therefore it would seem that the only mechanism by which sprinters can influence their speed is through increased force production within the ever-diminishing time in which they are in contact with the ground. How the sprinter should achieve this is a matter for debate.

As mentioned above, it is generally accepted by coaches that sprinting speed can be improved by means of strength training\textsuperscript{38}. The main methods employed include traditional strength training or explosive strength training. What is of interest is how these methods affect force and force production time, which is referred to as ground contact time in sprinting. Studies show that as a result of a traditional strength training programme, the time to produce 3000N (30% of maximum) reduced by 31\%\textsuperscript{39}. Similarly, explosive type strength training resulted in a reduction of 34\% in the time to produce 3000N\textsuperscript{40}. However, the time to produce 500N did not change as a result of strength training but this time was reduced by 18\% through explosive training (Figure 3 and Figure 4). This is of interest to sprinters and coaches as the forces are of relevant magnitudes to those experienced in sprinting.

Our calculation of forces produced in a sub-10 sec 100m reveals that horizontal force production is quite low, approximately 20kg (~200N) around the 30m point. However, for
the athlete to know what force to produce in training the horizontal force needs to be combined with vertical forces, for which the highest measured propulsive amount is 797N or 81.2kg at 9.96 m/sec\textsuperscript{41}. We cannot speculate as to whether the vertical force is higher or lower at speeds above 9.96 m/sec. Researchers\textsuperscript{18,41} report a net average vertical propulsion force of 615N or 62.7kg at 9.59 m/sec and of 621N or 63.3kg at supramaximal towing speeds of 10.82 m/sec where horizontal force is aided. Assuming therefore that the vertical force is around 81.2kg this would equate to a net resultant force of around 824N or 84kg somewhere near the 30m point. If the sprinter is 75kg the total vertical force would then be 1358N, which is much less than that produced in a counter-movement jump of around 2879N\textsuperscript{42}. For the sake of argument we could surmise that the total resultant force around the 30m point, where Bolt separated himself from his competitors in Beijing, is close to 1400N (143kg). In reference to the charts comparing traditional strength training with explosive training (Figure 3, Figure 4) we can see that the time to produce 1400N through explosive strength training reduces whereas there is negligible change from a traditional strength training programme.

An alternate and perhaps more relevant way of looking at this data is that within the time frame of 50 ms or at 100 ms the amount of force produced is enhanced from explosive strength training to a greater extent than from traditional strength training.

In order to provide the greatest transfer of strength gains into sprinting it is suggested that the training exercise used mimic sprinting in terms of specificity of movement and velocity\textsuperscript{15,16,17,18}.

With regards to Newton’s equation of motion for impulse, we need to consider force production and force production time (ground contact time). Plyometric training is generally classified as explosive training and is regarded as sprint specific\textsuperscript{15,41}. This type of training involving substantial horizontal exercise has consistently proven to reduce sprint times over 10m \textsuperscript{4,5,43}.

This brings into question the reasons why this type of training method has not proven much beyond 10m\textsuperscript{4,5}. Research has shown that resultant forces produced during plyometric exercise, such as maximal hopping,
are around two times greater than in maximal running. Equally of interest is the force production time, which is reported to be 1.9 times longer in maximal hopping compared to sprinting whilst the speed of execution of the exercise is slower. It would seem plausible to utilise maximal hopping type exercise with a lower magnitude of force production - but still higher than sprinting – quicker movement and shorter ground production times to have a greater specificity to sprinting.

**Conclusion**

The model of a sub-10 sec 100m shows that the forces in the horizontal direction are quite small and resultant forces are little more than body weight at speed. At such low force levels, the influence of maximal strength diminishes and the rate of force development becomes the predominant factor. Improvements to speed require more force production within the same ground contact time and may be better achieved through explosive strength training. Perhaps greater improvements can be achieved by modifying explosive strength training to accommodate more specific force production times to that in sprinting. It is suggested that explosive type training, such as plyometric exercises with more horizontal emphasis be carried out with less force, reduced ground contact time and greater joint velocity, be tried.

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Foot Placement by Elite Sprinters During Bend Running

By Oleg Nemtsev

ABSTRACT

What is the most optimal positioning of the foot in sprinting? Toes forward, inward or outward? And what about sprinting on a bend, which forces the runner to contend with the task of maintaining high running velocity while counteracting the effects of centrifugal force. Altering foot placement can lead to noticeable changes in the interaction between the runner’s musculoskeletal system and its underlying support (the ground) as well as in running efficiency. It is generally recommended that the foot should be placed with the toes turned slightly inwards on a bend. The author analysed the bend running efficiency of the finalists in the men’s 200m at the 2009 IAAF World Championships in Athletics by comparing their time for the first 100m of the race with their yearly best performance over 100m and then examined television images of the race. He found that Usain Bolt, who set a world record of 19.19 sec in the race, was no better than 5th among the finalists for bend running efficiency, despite following the foot placement recommendation. Among the conclusions are that world-class sprinters position their feet differently when sprinting around bends and that many turn their toes outwards without visible loss of efficiency.

AUTHOR

Professor Oleg Nemtsev is the Chair of Track and Field in the Physical Education and Judo Institute at Adygea State University in Maikop, Russia.

Introduction

The characteristics of bodily movement after interaction between bodies are determined by the movement those bodies perform before interacting combined with the location of the force application points relative to the centre of mass in question. This highlights the importance of knowledge concerning foot placement in sprinting and the related basic kinematics, since altering foot placement can lead to noticeable changes in the interaction between the runner’s musculoskeletal system and its underlying support as well as running efficiency in general.

However, most research into sprinting calls for considering the runner’s musculoskeletal system along the sagittal plane (plane of movement), which prohibits proper analysis of complex foot movements along the frontal and transverse planes1,2.

With that said, what is the most optimal way of positioning the foot while sprinting? Toes forward, inward or outward?
The aforementioned questions received preliminary answers in previous research dedicated to foot kinematics during sprinting\(^6\). However, the project only dealt with foot placement during linear sprinting.

Sprinting around a bend, as in the 200m, forces the runner to contend with the task of maintaining high running velocity and at the same time counteracting the effects of centrifugal force\(^4,5\). It is clear that the solution to such a task lies at least partially with the body part in direct contact with the ground: the foot.

Research notes by NEMTSEV & CHECHIN\(^6\) point out that six sprinters approaching a bend turned their right (external) toes outwards rather than inwards as recommended by a number of authors\(^7,8\), with the right (external) foot’s angle being larger than that of the left (internal) foot. NEMTSEV & CHECHIN explained this by stating that turning their right toes outwards allows the runners to counteract centrifugal force. However, this research included athletes whose results were far from world-class and who had never been taught the specifics of turning the right toe inwards on bends. Another, earlier research project recorded the placement of the right foot in the same manner (toes pointed outward) while sprinting on a bend for a known elite runner: Olympic silver medallists Frankie Fredericks (NAM)\(^9\).

This shows the need for further research into foot placement during competitions with a large number of elite sprinters as a base in order to provide objective data that would help to answer the question of which technique is optimal when it comes to sprinting around a bend.

### Methods

This project was based on video analysis of the men’s 200m (semi-finals and finals) during the 2009 IAAF World Championship in Athletics in Berlin. The video material used was recorded from a television transmission and therefore it is not possible to provide any precise data due to lack of information regarding the camera’s positioning, recording speed and so on. However, the recording did give us the ability to find out how the runners placed their feet on the bends.

We also assessed sprinting efficiency in the bend by calculating the ratio of the time for the first 100m of the 200m, taken from the championship’s website\(^1\), to the athlete’s 100m results. It was assumed that the lower the ratio, the higher the runners’ efficiency in the bend. The 100m results taken into account were the athletes’ best results for 2009\(^2\), taken from the IAAF’s season best list. No assessment was made for Charles Clark (USA) (best time 10.47 sec in 2005) and David Alerte (FRA) (best time 10.27 sec in 2007) as they are absent from the 100m list for 2009.

### Results and Discussion

Table 1 shows the results of the men’s 200m final at the 2009 IAAF World Championship in Athletics in Berlin.

<table>
<thead>
<tr>
<th>Name</th>
<th>Time</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Usain Bolt (JAM)</td>
<td>19.19</td>
<td>5</td>
</tr>
<tr>
<td>2 Alonso Edward (PAN)</td>
<td>19.81</td>
<td>6</td>
</tr>
<tr>
<td>3 Wallace Spearmon (USA)</td>
<td>19.85</td>
<td>4</td>
</tr>
<tr>
<td>4 Shawn Craford (USA)</td>
<td>19.89</td>
<td>8</td>
</tr>
<tr>
<td>5 Steve Mullings (JAM)</td>
<td>19.98</td>
<td>3</td>
</tr>
<tr>
<td>6 Charles Clark (USA)</td>
<td>20.39</td>
<td>7</td>
</tr>
<tr>
<td>7 Ramil Guliyev (AZE)</td>
<td>20.61</td>
<td>1</td>
</tr>
<tr>
<td>8 David Alerte (FRA)</td>
<td>20.68</td>
<td>2</td>
</tr>
</tbody>
</table>

In Figure 1, we see that the medallists Bolt, Spearmon and Edward positioned their feet differently in bend. Bolt turns his right toe slightly inward while Spearmon and Edward position their right feet with toes turned outward.

The shots of foot placement for the other finalists were of lower quality due to different camera angles so images from their semi-finals were used (Figure 2). However, regardless of
Table 2: Sprinting efficiency in the bend for selected finalists in the 200m at the 2009 IAAF World Championships in Athletics (ranked by efficiency)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Name</th>
<th>100m Bend [sec]</th>
<th>100m 2009 Best [sec]</th>
<th>100m Bend 100m 2009 Best [sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crawford (USA)</td>
<td>10.15</td>
<td>10.21</td>
<td>0.994</td>
</tr>
<tr>
<td>2</td>
<td>Mullings (JAM)</td>
<td>10.20</td>
<td>10.01</td>
<td>1.019</td>
</tr>
<tr>
<td>3</td>
<td>Spearmon (USA)</td>
<td>10.42</td>
<td>10.18</td>
<td>1.024</td>
</tr>
<tr>
<td>4</td>
<td>Edward (PAN)</td>
<td>10.37</td>
<td>10.09</td>
<td>1.028</td>
</tr>
<tr>
<td>5</td>
<td>Bolt (JAM)</td>
<td>9.92</td>
<td>9.58</td>
<td>1.035</td>
</tr>
<tr>
<td>6</td>
<td>Guliyev (AZE)</td>
<td>10.77</td>
<td>10.08</td>
<td>1.068</td>
</tr>
</tbody>
</table>

quality, the images provide enough evidence to conclude that Steve Mullings positions his right foot with the toes inward (just like Bolt) while the rest of the finalists turn their toes outward.

This leads an interesting observation. Bolt, despite incredible world records in both for the 100m and 200m in Berlin, ranks only fifth out of six in terms of sprinting efficiency on the bend (Table 2). This is despite the fact that he followed the generally accepted coaching ad-
vice to turn the toes slightly inwards when running around a bend. Of course, it is possible that Bolt’s or any other sprinter’s time for the first half of the 200m reflects tactics as much as or more than the foot-placement technique.

Conclusions

1) The materials used in this research show that, in contrast to the general advice given by many authors, many world-class sprinters position their feet with toes outwards on the bends without any visible loss of efficiency.

2) The lack of sufficient television coverage from the World Championship television recordings gives reason to organise a specialised research project to better understand elite sprinters’ foot placement during bend running.

3) It would be more correct to compare the time for the 100m on the bend gathered from 200m with 100m results from the same competition rather than separate ones.

Acknowledgement

The author thanks Moscow State University student E. Filipenko for the help in obtaining images from the 200m semi-finals at the 2009 IAAF World Championship in Athletics in Berlin.

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Applied Research

contents

- Phenomenology of Sprinting and Endurance: Toward a Uniform Performance Assessment Model
  by Wim Westera

- Biomechanical Factors of Competitive Success With the Rotational Shot Put Technique
  by Severin Lipovšek, Branko Škof, Stanko Štuhec and Milan Čoh
Phenomenology of Sprinting and Endurance: Toward a Uniform Performance Assessment Model

By Wim Westera

ABSTRACT

According to the IAAF scoring tables, Usain Bolt’s 100m world record of 9.58 sec is worth 1374 points, whereas Kenenisa Bekele’s 10,000m world record of 26:17.59 yields only 1295 points. This suggests a weakness in the current scoring methodology. This paper studies the relationship between running distance and running speed, and proposes an alternative scoring method. Firstly it presents the personal predictor model (PPM). This model uses two personal bests of an athlete for calibration, and then it allows predicting an athlete’s hypothetical personal bests for any other distance. The accuracy is well below 1% and it thereby greatly outperforms existing models. Secondly, it presents the normalised multi-event scoring model (NMSM). This model addresses the suggested anomalies in the current scoring tables; it demonstrates greater fairness, consistency and transparency. The impact of the new model is explained using empirical data. It substantiates the need for reviewing the existing IAAF scoring tables. Although combining the PPM and NMSM to derive a generic scoring formula that would cover any distance and any performance was not feasible for official use, a personalised scoring table using the two for converting individual performances at various distances into a unified personal score is presented.

INTRODUCTION

It is well established that average running velocity decreases with racing distance. In a 10,000m the average speed of top athletes is 20% lower than what is achieved in an 800m. This is not without logic. If this were not the case, the 10,000m runner could do a 9,200m race-pace warm-up and still beat the 800m specialists during the last two laps. Apparently, for races that require prolonged efforts, the internal physiology of energy and power reinforces effort levels that are well below maximum capacity. Naturally the same holds for swimming, speed skating and any other sports that involve traversing a certain distance within the fastest possible time.

Comparison of performances across different running events is a delicate topic. How would one ever be capable of comparing Usain Bolt’s outstanding sprinting performances...
with the likewise outstanding 10000m world record of Kenenisa Bekele? This would be like comparing apples and pears. Yet, in athletics this is common practice, even within the official framework of the sport’s governing body, the International Association of Athletics Federations (IAAF).

The decathlon would be a good case in point. The IAAF uses a detailed set of tables for converting performances in the various events to a single numerical value so that these can be added into a result score. For instance a high jump of 2.00m and 400m in 50.0 sec would yield a result score of (803 + 815)=1618 points.

WESTERA has severely criticised the validity of the decathlon tables. He argues that the tables display unacceptable bias since they favour some events over others. Sprinting-based performances yield disproportionately higher scores than the throwing events or the 1500m. Historical bias and frequent changes seem to demonstrate the arbitrariness of performance alignments in the decathlon tables. In fact, comparison to an alternative scoring model proposed by the author leads to the conclusion that the official tables have assigned the world record to the wrong athlete.

Similar objections hold for the other IAAF tables that are used for comparing different running events or for comparing athletes from different age groups. The IAAF Technical Committee, which is responsible for the validity of these tables, has made modifications in the past because of apparent irregularities in the relationship between results and assigned points. But even in the latest version inconsistencies and suspect data can easily be tracked. Figure 1 displays the result scores that the IAAF assigns to the diverse track running world records.

The large variability of the ratings demonstrates the weakness of the tables. The 100m world record is rated up to 80 points higher than the long distance records. Besides this, other unexplained differences are manifest in Figure 1. The world records, indicating the ultimate limits of human power, would be the perfect reference for aligning the scoring tables. Therefore each world record should, in principle, receive the same score.

Figure 1: IAAF scores for men’s track running world records
This paper will examine this rating problem. First, it will elaborate the relationship between running distance and running speed. It will explain the personal prediction model (PPM), an analytical model that can be used for determining an athlete’s personal best times at various distances, provided that two best times are available for calibration. Next, the paper will present the normalised multi-event scoring model (NMSM). This model addresses the identified anomalies in the current IAAF scoring tables. The impact of the new model will be explained. Finally, the two separate models will be combined for composing personalised scoring tables. These tables convert an athlete’s performances for any distance into a single score, which allows composing an absolute ranking of the athlete’s performances across various distances.

**Research Approaches**

To be able to properly compare the quality of performances in different running events, one needs insight into the relationship between human performance and the duration of the efforts involved. Although quite some research has been devoted to the topic, only very little is known at an analytical level. If a formula were available, one might - starting from some individual characteristics – be able to predict the athlete’s personal performance limits for a range of distances. In the ideal (but unrealistic) case, one would just collect an athlete’s shoe size, weight, height, leg length, lung capacity or any other relevant characteristic, and then use the formula to calculate the athlete’s anticipated performances on various distances. With these predictions one might be able to decide what distances offer the best chances and devise personalised training schedules for these. Unfortunately, things aren’t that straightforward.

In the studies that have been done three different approaches can be distinguished:

1) physiological models,  
2) statistical models,  
3) phenomenological models.

**Physiological Models**

These approaches search for explanations based on the underlying physiological processes. From various studies it is known that endurance performance is directly related with maximal aerobic power. Measurement of maximum aerobic running speed or speed at maximal oxygen uptake can be used for predicting performances in the range from middle distances to long distances, covering the range from say 1500m up to the marathon. At shorter distances predictions tend to be greatly unreliable because of disturbing interferences of anaerobic metabolisms. BUNDE et al. proposed a model that combined the physiological limits of anaerobic and aerobic power for predicting performances in both the sprinting and mid-range distances (ranging from a few seconds to a few minutes). They suggested a simple negative exponential relationship between velocity and running duration, and incorporated the different time scales that anaerobic and aerobic metabolisms are active. The approach isn’t very accurate though: the predictions deviate on average well above 3% from realised performances. This may seem a negligible percentage, but for a 15 minute effort duration it would mean an uncertainty of plus or minus half a minute. For athletes such inaccuracy doesn’t make sense. An additional disadvantage is that tests for assessing the athlete’s running velocity at maximal aerobic and anaerobic power are required. In practice, such tests are inaccurate as such, and because of the required maximum effort the administering of the tests may easily interfere with the pursued training approach. Various researchers carried out biomechanical studies of the running start-up process, but these are mostly concerned with the dynamics of body angle, the required metabolic power and the techniques for start-up optimisation, neglecting the speed-distance relationship.

**Statistical Models**

Likewise, progressive scoring tables based on statistical processing of large numbers of performance data are known to be inaccurate and unreliable. The IAAF uses such scoring
WESTERA\textsuperscript{11} introduced a phenomenological model for describing the dependence of running velocity and duration. Basically, it uses exponential decay rather than a power law. The accuracies are claimed to be typically around 1%, which is much better than existing models (typically 3% or higher). The model uses a limited set of “mechanical” presuppositions and then uses an interpolation technique for predicting an athlete’s personal best. It doesn’t use any physiological or biomechanical test data. Instead, the model uses two personal bests of an athlete for calibration, and then it allows predicting an athlete’s hypothetical personal bests for any other distance. The model is based on a first order estimate of the way lap time (which is equivalent with reciprocal speed) increments with total distance. Also, the model accounts for delays that occur during start-up. This way the model covers the entire range including endurance and sprinting distances. The model was validated with empirical data of four different groups of athletes: world-class male athletes, world class female athletes, committed male sub-elite athletes and committed female sub-elite athletes.

WESTERA\textsuperscript{3} also proposed a phenomenological model for the accurate calculation of scores in the decathlon. The model converts performances for any of the events into a numerical result score, so that a total score over the events can be calculated by addition. This paper builds on both the prediction model and the scoring model to improve the overall quality of scoring tables (cf. the anomalies in Figure 1). Below we will first briefly explain the two models.

Phenomenological Models

Phenomenological models use mathematical expressions for describing observed phenomena. The models should be consistent with underlying theories, but don’t necessarily include these. This reflects both a strength and a weakness. Blankly starting from manifest phenomena while neglecting underlying theories may help greatly reduce complexity, which makes it more feasible to find solutions. Inevitably, this neglect goes at the expense of explanatory power.

KATZ & KATZ\textsuperscript{9} demonstrated that athletics world records can be covered by power relationships between distance and exertion time. It should be noted that the IAAF scoring tables are all based on power laws that are calibrated via population statistics.

STANKIEWICZ\textsuperscript{10} used a power law dependence between velocity an distance for the comparison of decays in energy over time in road and track events. In all cases severe anomalies were observed.

HARDER\textsuperscript{8} tried to produce better tables by considering population fractions achieving a certain performance level. Calibration of the fractions between different events enables statistical mapping for inter-event comparison. Although Harder’s tables deviate from the IAAF-tables, they correlate very well with these, and thus unfortunately display the same inaccuracies. The statistical approaches have two things in common. Firstly, they reflect a population-based average representing a mixture of many different human features and conditions. Such a general approach may severely affect their applicability for individuals. Secondly, they are phenomenological in kind and do not rely on an underlying theory that would improve our understanding of the mechanisms involved.

The Personal Prediction Model

The personal prediction model (PPM)\textsuperscript{11} covers two different issues: 1) the general relationship between running velocity and running distance, 2) corrective formulas for delays that occur during start-up. Such a split has been suggested before in order to explain anomalies as a result of the different metabolic processes for sprinting (anaerobic) and endurance (aerobic)\textsuperscript{12}.
Connecting average running speed and running distance

The PPM considers the total time \( t \) and total distance \( s \) of a race. But it does not reflect the dynamics during the race, for instance intervening accelerations or weakening. We introduce the average lap time \( L \) (this corresponds with reciprocal running velocity), which is given by:

\[
L = \frac{t}{s} . \quad (1)
\]

As a first order estimate the lap time increment \( dL \) at fixed \( t \) is assumed to be reciprocally proportional to the distance \( s \), yielding

\[
dL = \alpha \cdot \frac{ds}{s} , \quad (2)
\]

where \( \alpha \) is a constant.

Integration over \( s \) gives a simple logarithmic expression

\[
L = \alpha \cdot \ln\left(\frac{s}{\beta}\right) , \quad (3)
\]

where \( \beta \) is a constant. The first order approximation reflected in equations (1) - (3) is not only theoretically grounded. Empirical evidence of its appropriateness can be found by using some existing data. This is done in Figure 2, which displays a single logarithmic plot of lap time \( L \) against the log of distance \( s \) for men’s track running world records. Although the fit of the data is not superior, the (log-)linear relationship comes encouragingly close, even though data of different athletes were used.

The straight line in figure 2 representing the world records is a special case defining the lower limits of lap time for each distance: humans cannot go any faster, at least for the time being. In the upper left part of the graph each individual athlete, having unique talents and powers, may be represented with his/her own personal line. For determining this personal line the athlete just chooses two separate personal bests and then calculates the two associated positions in the graph. Because of the log-linear relationship, the two points can then be connected with each other and thus reveal predicted personal best lap times (or velocity, or total time) for any other distance. Since mathematical formulas are available, this can be done analytically and accurately. The greatest accuracy will be obtained when the two distances that are used for the calibration span a sufficiently wide interval (interpolation). For instance, using someone’s personal records at 800m and 5000m would probably make a reliable interpolation basis for forecasting the person’s achievable performance at 1500m, 3000m or even an arbitrary 3968.7m. However, extrapolation, for instance when forecasting marathon performance from these points, is likely to be less accurate.

Compensating for Start-Up Losses

The model described so far is based on cruising velocity and therefore works alright for the middle- and long-distances. For sprint distances, say up to 400m, time delays incurred during the early phase of the race when the athlete has to accelerate from standstill to cruising velocity will greatly confound the outcomes. Errors up 5% are reported by WESTERA.\(^\text{11}\)

In the model so far described, it was silently assumed that cruising velocity is average velocity, but for sprinting this doesn’t quite hold: for sprinting distances cruising velocities are considerably higher than average velocities. Obviously, the difference increases at shorter distances because of the relatively long time spent on accelerating and the higher cruising velocities that the athlete tries to achieve.

WESTERA\(^\text{11}\) used available split times of various world-class sprinters\(^\text{13,14}\). In the 100m, the
Application of the PPM

A sample of cases is given in the tables below. Table 1 presents the calculations of a sample of male middle- and long-distance world-class athletes.

World-class athletes provide an important sample because they are usually well-prepared and perform near the limits of human capability. For each of the athletes three or occasionally four official personal bests are listed in the third column. Outer distances (shortest and longest) have been used for calibration, viz. the calculation of \( \alpha \) and \( \beta \) according to equations (5) and (6). Substituting these parameters in equation (7) produces the predictions for the intermediate distance events. The predictions are quite close to the official personal bests. The average deviation (minus signs neglected) of the sample is only 0.3\% (0.003, cf. bottom row of Table 1). More supportive evidence is given in WESTERA.

Table 1: Performance predictions for male world-class middle- and long-distance athletes

<table>
<thead>
<tr>
<th>Athlete</th>
<th>Distance (m)</th>
<th>Personal best (IAAF)</th>
<th>Predicted personal best</th>
<th>Absolute deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.E.G.</td>
<td>1500</td>
<td>3:26.00</td>
<td>3:26.00</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>7:23.09</td>
<td>7:20.87</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5000</td>
<td>12:50.24</td>
<td>12:50.24</td>
<td></td>
</tr>
<tr>
<td>B.L.</td>
<td>1500</td>
<td>3:26.34</td>
<td>3:26.34</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
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<td>7:33.15</td>
<td>7:24.26</td>
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</tr>
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<td></td>
<td>5000</td>
<td>12:59.22</td>
<td>12:59.22</td>
<td></td>
</tr>
<tr>
<td>K.B.</td>
<td>3000</td>
<td>7:25.79</td>
<td>7:25.79</td>
<td>0.007</td>
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<tr>
<td></td>
<td>5000</td>
<td>12:37.35</td>
<td>12:42.41</td>
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<td></td>
<td>10000</td>
<td>26:17.53</td>
<td>26:17.53</td>
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<td></td>
<td>5000</td>
<td>12:39.36</td>
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<tr>
<td></td>
<td>10000</td>
<td>26:22.75</td>
<td>26:22.75</td>
<td></td>
</tr>
<tr>
<td>R.R.</td>
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<td>1:44.05</td>
<td>0.017</td>
</tr>
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<td>3:29.14</td>
<td>3:32.61</td>
<td></td>
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<tr>
<td></td>
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<td>7:43.85</td>
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</tr>
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<td></td>
<td>5000</td>
<td>27:26.29</td>
<td>27:26.29</td>
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<td></td>
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<td></td>
</tr>
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<td>3:38.83</td>
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<td>5000</td>
<td>13:36.10</td>
<td>13:27.44</td>
<td></td>
</tr>
</tbody>
</table>

Phenomenology of Sprinting and Endurance: Toward a Uniform Performance Assessment Model

data indicate that cruising velocities are reached after about 30m. So by using the 30m split time, the cruising velocity over the last 70m can easily be calculated. The same could be done for 200m, although only few split time data could be found in the literature. The disturbing effect of start-up losses will gradually disappear at longer distances. By assuming exponential decay of this correction with distance and using the 100m and 200m cruise speed data for calibration, the start-up losses can be accounted for in an analytical way.

In sum, the general prediction procedure now reads as follows:

1) Establish two sound personal bests:
\[ s_1, t_1, s_2, t_2 \]

2) To account for start-up losses replace all distances \( s_1 \) and \( s_2 \) with \( s_1^* \) and \( s_2^* \), respectively by using
\[
 s^*(t) = s(t) + \gamma \cdot t \cdot e^{-\delta \cdot s}, \tag{4}
\]
with \( \gamma = 21.3 \) and \( \delta = 0.00365 \) (these data come from the 100m and 200m split times)

3) Calculate the personal coefficients \( \alpha \) and \( \beta \) through that determine the personal line offset and slope,
\[
 \alpha = \frac{t_1 - t_2}{s_1^* - s_2^*}, \tag{5}
\]
and
\[
 \ln(\beta) = \ln(s_1^*) - \frac{\ln(s_2^*)}{(1 - t_2^* \cdot s_1^*)}, \tag{6}
\]

4) Choose a distance \( s \) for predicting time \( t \).
5) Replace distance \( s \) with \( s^* \), using equation (4).
6) Calculate predicted time \( t \) by using:
\[
 t(s^*) = \alpha \cdot s^* \cdot \ln(s^*) \beta, \tag{7}
\]
Few cases for sprint distances could be elaborated. Because of specialisation only a very few world-class sprinters excel in three disciplines (100-200-400). Yet, a few exceptions could be found and these are presented in Table 2.

In the sprinting range, the results are a bit less accurate, but despite lacking statistics in 200m split times they are still better than those of other models.

To make these calculations, a computer programme can be devised, a preliminary version of which is available on the web. Users enter their two personal bests required for calibration and enter one or more distances for which they receive their prophesised times. The logarithmic linearity of equation (7) also offers the opportunity of a simple graphical representation of the model. This is displayed below in Figure 3. Since the vertical axis denotes lap time and the horizontal axis covers the (logarithmic) scale of distance, the performances of an individual athlete are given by a unique straight line. For reasons of convenience, performance times (derived from the product of lap time and distance) for each event are projected at the appropriate coordinates. The logarithmic linearity of equation (7) also offers the opportunity of a simple graphical representation of the model. This is displayed below in Figure 3. Since the vertical axis denotes lap time and the horizontal axis covers the (logarithmic) scale of distance, the performances of an individual athlete are given by a unique straight line. For

Table 2: Performance predictions for world-class sprinters

<table>
<thead>
<tr>
<th>Athlete</th>
<th>Distance (m)</th>
<th>Personal best (IAAF)</th>
<th>Predicted personal best</th>
<th>Absolute deviation</th>
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<tr>
<td>I.S.</td>
<td>100</td>
<td>0.11 10</td>
<td>0.11 10</td>
<td>0.029</td>
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<td></td>
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<td>0.22 21</td>
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<td></td>
<td>400</td>
<td>0.49 29</td>
<td>0.49 29</td>
<td></td>
</tr>
<tr>
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<td>100</td>
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<td>0.10 86</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
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<td>0.10 96</td>
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<tr>
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<td>0.10 30</td>
<td>0.042</td>
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<td>0.45 30</td>
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<td>0.10 10</td>
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<td>0.20 71</td>
<td></td>
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<tr>
<td></td>
<td>400</td>
<td>0.44 50</td>
<td>0.44 50</td>
<td></td>
</tr>
</tbody>
</table>

Overall deviation 0.03

Figure 3: Graphical representation of the logarithmic model
reasons of convenience, performance times (derived from the product of lap time and distance) for each event are projected at the appropriate coordinates.

Any individual could basically mark two different personal bests in the figure and then connect the two points with a straight line. This is illustrated by the yellow line (labelled “Example”) where two calibration points are indicated with yellow squares (0:55 at 400m and 40:00 at 10000m, respectively). The intersections with the ordinates provide predicted outcomes at the various distances (10.89 at 100m, 24.08 at 200m, 2:06.57 at 800m, 4:27.57 at 1500m, 10:02.65 at 3000m, 18:07.40 at 5000m, 1:32:55 at the half marathon and 3:21:41 at the marathon, respectively).

The dark lines in Figure 3 are the performance curves of selected world-class athletes who cover multiple distances: Kenenisa Bekele (K.B.), Hicham El Guerrouj (H.E.G.), and Paula Radcliffe (P.R.), respectively. According to the model, Bekele is supposed to break the marathon world record (2:00:07). Also, he will be able to run 400m in 52.20 sec, which is only slightly below times recorded for his final laps in 10000m races. Radcliffe seems to have a “weak” 10000m best: the prognosis is 29:49 (against 30:01.09 personal best). Note that the curves of these two athletes display about the same slope, indicating the same type of decay that is probably distinctive for long distance runners. The curve of El Guerrouj shows a steeper slope, which can be attributed to the higher cruise speeds that he is capable of in the mid-range distances. One of the things that turns out is that El Guerrouj would be capable of running 10000m in 27:17. His marathon of 2:09:10 would be respectable, but not world-class level.

The performance curve of Usain Bolt (U.B.) is also displayed in Figure 3. Here, his personal bests at 100m and 400m are used, although the latter (45.28) dates back to 2007, which is well before his breakthrough as a world class sprinter; indeed the predicted 200m time of 20.41 sec is far behind his actual best. Nevertheless, using the 100m and 200m events for calibration does not make much sense exactly because of the inaccuracies due to reinforced extrapolation. For the same reason the predictions for the longer distances (e.g. 30:39 at 10,000m) do not seem to make much sense here.

**The Normalised Multi-event Scoring Model**

For comparing the performances in different competitions, the IAAF uses pre-fixed scoring tables. The tables are based on a power law formula of the type:

\[ S = A \cdot (B - P)^{C} \]  

(8)

The formula converts a performance \( P \) into a result score \( S \). Here \( A \) is a scaling constant, \( P \) is exertion time, \( B \) is a lower limit threshold performance (i.e. time above which no score is assigned), and \( C \) is a power slightly larger than 1 for obtaining slightly progressive scoring curves. For each event different coefficients \( A \), \( B \) and \( C \) are prescribed by IAAF. For instance, for the 100m it is compulsory to use \( A = 25.43470, B = 18.0, C = 1.810 \).

For decathlon scoring tables W ESTERA proposed three alternative models that produce better alignment. The models are all based on the idea of normalisation, that is, all performances are reduced to performance rates and then equally treated in a progressive scoring formula, e.g. a power law. The power law solution for the result score \( S \) reads:

\[ S = A \cdot \left[ \frac{(P - P_{L})}{(P_{H} - P_{L})} \right]^{C} \]  

(9)

Here \( A \) is a scaling constant, \( P \) is performance (reciprocal time rather than time), \( P_{L} \) is a lower limit threshold performance (i.e. reciprocal time below which no score is assigned), \( P_{H} \) is a high level performance reference for calibration, and \( C \) is a power coefficient that is larger than 1 for obtaining slightly progressive scoring curves. Using empirical data of the world’s top 100 decathletes the parameters \( A \), \( C \), \( P_{H} \) and \( P_{L} \) could be determined. Rather than
the 30 parameters in the existing IAAF power law model of equation (8) (viz. A, P_L, and C 10 times each), the alternative model according to equation (9) requires only 22 (A, C, and 10 times P_L and P_H). It was established that the alternative model offers a balanced, transparent, uniform approach, uses less coefficients, and eliminates bias, arbitrariness and unfairness. The overrating of sprinting-based events in decathlon was eliminated. With the proposed tables decathletes would be able to collect their scores to the same extent from any of the 10 disciplines.

**Redefining the IAAF Scoring Tables**

With the normalised multi-event scoring model (NMSM) we are able to devise a set of scoring tables that are free of the existing anomalies. The results are basically given by equation (9), provided that we have available the two calibration levels P_L and P_H and the parameters A and C. These parameters can then be used in equation (9), which yields the result score S for any performance P at any distance s.

**The High-Level Performances Calibration P_H**

The choice of these parameters is not critical, if only they correspond with high performances. Since it is a basic requirement of the scoring model that world records in different distances receive the same (high) result score, we will use the world record data for each distance as the high-level reference points.

**The Low-Level Performances Calibration P_L**

These parameters refer to the threshold performances below which no score is assigned. The procedure we follow here is to conform to the IAAF tables and use the official threshold values B. For practical reasons we used the performances of result score S=1, because performances of result score S=0 are not listed in the IAAF tables. Table 3 lists the threshold performances on various distances. For comparison also 1/P_H is listed.

The fourth column 1/(B*P_H) lists the ratio of threshold performance and top performance. The ratios in this column reveal substantial irregularities indicating arbitrariness in the official IAAF threshold values B. It is hard to understand why this ratio is not a constant so that each distance uses the same relative scale. For better coherence, it is proposed here to use the average ratio (which is 0.523) as the fixed ratio for P_L/P_H. The resulting thresholds 1/P_L replacing the IAAF thresholds B are listed in the column at the right. One might still wonder why such a threshold should be exactly 0.523 or any other figure.

*Table 3: Performance thresholds and calibration values for various distances*
Power C
The power C is responsible for progression of scores with distance. It should be larger than 1 to make sure that equal improvements of performance receive higher scores in the high performance range. The underlying idea is that, for instance, improving your 5000m performance from 28 minutes to 26 minutes is less impressive than improving it from 14 minutes to 13 minutes. The IAAF tables use different values for C at different distances. We will use a uniform value of C=1.832, being the average of six values used for different distances by the IAAF.

Scaling Factor A
The scaling factor A represents the score we want to assign to the high level performance references \( P_h \), which we have chosen to be the same as the current world records. So A (more or less) corresponds with the maximum score an athlete can get. As a scaling factor its value is a bit arbitrary, it could be 1000 to make a neat figure. But we may also want to link the new score system with the existing one. Therefore we have chosen that A equals the average of the scores that world records receive in the existing regime. The data used are the same as represented in Figure 1. The average result score of world records is 1311 points (we only used the distances displayed in the figure). So A is set to 1311.

Having all parameters defined, we are now ready to evaluate the impact of the new scoring model. In Table 4 we have listed an excerpt of the tables.

From the calculations it follows that over almost the whole range the new scoring system differs significantly from the existing one. In most cases, the athlete has to run faster to obtain the same score the existing model would give. Differences may be up to 25% in the mid-range of performances, for instance, receiving 700 points at 5000m requires being one full minute faster in the new model, which is a difference of 7%. Receiving 700 points in the marathon requires 18%, 1000 points still requires doing more than 3% better. Because world records are used for calibration the differences go down in the high-end range. For instance, at 5000m world record level the difference between the two scoring tables is only three seconds. Although this is only 0.4%, it still makes a big absolute difference: up to 20m. It therefore demonstrates the impact of scoring tables is substantial over the whole range.

Table 4. Performance times (m:s) required for different scores and distances according to the new model (NMSM) and the current model (IAAF) ues for various distances
Toward Personalised Scoring Tables

The NMSM approach offers a normalised, uniform scoring model for a variety of distances. A disadvantage of the approach is that low-level and high-level calibration values must be determined for every single distance. One might consider linking the NMSM with the personal prediction model (PPM) in order to arrive at a single analytical expression for scoring with distance as the independent variable. The basic idea would be to assume a fictitious super athlete that holds all world records. Then equation (7) of PPM could be used to calculate the high-level calibration performances for any distance $s^*$ (note that performance $=1/t$). We would need only two world records for calibration so that $\alpha$ and $\beta$ can be determined. Since $P_L/P_H=$constant and while maintaining $C$ and $A$, equation (9) would then provide a result score $S$ for any distance $s^*$.

Unfortunately, world records are not owned by one single individual but by diverse individuals, each of them specialised in a discipline and displaying the characteristics for excelling in that discipline. Although the overall fit in Figure 2 was encouraging, it isn’t good enough for accurately describing the world records. Errors add up to over 7%, which is unacceptable. It is concluded that the PPM as a personal predictor does not hold for combining performances of different individuals.

As a replacement for equation (7), one might use a power law relationship between distance $s$ and exertion time $t$. KATZ & KATZ explained that a power relationship holds for world records. However, also in this case best-fit solutions fall short, displaying errors up to 9%, which is even worse than the PPM. So with these equations it is not possible to derive an analytical scoring formula using distance as the independent variable.

Nevertheless, at the individual level, the PPM and the NMSM still can be used to produce personalised scoring tables. Such scoring tables assign scores to individual performances for any distance: the personal score (not to be confused with the official IAAF result score) expresses the quality of the performance of the athlete, measured against other performances of the same athlete. Table 5 presents an example: it lists a ranking of Kenenisa Bekele’s best performances.

The table shows the ranking of 24 of Bekele’s race performances. Note that such ranking can be made for any athlete. Personal calibration - determining $\alpha$ and $\beta$ in equation (7) - was done with Bekele’s 3000m and 10,000m personal best times (cf. Table 1). Table 5 shows the calculated score $S$, the same score expressed as a ratio normalised to 1000 points, the IAAF result score, and the associated ranking based on IAAF score. Differences are striking. From the perspective of Bekele, neither the 5000m nor the 10,000m world records are at the top, but instead are two 1500m races. Although the 1500m times are not anywhere near the world record, the performances are of exceptional level taking into account the fact that Bekele is a long-distance runner specialised at 5000 and 10,000m. In fact, this is exactly what the PPM approach takes into account.

Conclusion

This paper explained the personal predictor model (PPM) and the normalised multi-event scoring model (NMSM) and presented a variety of empirical evidence for their validity.

The PPM produces valid and reliable predictions of personal performance limits in running events. The accuracy is well below 1% and thereby greatly outperforms existing models that typically achieve accuracies of 3% or higher. Besides its unchallenged accuracy, the model has some additional advantages. Importantly, the model is transparent, since it is based on theoretical principles. Furthermore it is self-contained, easy to use and affordable, because it does not require any physiological or biomechanical tests to be carried out: it just uses two personal bests for individual self-calibration. Since the model compensates for start-up delays it is valid across a wide range of events, including sprinting, middle- and...
Combining the PPM and NMSM for deriving a generic scoring formula that would cover any distance and any performance was not feasible because poor fits of the world record performances to either the PPM or existing power law models. However, a personalised scoring table was presented, converting individual performances at various distances into a unified personal score.

Table 5: Kenenisa Bekele’s personal performance rankings using PPM and NMSM

<table>
<thead>
<tr>
<th>Rank</th>
<th>Date</th>
<th>Distance</th>
<th>Time</th>
<th>New score</th>
<th>1000S/1375</th>
<th>IAAF score</th>
<th>IAAF rank</th>
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long-distance running. Finally, it can be demonstrated that the model displays a universal validity covering any velocity and distance related sports event, including running, speed skating and swimming.

The NMSM was developed to address anomalies of the IAAF scoring tables. The NMSM demonstrates greater fairness, consistency and transparency. Over the whole mid-range of performances the new scoring system differs significantly from the existing one, requiring higher performances for obtaining the same score as the current scoring method. Differences are up to 25%, but even small relative differences at world top level translate to appreciable absolute differences. It was demonstrated that the impact is substantial over the whole range. This substantiates the need for a new model.

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REFERENCES

Biomechanical Factors of Competitive Success With the Rotational Shot Put Technique

By Severin Lipovšek, Branko Škof, Stanko Štuhec and Milan Čoh

ABSTRACT

The aim of this study was to determine the biomechanical parameters in the rotational technique that have the greatest impact on the distance achieved and thereby on competitive success in the shot put. The sample consisted of 10 top-level putters competing at the 2008 European Cup Winter Throwing in Split, Croatia; the best throw by each of the subjects was selected for examination. A 3D kinematic analysis was made from recordings by two high-frequency cameras and APAS software was used to obtain values for selected parameters. The results confirmed a high correlation between the distance achieved and key release parameters, i.e. shot velocity, angle of release and release height. The analysis also showed the importance of parameters that consider the putter’s activity in preceding phases of the movement, i.e. foot placement at the beginning of the 2nd double-support phase and parameters calculated from the angular velocity of the shoulder, hip and knee joints. Using linear regression, the authors can explain 94.7% of competitive success from the studied parameters. The results indicate that release velocity alone is not enough to explain the effective process of acceleration, and that the momentum of the whole-body movement must also be considered.

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Introduction

Putting the shot is an extremely complex motion, which must be performed at high speed in a very limited space. Performance in the shot put is defined by the biological (anthropometrical, physiological and motor parameters of the competitor) and the physical–mechanical parameters defining the technique of the individual athlete.
In any case, the putter must optimise the release angle, release velocity and release height to achieve a maximal distance. The permanent question in theory and practice is how best to coordinate the individual segments of the throwing movement to produce maximum velocity of the shot at the point of release.

The world’s top performers currently use one of two basic techniques: the rotational or linear movement sequences, both of which have to be rhythmically correlated.

The rotational technique can be divided into the following elements:

- **Preparation** (1st double-support phase),
- **Transition** (1st single-support phase, 1st flight phase, 2nd single-support phase, beginning of 2nd double-support phase),
- **Completion/release** (2nd double-support phase, 3rd single-support phase, beginning of 2nd flight phase) and 4) 2nd flight phase.

Existing studies of the shot put mostly focus on analysis of kinematic (mechanical) parameters, with the greatest emphasis on the release phase.

In an analysis of the shot put at the 2004 Olympic Games, ARIEL et al. (2004) calculated an average release height 2.39m, an average release angle of 36° and an average release velocity 13.8 m/sec for a 21m performance. In an analysis of a 19.58m put by the Slovene record holder Miran Vodovnik, COH et al. (2005) calculated a release velocity of 12.94 m/sec, a release angle of 36° and a release height of 2.27m. STEPaneK (1987), TIDOW (1990) and BARTONIETZ (1994) report very similar values for the mentioned parameters.

Analyses of the correlation, impact and importance of individual parameters to the final result, particularly in the rotational technique, have not been seen in the existing studies. The relationship between release velocity and performance was successfully calculated in a study of the finalists at the 2007 IAAF World Championships in Athletics by BYUN et al. (2008), who confirmed the correlation between release velocity and distance (r=0.87, p<0.01).

However, release velocity is only a consequence of the preceding movements. With that in mind, the main goal of the present study of a sample of top-level putters was to determine which biomechanical parameters in the transition and release phases of the rotational technique have the greatest impact on the final distance and thereby on success in this discipline.

**Methods**

**Subjects and experimental procedure**

Measurements were taken in competitive conditions at the 2008 European Cup Winter Throwing in Split, Croatia, the results of which are shown in Table 1. A 3D kinematic analysis of the technique of ten selected throws (in each case the best in the competition by the respective athlete) was made.

The subjects’ average age was 28.5 years, the average body weight was 123.6kg, and the average body height was 1.89m. All subjects were right-handed.

**Data acquisition and processing**

The recordings were made with two synchronised high-frequency cameras (SONY DVCAM DSR-300 PK), placed at 45° and 135° angles in relation to the putting direction. The frequency of both cameras was set to 50Hz with 720 x 576 pixel resolution. The analysed space of the throwing circle was calculated on the reference measure frame dimensions 1m x 1m x 2m, and eight reference angles were considered for calibration. Length was defined by the X-axis, height by the Y-axis, and the depth of the analysed movement by the Z-axis.

The obtained data were processed in the laboratory for kinematics at the Sport Institute of Ljubljana, Slovenia. For determination of biomechanical parameters of the technique APAS software (Ariel Dynamics Inc., San Diego, Ca) was used. Digitalisation was made of
Table 1: Results of the Men’s Shot Put at the 2008 European Cup Winter Throwing (analysed throws are highlighted in bold)

<table>
<thead>
<tr>
<th>Athlete (Country)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rutger Smith (NED)</td>
<td>19.87</td>
<td>19.22</td>
<td>x</td>
<td>19.88</td>
<td>20.30</td>
<td>20.77</td>
</tr>
<tr>
<td>2 Marco Fortes (POR)</td>
<td>17.53</td>
<td>x</td>
<td>18.55</td>
<td>19.13</td>
<td>x</td>
<td>20.13</td>
</tr>
<tr>
<td>3 Hamza Alic (BIH)</td>
<td>x</td>
<td>18.15</td>
<td>x</td>
<td>20.13</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>4 Robert Häggblom (FIN)</td>
<td>19.75</td>
<td>20.06</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5 Miran Vodovnik (SLO)</td>
<td>19.77</td>
<td>x</td>
<td>x</td>
<td>19.49</td>
<td>19.72</td>
<td>19.10</td>
</tr>
<tr>
<td>6 Nedžad Mulabegovic (CRO)</td>
<td>18.96</td>
<td>19.47</td>
<td>x</td>
<td>19.28</td>
<td>19.43</td>
<td>19.58</td>
</tr>
<tr>
<td>7 Andrei Siniakou (BLR)</td>
<td>19.12</td>
<td>x</td>
<td>19.29</td>
<td>19.08</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>8 Anton Lyuboslavskiy (RUS)</td>
<td>18.21</td>
<td>19.21</td>
<td>18.72</td>
<td>18.85</td>
<td>18.88</td>
<td>18.78</td>
</tr>
<tr>
<td>9 Andréas Anastasópoulos (GRE)</td>
<td>18.75</td>
<td>x</td>
<td>18.03</td>
<td>18.60</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>10 Marco Schmidt (GER)</td>
<td>17.99</td>
<td>18.57</td>
<td>x</td>
<td>x</td>
<td>18.49</td>
<td>17.70</td>
</tr>
<tr>
<td>11 Ivan Emilianov (MDA)</td>
<td>18.34</td>
<td>18.38</td>
<td>18.01</td>
<td>18.16</td>
<td>18.31</td>
<td>18.29</td>
</tr>
<tr>
<td>12 Mihail Stamatóyiannis (GRE)</td>
<td>18.25</td>
<td>18.12</td>
<td>18.24</td>
<td>x</td>
<td>19.90</td>
<td>18.25</td>
</tr>
<tr>
<td>13 Raigo Toompuu (EST)</td>
<td>18.13</td>
<td>x</td>
<td>18.06</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

a 15-segment model of a putter’s body, defined by 18 reference points. The 18th point was the implement’s centre of mass (CM). Model segments represent the body parts related with associated joints. The CM of the body segments and whole body were calculated according to the Anthropometric Model of Dempster et al. (WINTER, 2005). The body-point coordinates were smoothed with a 7-degree digital filter. Using the APAS software, we determined the data for velocities, angles and trajectories of the individual body segments.

Statistical procedures were processed with SPSS Statistics software, version 17.0. To establish correlations between the chosen kinematic parameters and the final result the Pearson’s coefficient of correlation was used, and for calculation of the importance of the individual biomechanical parameters a linear regression was used.

**Model of Biomechanical Parameters**

Based on existing research and studies, we developed a model of 13 biomechanical parameters from two phases of the rotational technique: the second – the transition phase – and the third – the completion/release phase.

The model (see Figure 1 and Figure 2) includes:

- $V_x$ – horizontal release velocity,
- $V_y$ – vertical release velocity,
- $V_{xyz}$ – absolute release velocity,
- $H$ – release height,
- $L$ – acceleration path length after 2nd single-support phase,
- $\alpha$ – release angle,
- $K_{vKM}$ – angular velocity of the right shoulder at the moment of release,
- $K_{vKN}$ – angular velocity of the right knee at the moment of release,
- $Z_{dif}$ – deviation from ideal foot placement in “z” axis (width) at the beginning of 2nd double-support phase,
- $\beta$ – angle of torsion of the trunk (angle between hip and shoulder axes) at the beginning of the 2nd double-support phase,
- $K_{vDavg}$ – absolute value of the average angular velocity in the right knee joint in the 2nd double-support phase + difference in absolute value of the average angular velocity in the right knee joint in the 2nd double-support phase and absolute value of
the average angular velocity in the right knee joint in the 3rd single-support phase,
• **KvRKavg** – the sum of absolute value of the average angular velocity between shoulder and hip axes in the 2nd double-support phase and absolute value of the average angular velocity between shoulder and hip axes in the 3rd single-support phase,
• **TUabs** – absolute technical efficiency, which is the sum of KvDavg and KvRKavg parameters ($TUabs = KvDavg + KvRKavg$).

**Results**

Basic statistical data of the selected sample of throws are shown in Table 2.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length [m]</td>
<td>18.06</td>
<td>20.77</td>
<td>19.48</td>
<td>0.884</td>
</tr>
<tr>
<td>Vx [m]</td>
<td>9.49</td>
<td>11.58</td>
<td>10.32</td>
<td>0.619</td>
</tr>
<tr>
<td>Vy [m]</td>
<td>7.09</td>
<td>8.47</td>
<td>8.09</td>
<td>0.422</td>
</tr>
<tr>
<td>Vxyz [m]</td>
<td>12.52</td>
<td>13.58</td>
<td>13.13</td>
<td>0.353</td>
</tr>
<tr>
<td>H [m]</td>
<td>2.05</td>
<td>2.31</td>
<td>2.16</td>
<td>0.081</td>
</tr>
<tr>
<td>L [m]</td>
<td>1.37</td>
<td>1.64</td>
<td>1.51</td>
<td>0.088</td>
</tr>
<tr>
<td>A [m]</td>
<td>31.5</td>
<td>41.3</td>
<td>38.13</td>
<td>2.858</td>
</tr>
<tr>
<td>B [m]</td>
<td>35</td>
<td>61</td>
<td>44.25</td>
<td>8.028</td>
</tr>
<tr>
<td>Zdif [m]</td>
<td>2</td>
<td>22</td>
<td>9.20</td>
<td>7.899</td>
</tr>
<tr>
<td>KvKM [m]</td>
<td>871</td>
<td>1308</td>
<td>1064</td>
<td>172.597</td>
</tr>
<tr>
<td>KvKN [m]</td>
<td>-224</td>
<td>235</td>
<td>9</td>
<td>157.932</td>
</tr>
<tr>
<td>KvDavg [m]</td>
<td>104</td>
<td>399</td>
<td>234</td>
<td>94.774</td>
</tr>
<tr>
<td>KvRKavg [m]</td>
<td>41</td>
<td>594</td>
<td>331</td>
<td>194.971</td>
</tr>
<tr>
<td>TUabs [m]</td>
<td>303</td>
<td>809</td>
<td>565</td>
<td>184.160</td>
</tr>
</tbody>
</table>
Biomechanical Factors of Competitive Success with the Rotational Shot Put Technique

From the calculated correlations we established that the final distance is most closely related to Vxyz shot velocity ($r=0.902$, $p<0.01$) (see Table 3/page 106). The distance also significantly correlates with biomechanical parameters of horizontal shot velocity Vx ($r=0.643$, $p<0.05$), release height H ($r=0.669$, $p<0.05$), deviation from ideal foot placement Zdif ($r=-0.648$, $p<0.05$), average angular velocity between shoulder and hip axes $KvRKavg$ ($r=0.651$, $p<0.05$) and absolute technical efficiency $TUabs$ ($r=0.746$, $p<0.05$).

The impact of the chosen biomechanical parameters on the competitive success was calculated using the linear regression statistical method, in which only certain biomechanical parameters were included, i.e. Vxyz, H, α, $TUabs$ and Zdif, respectively. With the chosen parameters we managed to explain 94.7% of competitive success ($R^2=0.947$) (see Table 4).

The results show that the chosen model of variables is statistically significant, $F (4, 5) = 14.253$, $p<0.05$ (see Table 5).

When reviewing the individual parameters and their contribution to our regression model we can see that only the final Vxyz release velocity is a typical predictor from our model ($p=0.011$) (Table 6).

---

**Table 4: Linear regression of competitive success**

<table>
<thead>
<tr>
<th>Model</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0.973</td>
<td>0.947</td>
<td>0.30579</td>
</tr>
</tbody>
</table>

Legend: a = Predictors: (Constant), Zdif, α, H, Vxyz, $TUabs$.

**Table 5: Analysis of variance (ANOVA) for model of variables**

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>6.664</td>
<td>5</td>
<td>1.333</td>
<td>14.253</td>
<td>0.012a</td>
</tr>
<tr>
<td>Residual</td>
<td>0.374</td>
<td>4</td>
<td>0.094</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7.038</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend: a = Predictors: (Constant), Zdif, α, H, Vxyz, $TUabs$.

**Table 6: Analysis of variance (ANOVA) for variables in model**

<table>
<thead>
<tr>
<th></th>
<th>Unstandardised Coefficients</th>
<th>Standardised Coefficients</th>
<th>T</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>-23.674</td>
<td>8.541</td>
<td>-2.772</td>
<td>0.050</td>
</tr>
<tr>
<td>Vxyz</td>
<td>2.707</td>
<td>0.604</td>
<td>1.082</td>
<td>4.481</td>
</tr>
<tr>
<td>H</td>
<td>1.383</td>
<td>2.141</td>
<td>0.127</td>
<td>0.646</td>
</tr>
<tr>
<td>L</td>
<td>-0.611</td>
<td>2.243</td>
<td>-0.061</td>
<td>-0.273</td>
</tr>
<tr>
<td>A</td>
<td>0.122</td>
<td>0.066</td>
<td>0.395</td>
<td>1.856</td>
</tr>
<tr>
<td>$TUabs$</td>
<td>3.166E-5</td>
<td>0.001</td>
<td>0.007</td>
<td>0.028</td>
</tr>
<tr>
<td>Zdif</td>
<td>-0.005</td>
<td>0.018</td>
<td>-0.043</td>
<td>-0.271</td>
</tr>
</tbody>
</table>
### Table 3: Pearson's coefficients of correlation

<table>
<thead>
<tr>
<th>Variables</th>
<th>Length</th>
<th>Vx</th>
<th>Vy</th>
<th>Vxyz</th>
<th>H</th>
<th>L</th>
<th>A</th>
<th>KvKM</th>
<th>KvKN</th>
<th>B</th>
<th>KvDavg</th>
<th>KvRKavg</th>
<th>TUabs</th>
<th>Zdif</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1</td>
<td>.643*</td>
<td>.024</td>
<td>.902**</td>
<td>.669*</td>
<td>.621</td>
<td>-.373</td>
<td>-.179</td>
<td>-.232</td>
<td>.017</td>
<td>.112</td>
<td>.651*</td>
<td>.746*</td>
<td>-.648*</td>
</tr>
<tr>
<td>Vx</td>
<td>.643*</td>
<td>1</td>
<td>-.734*</td>
<td>.888**</td>
<td>.184</td>
<td>.329</td>
<td>-.946**</td>
<td>.184</td>
<td>-.227</td>
<td>-.116</td>
<td>.047</td>
<td>.661*</td>
<td>.724*</td>
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<tr>
<td>Vy</td>
<td>.024</td>
<td>-.734*</td>
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<td>-.342</td>
<td>.297</td>
<td>.101</td>
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<td>-.524</td>
<td>.102</td>
<td>.203</td>
<td>.008</td>
<td>-.285</td>
<td>-.297</td>
<td>.223</td>
</tr>
<tr>
<td>Vxyz</td>
<td>.902**</td>
<td>.888**</td>
<td>-.324</td>
<td>1</td>
<td>.466</td>
<td>.534</td>
<td>-.692*</td>
<td>-.102</td>
<td>-.259</td>
<td>-.038</td>
<td>.052</td>
<td>.729*</td>
<td>.799**</td>
<td>-.665*</td>
</tr>
<tr>
<td>H</td>
<td>.669*</td>
<td>.184</td>
<td>.297</td>
<td>.466</td>
<td>1</td>
<td>.713*</td>
<td>.035</td>
<td>-.196</td>
<td>-.338</td>
<td>.065</td>
<td>.087</td>
<td>.532</td>
<td>.608</td>
<td>.462</td>
</tr>
<tr>
<td>L</td>
<td>.621</td>
<td>.329</td>
<td>.101</td>
<td>.534</td>
<td>.713*</td>
<td>1</td>
<td>-.143</td>
<td>-.243</td>
<td>-.253</td>
<td>-.145</td>
<td>-.107</td>
<td>.686*</td>
<td>.671*</td>
<td>-.582</td>
</tr>
<tr>
<td>A</td>
<td>-.373</td>
<td>-.946**</td>
<td>.914**</td>
<td>-.692*</td>
<td>.035</td>
<td>-.143</td>
<td>1</td>
<td>-.362</td>
<td>.173</td>
<td>.159</td>
<td>-.029</td>
<td>-.530</td>
<td>-.576</td>
<td>.449</td>
</tr>
<tr>
<td>KvKM</td>
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<td>.184</td>
<td>-.524</td>
<td>-.102</td>
<td>-.196</td>
<td>-.243</td>
<td>-.362</td>
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<td>-.155</td>
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<td>.178</td>
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<tr>
<td>KvKN</td>
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<td>-.227</td>
<td>-.102</td>
<td>-.259</td>
<td>-.338</td>
<td>-.253</td>
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<td>.197</td>
<td>1</td>
<td>-.188</td>
<td>-.441</td>
<td>.037</td>
<td>-.188</td>
<td>.816**</td>
</tr>
<tr>
<td>B</td>
<td>.017</td>
<td>-.116</td>
<td>.203</td>
<td>-.038</td>
<td>.065</td>
<td>-.145</td>
<td>.159</td>
<td>-.347</td>
<td>-.188</td>
<td>1</td>
<td>.633*</td>
<td>-.222</td>
<td>.091</td>
<td>-.097</td>
</tr>
<tr>
<td>KvDavg</td>
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<td>.047</td>
<td>.008</td>
<td>.052</td>
<td>.087</td>
<td>-.107</td>
<td>-.029</td>
<td>-.169</td>
<td>-.441</td>
<td>.633*</td>
<td>1</td>
<td>-.354</td>
<td>.140</td>
<td>-.327</td>
</tr>
<tr>
<td>KvRKavg</td>
<td>.651*</td>
<td>.661*</td>
<td>-.285</td>
<td>.729*</td>
<td>.532</td>
<td>.686*</td>
<td>-.530</td>
<td>-.155</td>
<td>.037</td>
<td>-.222</td>
<td>-.354</td>
<td>1</td>
<td>.877**</td>
<td>-.396</td>
</tr>
<tr>
<td>TUabs</td>
<td>.746*</td>
<td>.724*</td>
<td>-.297</td>
<td>.799**</td>
<td>.608</td>
<td>.671*</td>
<td>-.576</td>
<td>-.251</td>
<td>-.188</td>
<td>.091</td>
<td>.140</td>
<td>.877**</td>
<td>1</td>
<td>-.588</td>
</tr>
<tr>
<td>Zdif</td>
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<td>-.586</td>
<td>.223</td>
<td>-.665*</td>
<td>-.462</td>
<td>-.582</td>
<td>.449</td>
<td>.178</td>
<td>.816**</td>
<td>-.097</td>
<td>-.327</td>
<td>-.396</td>
<td>-.588</td>
<td>1</td>
</tr>
</tbody>
</table>

Legend: * p<0.05; ** p<0.01.
Discussion

Table 1 and Table 2 show that the competition in Split was at a very high level and that the average distance of the analysed throws was 19.48m (shortest 18.06m, longest 20.77m). For these throws, the average release height was 2.16m (2.05m – 2.31m), the average release angle was 38° (31.5° – 41.3°) and the average release velocity was 13.13 m/sec (12.52 m/sec - 13.58 m/sec).

In their research of top shot putters, ARIEL et al. (2004) got similar results. In their analysis of the best three competitors in the 2004 Olympic final where the average result was 21.13m, the calculated average release height was 2.39m, the average release angle was 36° and the average release velocity was 13.8 m/sec. In their analysis of the finalists at the 2007 IAAF World Championships in Athletics, where the average result was 20.82m, BYUN et al. (2008) calculated an average release height of 2.33m, an average release angle 35° and an average release velocity 13.4 m/sec. Other authors (STEPANEK, 1987; BARTONIETZ, 1994; COH & SUPEJ, 2007) report similar values for individual biomechanical parameters at similar performance levels, strongly suggesting that the above-mentioned values for the three basic release parameters are required to achieve distances of 20m and more.

As was expected, throwing distance most strongly correlates with release velocity ($r=0.902$, $p<0.01$). BYUN et al. (2008) found a similar albeit slightly lower correlation ($r=0.87$, $p<0.01$). According to the physical laws that determine the trajectory of a simple projectile, the other two key parameters are release angle and release height. In our study, the final result is significantly correlated only with release height ($r=0.669$, $p<0.05$), and not with release angle ($r=-0.373$). So, in terms of the physical laws, assuming that satisfactory body height of the top putters is not questionable, the essence of successful shot putting is to accelerate the shot in the best possible manner throughout the whole putting motion with the aim of achieving maximum velocity in the point of release.

From the factors indicating shot put technical efficiency itself, the foot placement at the beginning of the 2nd double-support phase $Z_{df}$ ($r=-0.648$, $p<0.05$) significantly correlates with the final result. More important than the distance between the rear and front feet is the width between them (see Figure 2), as this is a precondition of efficient leg action in the release phase. This indicates the importance of the first part of the movement in providing optimal conditions for the release phase. The correlation of this parameter with the final result has a negative value, as any bigger deviation from the ideal placement, which is considered to be approximately 20cm, means a worse result.

Significant correlations with the final result were also found for the parameters $K_{vR}K_{avg}$ ($r=0.651$, $p<0.05$) and $T_{Uabs}$ ($r=0.746$, $p<0.05$). These indicate an efficient and synchronised activity of the lower and upper parts of the body after the beginning of the 2nd double-support phase. This is reflected in a better rotation of the body when the putter begins the 2nd double-support phase and has a considerable impact on the final release velocity. High angular velocity values between shoulder and hip axes before the beginning of the 2nd double-support phase denote an unsynchronised movement, which was noted in the competitors with worse results on the competition.

The Torsion angle after the 1st flight phase is considered to be a key element of good technique. Correlation analysis in our study showed that the angle between shoulder and hip axes $\beta$ – torsion angle, which defines the above-mentioned technical element, has no significant importance, as the obtained correlation is statistically non-significant ($r=0.017$). Notwithstanding the result, we have to conclude that this parameter should not be ignored, as the significant correlation of the $\beta$ parameter with the $K_{vDavg}$ parameter ($r=0.633$, $p<0.05$) indicates that the torsion angle is important for the efficient action of the right leg after the 2nd double-support phase until the release of the shot.

We assume that the angle between the shoulder and hip axes in the beginning of the
2nd double-support phase is more important for the putters using the linear technique, as these athletes do not use the rotation momentum. This suggests the conclusion that in the rotational technique the whole putter’s motion or the rotational momentum has a much more important role after the preparatory phase. In our research this momentum is presented in terms of angular velocities between the shoulder and hip axes in relation with the angular velocity of the right knee (parameters KvRKavg and TUabs). This fact is also confirmed by high and significant correlation of the parameter with the final result (KvRKavg, r=0.651, p<0.05; TUabs, r=0.746, p<0.05). BYUN et al. (2008) and COH & SUPEJ (2007) obtained similar findings when they analysed the whole movement of the putter in terms of linear and angular momentum or mechanical energy and power differential, respectively.

A high, but non-significant correlation with the final result was found for biomechanical parameter L, the acceleration path length after 2nd single-support phase (r=0.621). The higher value of Pearson’s correlation coefficient is reinforced by the fact that the longer path, made with the shot, denotes a greater possibility for effective acceleration and thus a higher release velocity. As expected, the acceleration path length significantly correlates with release height (r=0.713, p<0.05), as well as with the parameter TUabs (r=0.671, p<0.05). This proves that for rotational momentum efficiency the athlete needs to effectively use the rotation movement, thus making the trajectory of the shot through the whole put as wide as possible.

The correlation calculations (Table 3) also provide some important correlations between individual biomechanical parameters. We would underline the high correlation between Vxyz release velocity and TUabs parameter (r=0.799, p<0.01), which provides additional evidence of the importance of the body rotation in order to achieve higher release velocity mentioned previously. A very high correlation between angular velocity of the right knee in release phase KvKN and deviation from the ideal foot placement in the beginning of the 2nd double-support phase Zdif (r=0.816, p<0.01) also has to be pointed out.

The latter additionally confirms our thesis that inappropriate foot placement hinders efficient leg action after the beginning of the 2nd double-support phase.

For the calculation of potential competitive success, we chose those biomechanical parameters that significantly correlate with the shot put distance, where Vx horizontal velocity and KvRKavg parameter were excluded, because of their high correlation with Vxyz and TUabs, respectively. In the selection of variables, the release angle α was also included. With the described selection of variables (biomechanical parameters) with linear regression we managed to explain 94.7% of competitive success (R2=0.947) (Table 4), and the chosen model of variables is statistically significant, F (4, 5) = 14.253, p<0.05 (Table 5).

From the individual parameters in our model, only release velocity Vxyz (p=0.011) is a significant predictor of competitive success. Using linear regression, we also calculated the values of Beta coefficients (Table 6), which theoretically present the contribution of the individual parameter to the final result, provided that other parameters are held as constant. Thus we can see that with an increase of release velocity of 1 m/sec, assuming that all other parameters are constant, the distance is longer by 2.71m. In other words, to gain one metre, the release velocity needs to be increased by 0.37 m/sec. When release height parameter is considered, its Beta coefficient shows that with a one metre increase in release height, when the other parameters are constant, shot put distance increases by 1.38m. In practice, the release height is mostly defined by the body height of the athlete. Therefore, it is more appropriate to state that a 10cm increase in release height would mean a 14cm longer throw. Finally, considering the release angle α, we can see that a 1º increase of this parameter would mean a 12cm longer throw, or a 5º increase would mean a 60cm longer throw. It has to be mentioned that this holds true only when the angle
is smaller than 45º, as according to the physical laws of projectile flight a further increase of release angle would have a negative impact on the final distance.

Conclusion

The results of our study on a sample of top-level shot putters using the rotational technique confirmed the importance and correlation of certain biomechanical parameters with the final result. Release velocity is the main success factor. But release velocity itself is not enough to explain the process of effective shot acceleration. When examining the rotational technique we have to have in view the putter’s whole motion in both the transition and release phases. With calculated parameters, which consider angular velocity between shoulder and hip axes, and angular velocity in the right knee, we showed the importance of rotational momentum efficiency throughout the whole put. We presume this is one of the key factors to ensure the highest possible release velocity when using the rotational technique.

Additionally, we showed the importance of other factors that have a significant impact on the final distance achieved. Foot placement in the beginning of the 2nd double-support phase is a key factor in that it enables effective action of the right leg through the release phase, which must not be too wide or too narrow. Release height is also a significant factor for the final distance, therefore, a large body height in the athlete is a prerequisite for achieving results at the highest level in the shot put. Another important factor is the acceleration path length, as a longer and wider trajectory of the shot through the whole putting movement enables better efficiency of rotation technique, and thereby higher release velocity.

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REFERENCES


Coaching

contents

- The Critical Role of Core Strength and Balance in Preventing Spinal Injuries
  by Bob Adams, Frederic Depiesse, Jack Ransone

- Conference Report - The 1st European Race Walking Conference
The Critical Role of Core Strength and Balance in Preventing Spinal Injuries

By Bob Adams, Frederic Depiesse, Jack Ransone

ABSTRACT

The stability of the body’s core is essential for track and field athletes, both to maximise performance and reduce the incidence of injuries. Recent studies of elite athletes show that approximately one quarter of their injuries involve the trunk or thigh, indicating problems with the core stabilisers, both the general stabilisers (like the external obliques, rectus abdominis and the erector spinae) and local stabilisers (like the transverses abdominus, the internal obliques, the multifidi, the pelvic floor muscles, and the diaphragm). Therefore work on balance and core stability should be elements of any training or rehabilitation programme. With the aim of providing background information and general advice for coaches and medical practitioners who work with elite athletes, this article discusses the importance of balance and core stability then outlines the causes, evaluation and treatment of spinal injuries. It concludes by stating that managing and preventing recurrences of back injuries in athletes begins with an understanding of what they do, how they do it, and the cause of injury. The basic principles of prevention are avoidance of extreme positions or stress for long periods, and preventative/maintenance exercises for range of motion, muscle flexibility, strength and power.

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Introduction

Until recently, only a few studies on injuries in elite athletics could be found in the literature. Those that did deal with athletics related injuries tended to be limited by focusing on non-elite athletes, small
Balance

We tend to think of balance as a static position due to the traditional definition as a set position maintained for a period of time. But in a sports context, balance is more about control of one’s centre of mass and body angles to ensure equilibrium. It has been suggested that balance is the single most important component of athletic ability as it underpins all movements whether they are dominated by strength, speed or endurance. Additionally, balance is closely related to neural coordination and agility. Maintaining a state of dynamic equilibrium involves the ocular, vestibular, kinesthetic and auditory systems. Poor balance may lead to poor technical or skill development, which in turn often results in injury.

A relatively simple activity, such as sprinting, when seen from a balance perspective is actually highly complex. At speeds in excess of 11 m/sec the sprinter must alternate balancing on one leg and then the other within periods of less than one tenth of a second. Try losing and regaining your balance in such a timeframe and you will see the difficulty of the required skill. Therefore, balance must be constantly trained as a fundamental component of all movement skills.

Core Stability

The core of the body is the trunk complex, which can be depicted as a cylinder bounded by the abdominals anteriorly, back extensors posteriorly, the quadratus lumbarum laterally, the pelvic floor muscle inferiorly and the diaphragm superiorly. However, a critical detail is the concept of general and local muscular stabilisers, the muscle groups requiring a coordinated activation to achieve spinal stabilisation during trunk movement.

The general stabilisers are the larger, more superficial muscles that control movement: the external obliques, rectus abdominis and the erector spinae. The control of movement by the general stabilisers is substantially less...
effective without the coordinated activation of the local spinal stabilisers. In general, the local stabilisers are considered to be the transverses abdominus, the internal obliques, the multifidi, the pelvic floor muscles, and the diaphragm. Activation of the general and local stabilisers that is out of sequence will not provide the necessary functional stability.

It should be noted that the biomechanical body posture also has an important influencing role on core stability. Posture and gait must be evaluated both statically and dynamically to identify any deviation or substantial muscle imbalances. As the body is a kinetic chain system, any muscle imbalances will influence both the posture and dynamic movement.

Causes of Spinal Injuries

Athletics training and competition create many chances for significant acute and overuse spinal injuries. Postural stress can cause general and specific aches and pains and, through stress of joint and soft tissue structures, result in dysfunction. Lifting in strength training, throwing weighted implements as well as the spinal torsion and compression caused by pole vaulting, jumping, hurdles, and running can all cause acute or chronic back syndromes. Precipitating factors include:

1) Sitting Posture

A good sitting posture maintains the spinal curves normally present in erect standing posture. Poor sitting posture reduces or accentuates the normal curves enough to stress the ligamentous structures and induce pain. A poor sitting posture can produce pain to the back itself without any additional stress or injury. An athlete suffering from low back pain can experience increased pain from sitting or rising from sitting. When an individual sits in a chair for a few minutes, the lumbar spine assumes the fully flexed position, in which the muscles are relaxed and the weight bearing stress is absorbed by the ligamentous structures. An increase in intradiscal pressure occurs as the spine moves toward the flexed position in sitting, and decreases as the spine moves into extension. Athletes are frequently required to sit for long periods at work or school and often on flights to competition sites (domestic or overseas). One should take frequent breaks from sitting, perform active stretches, and ensure adequate hydration.

2) Lack of Postural Extension

Another predisposing factor to low back pain is the loss of lumbar extension. A loss of spinal extension influences the athlete's posture in sitting, standing, walking and running. From faulty postural loading, the spine undergoes adaptive changes.

3) Frequency of Flexed Position

The majority of activities that an individual performs occur in the flexed position. Theoretically, this produces stress on the annular wall and causes the fluid nucleus to move posteriorly.

4) Unexpected and Unguarded Movements

In athletics unexpected and unguarded movements may cause an acute episode of low back pain. Throwers and jumpers often experience muscular strains or ligamentous sprains due to the explosive nature of their events. In attempts to reduce low back pain episodes, it is necessary to examine and advise each athlete regarding the precipitating factors involved.

5) Lifting

Correct lifting and throwing techniques are vital in preventing back injuries. Lumbar intradiscal pressure has been shown to increase with lifting movements from a forward bent position. Maintaining a functional neutral position (an individual’s functional range between flexion and extension) and lifting with bent knees aids in symptom-free lifting.

Evaluating Spinal Injuries

Assessment of back pain should begin with a thorough history and examination. Medical practitioners should listen and communicate with the athletes to understand their subjective complaints and comments, and to determine
the area, nature and severity of their symptoms. They should also determine whether the symptoms are constant or intermittent and what positions or movements provoke the pain. Objective evaluation of movement testing to reproduce the symptoms should be performed. A neurological examination should be performed as indicated. The medical practitioner should identify asymmetries and deficits. Communication with the coach will certainly be useful. A comprehensive treatment plan should include exercise prescription to enhance strength deficiencies and inflexibility.

Back pain of mechanical origin can be classified as one of three syndromes:

1) Postural Syndrome
   Pain of postural origin is intermittent and appears when soft tissues surrounding the lumbar joints are placed under prolonged stress. Upon evaluation, inspection and lumbar range of motion is normal. Postural assessment generally indicates poor sitting and standing posture. Treatment should correct posture, strengthen muscles if any weakness is found, and increase the flexibility of tight structures.

2) Dysfunction Syndrome
   Dysfunction syndrome occurs when adaptive shortening and resultant loss of mobility causes pain before gaining a full range of motion. Adaptive shortening and loss of mobility can result from poor postural mechanics, spondylosis, acute trauma, or disc derangement. Treatment should emphasise lengthening of the shortened tissue and improving range of motion.

3) Derangement
   Disturbance of the intervertebral disc mechanism is responsible for the most disabling cause of mechanical low back pain. The actions of the disc have been described and documented by various authorities to explain the relationship of the disc and increased pain upon movements. Minor disc bulging may cause spinal deformity and limitation of certain movements of the spinal column increasing the bulge while others may reduce it. Shifting the fluid nucleus of the disc may also disturb annular material. A herniated nucleus pulposus may cause nerve root compression, radicular symptoms, and altered neurological findings.

Treatment and Rehabilitation

After the potential stresses and the structures are identified, a plan of treatment may include back education, including a review of proper back mechanics and assessment of any faulty mechanics present while executing the athlete’s specific skill; modality intervention; and mobilisation and exercises to achieve pain relief and regain function. A treatment plan should include an individualised self-, coach- or medical practitioner-monitored home programme.

The primary treatment aim is restoration of normal painless joint range by:
- relief of pain and reduction of muscle spasm;
- restoration of normal tissue-fluid exchange, soft tissue extensibility and normal joint relationship and mobility;
- correction of muscle weakness or imbalance;
- restoration of adequate control of movement and stabilisation;
- relief from chronic postural stress;
- functional return for the athlete;
- prevention principles to avoid recurrence;
- restoration of the athlete’s confidence.

The priority of goals may differ with each individual. The philosophy of treatment and rehabilitation of specific back injuries may differ depending on the medical practitioner’s educational and clinical background and experience, as well as the treatment and rehabilitation techniques that have proven successful for the individual patient.

Self-treatment should emphasise the principles of postural correction, repeated extension or flexion movements, use of lumbar aids and supports, and use of various local treatment modalities such as cryotherapy or heat treatment. Other treatments may include:
- electrical stimulation,
- traction,
• acupressure/acupuncture,
• local injections or oral analgesic/or anti-inflammatory medications,
• joint mobilisation and osteopathic manipulation,
• muscle energy techniques for regaining muscle balance,
• proprioceptive neuromuscular facilitation (PNF) or soft tissue and nerve mobilisation,
• core stabilisation.

Conclusions and Outlook

The lumbar spine has optimal positions in which it functions most efficiently and these positions vary depending on the stresses it must withstand. There is no one best position for all functional tasks and activities, and it will vary from athlete to athlete. A good functional position is generally near the mid-range of all available movement of the lumbar spine and the athlete must learn how to obtain and maintain core stability.

For the athlete to learn to maintain the low back within a functional range, he or she must develop a kinesthetic sense in order to feel and control back movements and positions so that it becomes a habit during all activities. The athlete must also maintain the necessary coordination, strength, flexibility, and endurance to perform well.

Managing and preventing recurrences of back injuries in track and field athletes begins with an understanding of what they do, how they do it, and the cause of injury. The basic principles of prevention are avoidance of extreme positions or stress for long periods, and preventative/maintenance exercises for the range of motion, muscle flexibility, strength and power.

REFERENCES


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The 1st European Race Walking Conference

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Introduction

The twin pillars of long-term athlete development and coach development were the focus of the 1st European Race Walking Conference, which attracted 75 participants from 16 countries as far afield as Australia, USA and South Africa. The conference, which took place at the National Centre for Race Walking, Leeds Metropolitan University, UK, from Friday 6th to Sunday 7th November 2010, was a part of the European Athletics Coaching Summit Series and received financial support from England Athletics, UK Athletics and European Athletics. In addition, some delegates from the 13 European nations represented were able to take advantage of scholarships provided by European Athletics to help cover the cost of attending.

After a joint opening address by the former Welsh international Rugby Union player Gareth Davies, who is the Dean of the Carnegie Faculty, Leeds Metropolitan University, and former Olympic 20km race walker Martin Rush, who is National Coach Mentor (Endurance), for England Athletics, the programme took up the two themes in a mixture of keynote addresses, lectures, discussions around best practice and practical workshops, which are summarised in this report.

Day 1 – Afternoon Session

Keynote: Planning & Preparation Ivano Brugnetti

Antonio La Torre (ITA)

Ivano Brugnetti (ITA) was World Champion in the 50km Race Walk in Seville in 1999 and became Olympic Champion in the 20km Race Walk in Athens in 2004. La Torre, who is Associate Professor in Methods of Educational & Sports Activities at the University of Milan, an Expert Consultant to the Technical Committee of the Italian National Olympic Committee (CONI), a member of Technical-Scientific Committee of the Italian athletics federation (FIDAL) and a Senior Lecturer in the IAAF Coaches Education and Certification System (CECS), described the evidence based decision making process that lead to the successful switch of Brugnetti’s focus to the 20km distance for 2004.

Brugnetti’s technical competence; ability to work at a high basic race walking speed; maximum oxygen uptake (VO$_{2\text{max}}$), i.e. ~ 70 ml·kg$^{-1}$·min$^{-1}$; good race walking economy; and high blood lactate tolerance were the factors considered when making the methodological changes in preparation, whereby training quality was increased and volume decreased bringing early success at 10km and 5000m indoors (see Table 1 and Table 2). The key points drawn from the analysis are: a training plan favoring quality vs. quantity; introduction of cutting-edge power stimulus in an already high-performance endurance athlete; training monitoring (utilisation of testing in physiology and biomechanics), the role of different race distances (e.g. 5km to 50km) in the overall preparation.
Table 1: 2004 Altitude strategy: Ivano Brugnetti (ITA)

<table>
<thead>
<tr>
<th>Altitude Stage</th>
<th>Period</th>
<th>Venue</th>
<th>Altitude</th>
<th>Key sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Feb-Mar</td>
<td>Albuquerque, New Mexico, USA</td>
<td>1500m</td>
<td>• 15km: 1:04:06&lt;br&gt;• 2 x 10km: 44:16 + 41:53&lt;br&gt;• 10 x 1000m: mean of 4:00-km⁻¹&lt;br&gt;• Long distances: mean of 5 min – 4:55-km⁻¹</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td></td>
<td></td>
<td>24 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• 2 x 10km: 44:16 + 41:53&lt;br&gt;• 10 x 1000m: mean of 4:00-km⁻¹&lt;br&gt;• Long distances: mean of 5 min – 4:55-km⁻¹</td>
</tr>
<tr>
<td>2</td>
<td>June</td>
<td>Courmayeur, Italy</td>
<td>3300m</td>
<td>Torino Hut, LHTH&lt;br&gt;• 4 h/day at 1600m (one training session)&lt;br&gt;20 h/day at 3300m&lt;br&gt;• 250 steps to reach the hut</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td></td>
<td></td>
<td>22 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• 250 steps to reach the hut&lt;br&gt;12 high-very high intensity training sessions&lt;br&gt;3 uphill trainings of 11-15km with extended finishing sprint</td>
</tr>
<tr>
<td>3</td>
<td>July</td>
<td>Sestriere, Italy</td>
<td>2090m</td>
<td>LHTH Never under 1354m&lt;br&gt;12 high-very high intensity training sessions&lt;br&gt;3 uphill trainings of 11-15km with extended finishing sprint</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td></td>
<td></td>
<td>22 days</td>
</tr>
</tbody>
</table>

Table 2: 2004 Crucial sales: Ivano Brugnetti (ITA)

<table>
<thead>
<tr>
<th>Competition</th>
<th>Venue</th>
<th>Result</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.03.04 - IAAF RW Challenge</td>
<td>Tijuana, Mexico</td>
<td>20km, 1st: 1:19:42 (3:59-km⁻¹)</td>
<td>Personal best; 2nd Italian all-time performance; developed awareness that on right (20km) path</td>
</tr>
<tr>
<td>02.05.04 - IAAF RW World Cup</td>
<td>Naumberg, Germany</td>
<td>20km, 6th: 1:20:06 (4:00-km⁻¹)</td>
<td>Target: self control</td>
</tr>
<tr>
<td>29.05.04 - FIDAL Championships</td>
<td>San Giovanni, Marignano, Rimini, Italy</td>
<td>20 km, 1st: 1:21:31 (4:04.55-km⁻¹)</td>
<td>Alone throughout the race (2nd at 3 min 00 sec); 30°C</td>
</tr>
<tr>
<td>04.08.04 Italian Summer Race</td>
<td>Saluzzo, Italy</td>
<td>10000m, 1st: 38:23.05 (3:50-km⁻¹)</td>
<td>Italian Record and 5th world all-time performance</td>
</tr>
<tr>
<td>20.08.04 XXVIII Olympic Games</td>
<td>Athens, Greece</td>
<td>20 km, 1st: 1:19:40 (3:59-km⁻¹)</td>
<td>Personal best; 2nd Italian all-time performance</td>
</tr>
</tbody>
</table>
Workshop: Race Walking Biomechanics
Brian Hanley (IRL)

Hanley, a Senior Lecturer in Sport and Exercise Biomechanics, Carnegie Faculty, Leeds Metropolitan University, demonstrated how biomechanics can be used to improve performance in race walking. First, he led the participants through a typical data collection session in the laboratory with the assistance of athletes from the UK Athletics National Centre programme. This involved high-speed video to capture the movement, force plates to measure important features such as braking and propulsion, and electromyography (EMG) to gain an insight into the workings of relevant muscle groups such as the hamstrings and quadriceps. He highlighted how these data can be interpreted to compare and contrast technical aspects between athletes. These tests can be used to identify strengths and weaknesses in an athlete’s technique, including recognising where an injury risk might exist. Finally, he demonstrated the use of the h/p/Cosmos Gaitway treadmill, which has indwelling force plates that allow for the analysis of variables of particular interest such as stride width and angle of turn-in of the feet, which are usually very difficult to measure.

Workshop: Athlete Profiling - Effects on Common Race Walking Injuries
Fraser McKinney (GBR)

McKinney, a Clinical Physiotherapist at the Carnegie Sports Physiotherapy Clinic and the Head Physiotherapist & Lead Sports Science Co-ordinator for Great Britain Basketball, demonstrated two key areas of testing to highlight how to develop a profiling system. His workshop showed how assessment of the kinetic chain could be linked to reductions in injury and improvements in performance. He took the participants through analysis of a tibialis anterior injury due to hip tightness; and a hamstring tightness/injury due to shoulder girdle tightness – these examples were chosen as race walk athletes had presented with need for development in these areas in the Carnegie Sports Physiotherapy Clinic. He said will consider all components of a muscle and effects: directly on length, on the kinetic chain, and on (individual) athlete performance and his process of gaining physical, mental and skill level information about athletes follows a four-stage process:

1) Understanding: Highlight areas for development
2) Analysis: Identify the characteristics and desired movements/strength/flexibility patterns
3) Interpretation: Screen the athlete
4) Delivery: Analysis of the results with aim to develop method of improving that athlete

Lecture: Race Walk Judging
Luis Saladie (ESP) and Peter Marlow (GBR)

Both Saladie and Marlow are highly respected international race walking judges (IAAF Level 3) and members of the IAAF Race Walking Committee. Saladie is also the Events Manager at the Royal Spanish Athletic Federation and the federation’s Race Walking Coordinator while Marlow is the Head of UK Athletics Race Walking Policy & Support Team. They provided an update on international race walking judging. This included a rare and much needed opportunity for coaches to interact and enter into dialogue with representatives of the international judging community.

The speakers gave an overview and update of the rules of race walking and a more in depth discussion around the principles and under pinning philosophies that have been adopted by the international judging panels. They also outlined recent rule changes around the use of cautions. The participants got to sit the video examination that was used at the IAAF Level 3 Examinations in Paris the preceding weekend. This provoked lengthy discussion around the interpretation of the rules of race walking.
Day 2 – Morning Session

Keynote: Transitional Factors in Race Walking
Brent Vallance (AUS)

The conference organisers acknowledged Australia as a nation successful in managing the transition from junior to senior athlete in the race walking events. Vallance, a Senior Athletics Coach for Race Walking at the Australian Institute of Sport (AIS), gave an overview of Australia’s Little Athletics programme for children aged 5 to 16 years, which features 1100m and 1500m race walks for 10 & 11 year olds and 12-16 year olds, respectively. These events give race walk exposure to more than 95,000 girls and boys across the continent, each year.

Elsewhere globally, there are 17-year-old athletes (e.g. China) making the IAAF 20km senior ranking lists with “A standard” performances – as Vallance stressed, quite a difference! Australia is a nation with a relatively small talent pool compared to China and Russia and Vallance highlighted Portugal as an example of good practice in managing a small talent pool.

Vallance outlined the needs of a high performance system to support the coaching process required order for successful junior to senior transition to occur:
- a feeder System of athletic talent:
  - From where? (e.g. pockets of excellence linked to active coaches across Australia – large distances involved),
  - To the AIS or elsewhere?
  - At what age? (e.g. National Youth Program under 17 and under 19 camps);
- provide talent with opportunities:
  - Training camps (e.g. month long January camp at AIS),
  - International touring and competition.
  - Close contact with established seniors.

He said that in practical terms, junior athletes accessing the AIS Programme will normally focus their preparations on:
- establishing race walk patterns (5 days/wk);
- establishing twice per day training patterns including strength & conditioning and cross-training;
- developing good training habits; supported by use of AIS services;
- long walks becoming the main part of training diet.

Workshop: Race Walking Drills & Skills
Martin Rush (GBR)

Rush, followed up his opening address with a practical workshop in which he shared knowlege about the uses of drills in race walking. Skill learning was cited as the principal use of event specific drills, with additional roles in skill reinforcement/development (as a tool for fault correction); and the development of mobility, together with general and functional conditioning. The participants discussed when and where to programme these activities within training cycles and/or athlete development stages. Rush also worked with athletes from the National Centre to demonstrate examples.

Lecture: Biomechanics
Brian Hanley (IRL)

Hanley followed up his workshop of the previous day by presenting findings from three kinematic studies on elite race walking. First, he presented results of a study of 90 elite walkers, thirty from each senior race at the 2008 World Race Walking Cup. He said that world class walkers have a stride length of approximately 70% of their height, which allows them to maintain high stride frequencies and prevent visible loss of contact.

He then discussed his findings from a study on elite walkers at the 2007 European Cup Race Walking, where twelve athletes in each senior race had been analysed at four split distances. He showed how loss in walking speed in this longest of athletic events was predominantly due to decreases in stride length and pelvic rotation and increased contact time.
Conference Declaration

- Race Walking as a discipline should be developed in parallel with wider developments in European and international athletics coach development (e.g. CECS) but with specific reference to the needs of race walk athletes and their coaches.
- Race Walking as a discipline should be developed by adopting the principles of Long Term Athlete Development (LTAD) and Long Term Coach Development (LTCD).
- The delegates also confirm the value of periodic Race Walking coach interaction as well as interaction within the wider sphere of athletics.
- Race Walking as a discipline should be developed by adopting evidence based practice and models of good practice.
- In order for race walking as a discipline to develop further and flourish it should be embedded within the structures and programmes of athletics, internationally, nationally and at local levels.
- Race Walking as a discipline should be developed through opportunities for regular and appropriate international competition.
- Race Walking as a discipline should be developed through regular Coaching Conferences/Seminars… These could be attached to EAA/IAAF competitions but event development should also to explore the use of new technology e.g. webinars/podcasts.
The final study presented was on twenty athletes from each of the junior events held at the 2009 European Cup Race Walking. This showed that although the junior athletes had similar attributes to the senior walkers, they tended to have less pelvic rotation and more upper body movements, which made them less efficient.

Day 2 – Afternoon Session

**Keynote: Coaching Competence and Qualifications**

*Pat Duffy (IRL)*

Duffy, who is Professor of Sport Coaching, Carnegie Faculty, Leeds Metropolitan University and the Chairman, European Coaching Council, examined models of Long-Term Athlete Development (LTAD) and Long-Term Coach Development (LTCD) and set his work in the context of coaching competence and qualifications, discussing similarities and differences between the European Coaching Council and the IAAF CECS models. Practical implications were drawn from a high performance race walking coach-athlete case study.

He said that coaches need to be able to identify the stages of development for race walkers, i.e. LTAD. Moreover, coaches should identify the key capabilities required for success along the way in the athlete. Related to their own coaching practice the study found that coaches should understand the coaching domains, roles and capabilities, i.e. LTCD in race walking and how these relate to the IAAF CECS. Specifically from the high performance case study Duffy found:

- alignment of coach capability and athlete need;
- knowing the athlete/(self)developing the coach;
- all categories of coaching expertise called upon;
- significance of ‘team’ and ‘environment’ related capabilities;
- transfer rather than retention of athletes?;
- coach capability to ‘pass on’ and to ‘bring up’?

**Workshop: Coach Development**

*Andy Abraham (GBR)*

Abraham, a Senior Lecturer in Sport Coaching, Carnegie Faculty, Leeds Metropolitan University, led a workshop on coach development drawing on his work with Professor Dave Collins (University of Central Lancashire). He used a problem-solving task to draw out delegate’s ideas about coaching expertise and decision making.

**Workshop: Nutrition**

*Louise Sutton (GBR)*

Sutton, the Principal Lecturer in Sport and Exercise Nutrition, Carnegie Faculty, Leeds Metropolitan University, reviewed the consensus on nutrition and athletic performance and shared experiences in delivering a nutrition education programme to race walkers. Providing performance nutrition for race walking, is not ‘rocket science’ but ‘common sense’ and the successful practice requires focussed application and effort on the part of the athlete.

Her workshop highlighted that nutritional strategies/recommendations should:

- be based on scientific evidence;
- consider the physiology of the event;
- be realistic and achievable;
- take account of the rules and regulations.

**Workshop: Athlete Development**

*Pat Ryan (IRL)*

Ryan, who is Director of Development for Athletics Ireland, led a discussion around how to develop race walking based on the Athletics Ireland (AI) Model and current practices and strategies in other countries. Ryan outlined how his federation had attempted to capitalise on a golden generation of Irish race walkers, who had achieved success at the highest international level over the last decade. He advocated that race walking be embedded into athletics programmes and structures as opposed to the ‘Separatist Approach’ that has been in
the ascendency in other countries, such as the UK, which considers race walking to be a sport in its own right.

He also outlined the Irish approach of ensuring race walking was part of the competitions structure of club league based competitions; the schools athletics programme; and other community athletics competitions/structures. Another feature of the strategy has been to make sure that race walking is embedded in coaching courses and education. This is ensured by making sure that it is a component of the curriculum of Level 1 Coaching Awards. Future developments include the need to develop a nationwide pool of officials who are competent race walking judges to support the competition programme.

**Day 3 – Morning Session**

**Keynote: Planning & Preparation - Jared Tallent**

Brent Vallance (AUS)

Vallance’s second presentation at the conference was a case study of double Olympic medallist Jared Tallent’s development from competing at the World Youth Championships in 2001 to date. From his early training in his home of Ballarat where he was mixing swimming, athletics and triathlon, Jared entered the Australian Institute of Sport programme in 2003 and made his first World Championships Team in 2005, placing 18th in the 20km walk. At 23, with a string ranking of 40th on the 2007 Performance Rankings, he was disqualified at 16km of the world championships 20km when in 5th position. These two performances evidenced championship capabilities.

In his presentation, Vallance highlighted the “Australian Dilemma”, i.e. the non-alignment of the country’s competitive season with a European summer, which requires multiple performance peaks that most athletes do not have in their programmes. He also described in detail the Australian Institute of Sport’s altitude training support for Jared and how this is utilised, in particular the role of the Altitude House at the AIS.

**Lecture: Evidence Based Practice**

Andrew Drake (GBR)

Drake is the Head Coach at the National Centre for Race Walking, England Athletics. He drew on a range of evidence to support the work of the conference speakers/leaders and reviewed the coaching and scientific literature related to athletic programme characteristics; race walk athlete development; and nurturing race walk talent. He described the National Centre for Race Walking’s plan to impact on the race walk events: establish a clear strategy/objective; create an environment in which talent can thrive; and identify the athlete base. The strategies/objectives are driven by a passion for developing talent towards championship teams and fulfilling potential. The environment in which athletes can thrive is key to the success of any programme. There is already a team in place at Carnegie who have experience of working with National Race Walk Squads/Teams and who are expert in their own fields, e.g. sport science support, strength & conditioning, physiotherapy and coach education. Moreover the programme engages with overseas squads and coaches who share their expertise. The final phase of establishing the programme has been to work with the athletes - often seen as the starting point of a programme launch; however it is typically without the crucial first two stages being fully developed/implemented! In short as the programme gathers momentum it will begin to make a difference.

**Day 3 – Afternoon session**

**Plenary Session/Round Table**

The conference closed with a plenary session and round table discussion featuring the speakers, presenters and contributors from the weekend, which was led by Malcolm Brown (GBR), Olympic Performance Manager for British Triathlon, Great Britain Athletics Team
Coach and the former Director of Sport & Associate Dean, Carnegie Faculty, Leeds Metropolitan University, together with Ian Richards (GBR) from the Carnegie Faculty, Leeds Metropolitan University. A number of the issues raised during the conference were discussed in this session.

As this was the first conference of its type, the opportunity was taken to develop an agreed standpoint of the views of the participants through a conference declaration (see box). The declaration was signed by all the participants and it is hoped this will drive the agenda of race walking coaching across Europe and be used as a blueprint for future discipline specific conferences.

Reported by Ian Richards and Andrew Drake

Ian Richards, PhD, is a Senior Lecturer in Sport in the Carnegie Faculty at Leeds Metropolitan University. He can be contacted at i.richards@leedsmet.ac.uk

Andrew Drake, PhD, is the Head Coach, National Centre for Race Walking. He can be contacted at adrake@englandathletics.org
Development

contents

- Development Spotlight – Brazil
  by Helmut Digel

- The Formation of Cuban Track and Field Champions
  by Ariel Muñiz Sanabria

- The Evolution of the Combined Events: Is a One-Day Decathlon Possible?
  by Anatoliy Fatieiev
Development Spotlight – Brazil

By Helmut Digel

(Translated from the original German by J. Schiffer)

ABSTRACT

From the point of view of organisation, the development of athletics is a global success story. Europe has played a dominant role, both in terms of governance and competition results but with the end of colonialism and, later, the break up of the Soviet empire, the distribution of top performers has changed. The author, an IAAF Council member and a former national federation president, outlines the positive development of performances and their spread around the globe. He also notes that in many aspects the sport is still a patchwork of positive and negative stories. However, there are a number of shining examples that should be learned from. One of these is Brazil, where since 1987 the federation has developed its governance and management structures, been a catalyst for the creation of new tracks and other infrastructure, staged many international events and led a phenomenal increase in performance levels. After detailing the country’s various successes, the author concludes with the hope that the federation will continue on its path and profit from the staging of the 2016 Olympic Games in Rio de Janiero.

AUTHOR

Helmut Digel is a Professor of Sport Science and Sport Sociology. He is an IAAF Council member, Chairman of the IAAF Marketing and Promotion Commission, a member of the IAAF Development Commission and a Consultant Editor for New Studies in Athletics. He also holds various leadership positions in both sport and sport science in Germany.

Introduction

The International Associations of Athletics Federations (IAAF) was established in Stockholm, Sweden, in 1912. Only a few nations took part in the foundation assembly but when, in 2012, the IAAF celebrates its 100th anniversary, there will possibly be no country in the world that is not a member of this international organisation.

This means that from the point of view of organisation, the development of athletics is an unequalled global success story. Initially, athletics was particularly strong in its home countries, Britain and the United States, but also in some European countries, for example in Finland, Russia, Germany, Sweden and France. In fact, from the beginning, Europe played a dominant role, both in terms of governance and competition. Its competitive power could be seen in all the athletics disciplines, running, throwing, and
jumping and walking, to a more or less equal extent. Australia, New Zealand and South Africa, whose sport traditions are very much influenced by Britain, also played an important role from the start and they have regularly achieved competitive success at the highest levels.

With the end of colonialism and, later, the break up of the Soviet empire, there has been an extensive rearrangement of the world and the foundation of many new states. The distribution of top performers in all sports has also changed. In athletics, this process can be seen very clearly. During the last thirty years, countries around the world have tried to catch up with Europe. In all IAAF Member Federations, the people responsible are trying to keep up with the world class, to build new infrastructure, to train coaches, to guide athletes to reaching the top, and to develop sustainable athletics structures. The IAAF has supported this work by investing millions of dollars each year in its multi-faceted development programme.

However, there are both bright and dark sides to these processes. In only a few countries has there been continuous improvement of general performance levels and in fewer still has athletics developed in such a way that the sport on the national level is self-sustaining and international success can be secured on a long-term basis.

In this article I would like to briefly outline the long-term process of development taking place in athletics and focus on one country that has made great strides in recent years: Brazil.

The Globalisation of Top Performance

On the fringes of Europe, in the former Soviet republics of both Eastern Europe and Asia, international success has been achieved by newly developed structures, with the Ukraine being a prime example. But top performers are regularly emerging from Belarus and occasionally from the other countries of the region as well. Of course, Russia continues to hold a special status at the top of the performance rankings together with the USA.

Further afield, Africa has increasingly enjoyed success in top-level competitions since World War II. At first this was particularly true of the Kenyan middle and long-distance runners but later, Ethiopia, Morocco and other nations appeared on the scene too. However, it was not just in the endurance events. From time to time sprinters from Nigeria, Ghana and Namibia have attracted attention.

And with Jamaica’s Usain Bolt as the latest and greatest in a long line of stars from his region, few people need reminding that as the nations of the Caribbean became independent, their sprinters and jumpers have shone brightly on the world stage.

Asia and South America have also played their own roles. In the case of Asia, it was mainly athletes from Japan and Korea who were initially successful. These countries have also contributed to the running of the sport on the international level and, importantly, staged successful major events. India, on the other hand, with its population of over one billion must be called a negative example, at least from the performance perspective.

But in all the cases mentioned, the number of strong, well-run federations capable of managing and marketing the sport in such a way that it achieves its full potential is limited. Many times we see that top performers are actually developed abroad, at training centres and universities in Europe or the USA, or with such extensive coaching and resource input from other countries, the IAAF, the IOC or other sources that it is impossible to call them home-grown.

Brazil Facts

Area: 8.45 million km²  
Population: 201 million  
Capital: Brasilia - pop. 2.1 million  
GDP per Capita: $ 10,200 (2007)  
Government: Federal Republic, independent from 1822  
Source: www.infoplease.com
The sport of athletics is truly a worldwide phenomenon and increasingly top performers are representing countries from every corner of the globe. But development of the sport is still very much a patchwork. Which means we should take notice and learn from these places where real progress and success have been achieved.

**The South American Giant**

One of the most remarkable countries in international athletics is in South America. Here, during the past thirty years, Brazil has been able to develop structures that are particularly notable and become a leader in the region. Under the guidance of federation president Roberto Gesta de Melo, a strong sport structure has been developed and in many respects it can be regarded as a shining model.

For example, the infrastructure has been optimised in favour of athletics and training centres have been established. Prior to 1987 there was only one synthetic track in the country and it was in poor condition. Currently there are five tracks with the IAAF Level I certification, 11 with the IAAF Level II certification and 10 others in good condition.

---

**Table 1: Brazil’s success in international athletics competitions prior to and since 1987**

<table>
<thead>
<tr>
<th>Competition</th>
<th>1924-1984 (60 years and 14 editions):</th>
<th>1988-2010 (22 years and 6 editions):</th>
<th>Total:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OLYMPIC GAMES</strong></td>
<td>3 gold, 1 silver and 4 bronze</td>
<td>1 gold, 2 silver and 3 bronze</td>
<td>8 medals</td>
</tr>
<tr>
<td><strong>YOUTH OLYMPIC GAMES</strong></td>
<td></td>
<td></td>
<td>6 medals</td>
</tr>
<tr>
<td>Until 1987: Event was not stages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Since 1987: (1 edition): 1 gold and 1 silver</td>
<td></td>
<td></td>
<td>2 medals</td>
</tr>
<tr>
<td>Remark: another gold medal was obtained in the America’s medley relay team</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IAAF WORLD CHAMPIONSHIPS IN ATHLETICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Until 1986: (1 edition): 1 bronze – Total: 1 medal</td>
<td></td>
<td></td>
<td>9 medals</td>
</tr>
<tr>
<td>Since 1987: (11 editions): 5 silver and 4 bronze</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IAAF WORLD INDOOR CHAMPIONSHIPS</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Until 1987: Event was not stages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Since 1987: (13 editions): 2 gold, 5 silver and 5 bronze</td>
<td></td>
<td></td>
<td>12 medals</td>
</tr>
<tr>
<td><strong>IAAF WORLD JUNIOR CHAMPIONSHIPS</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Until 1987: Event was not stages</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Since 1987: (11 editions): 2 gold, 1 silver and 4 bronze</td>
<td></td>
<td></td>
<td>7 medals</td>
</tr>
<tr>
<td><strong>IAAF WORLD YOUTH CHAMPIONSHIPS</strong></td>
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</tr>
<tr>
<td>Until 1987: Event was not stages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Since 1987: (6 editions): 2 gold, 2 silver and 4 bronze</td>
<td></td>
<td></td>
<td>8 medals</td>
</tr>
<tr>
<td><strong>IAAF CHAMPIONSHIPS TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ALL EVENTS AND CATEGORIES)</td>
<td>5 gold and 2 bronze</td>
<td></td>
<td>7 medals</td>
</tr>
<tr>
<td>Until 1986:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Since 1987: 15 gold, 24 silver and 24 bronze</td>
<td></td>
<td></td>
<td>63 medals</td>
</tr>
<tr>
<td><strong>SOUTH AMERICAN CHAMPIONSHIPS TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ALL EVENTS AND CATEGORIES)</td>
<td>620 gold, 517 silver and 433 de bronze</td>
<td>1132 gold, 865 silver and 685 bronze</td>
<td>1570 medals</td>
</tr>
<tr>
<td>Until 1986:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Since 1987:</td>
<td></td>
<td></td>
<td>2682 medals</td>
</tr>
</tbody>
</table>
In the same 34-year period, the national competition structure has been revamped and at the same time the federation has aimed to organise international athletics events more and more frequently in Brazil. Since 1987 there have been 49 international meetings in the country (there were only two before then). Among these events have been many South American championships, international Grand Prix meetings as well as the IAAF World Half Marathon Championships. The efforts to play a strong role in the international system no doubt enhanced Brazil’s standing and contributed positively to the efforts to secure the 2016 Olympic Games in Rio de Janeiro.

Since the election of de Melo in 1987, the country’s athletics network has been systematically improved and has become possible to draw more and more young people, male and female, who want to compete against the best athletes in the world into high-performance athletics. The achievements of these athletes are reflected in the fact that in the senior category a total of 316 national records have been set in 46 of the 47 Olympic programme events since 1987 (the only event where a national record has not been set in this period is the men’s 800m, where the 1984 record of 1:41.77 by Joaquim Cruz remains the 4th best time on the world list).

On the world level, top performances by Brazil’s athletes have become more and more common. In 1986, Brazilians featured in the world top 50 in 10 events (six individual and four relays) with no women in this group. From 1987 to 2009, an average of 21.8 Brazilians made the world top 50 each year and from 2000 to 2009 the average was 29.2. In 2009, Brazilian athletes were in the top 50 in 25 individual events and four relays and this figure includes 11 women.

Brazil’s performances at international major events are summarised in Table 1.

The list of the special performances by Brazilian athletes could be continued. These clearly show that positive national developments in athletics are possible and Brazil seems to be a particularly strong example.

Building on this raising of the national performance level, the federation has also assumed the leading role for the South America Area Group, including responsibility for the IAAF Regional Development Centre and the IAAF High Performance Training Centre, where athletes from other countries come to train and take advantage of Brazilian expertise.

On the basis of a solid financial foundation, the sport of athletics has been systematically amplified, democratic structures have been strengthened, supporting structures have been newly developed, and the participation of children and youths at grassroots level has been continuously increased. All this is accompanied by a positive development of the infrastructures and sustainable support. The work of the federation is exemplary, especially as far as charismatic leadership and systematic management are concerned.

It is to be hoped that Brazil and its athletics federation will continue in this way. In any case, one can be sure that the Olympic Games in Rio de Janeiro will be a helpful support for the further development of Brazilian athletics.
The Formation of Cuban Track and Field Champions

By Ariel Muñiz Sanabria

Introduction

The successful participation of Cuban performers on the world athletics stage can be traced back to sprinter Enrique Figuerola, who after placing fourth in 1960 Olympic Games in Rome, took the 100m silver medal at the 1964 Olympic Games in Tokyo and four years later led the national team to a silver medal in the 4 x 100m relay at the Games in Mexico City.

At the 1976 Games in Montreal, Alberto Juan-torena Danger raised Cuba to the top rank of athletics nations when he won Olympic gold with a brilliant world record of 1:43.50 in the 800m and then came back to take a second gold with his 44.26 in the 400m.

In the decades since, other Cuban athletes have consolidated the country’s position by becoming Olympic and world champions and winning a host of medals in top-level competition. The success of Cuban athletes over the
last half-century can be summarised in the following three points:

1) In the Olympic Games, outdoor and indoor World Championships in Athletics and World Junior Championships, Cuban athletes have won a total of 219 medals, 73 of which have been gold.
2) Medals have been won in 26 disciplines covering the five event groups at the World Championships in Athletics and Olympic Games.
3) Nine Cuban athletes have set 14 world records in the following six events:
   - 100m: Enrique Figuerola, 10.0, Budapest, 17/06/1967 and Silvio Leonard, 9.9, Ostrava, 05/06/1975;
   - 800m: Alberto Juantorena, 1:43.50, Montreal, 25/07/1976, 1:43.44, Sofia, 21/08/1977
   - 110m/h: Alejandro Cazañas, 13.21, Sofia, 21/08/1977 and Dayron Robles, 12.87, Ostrava, 12/06/2008;
   - High Jump: Javier Sotomayor, 2.43m, Salamanca, 09/09/1988, 2.43m (indoor), Budapest, 04/03/1989, 2.44m, San Juan, 29/07/1989, 2.45m, Salamanca, 27/07/1993;
   - Triple Jump: Pedro Pérez Dueñas, 17.40m, Cali, 05/08/1977, Aliecer Urrutia, 17.83m, Sindelfingen, 01/03/1977;
   - Javelin Throw: Osleidys Menendez, 71.54m, Rethimno, 01/07/2001, 71.70m, Helsinki, 14/08/2005.

Keeping in mind that Cuba has a relatively small population base compared to the world’s other top athletics nations (in 1960 there were approximately seven million inhabitants and this figure has grown to about 11.5 million today), its success has been achieved with the support of a well-planned and scientifically-based athletic development process, which has made international researchers, professionals and specialists wonder about the so-called Cuban secret for producing champions.

From that perspective, and in the framework of appropriate “disclosure”, it is worth-while describing the organisational-methodological foundations underlying the sustained development of athletics in Cuba. Three main questions lead to the answers of the most common and important concerns of those wishing to know the key to Cuban success.

1) How has the formation of Cuban athletics champions been maintained for Olympic cycles and even decades?
2) What particularities and guarantees identify the long-term preparation process of the Cuban talents in athletics?
3) How are high-performance athletes trained for success in the top-level competitions?

Foundations for the Formation of Champions

It is important to mention that Cuban athletics, for its particular identity, reflects a genuine development adjusted to the socio-cultural characteristics of the Cuban population. Even though success is mainly the country’s own achievement, the contributions the Polish, German and Soviet schools made during the 1960s and 1970s must be acknowledged. These schools provided their technical force and support for the training of coaches and for the waking-up of a particular philosophy of athletic development.

From then on, Cuba started to develop independently, to innovate and to identify both our potential and the organisational-methodological requirements required to improve the efficiency and efficacy of the athletic training and preparation processes. As a result of this, we can mention today as our main basis of success, the following:

1) A comprehensive pyramidal approach to the athletic development process.
2) Timely specialisation of athletic talents.
3) Methodologies of success in high-performance athletics.
Pyramid Approach

The development of athletic talents in Cuba is based on a pyramidal structure (Figure 1) that includes a strict definition in relation to the objectives of the different ages and competitive categories. Its comprehensive and unified approach sets the path high-performance athletes are to meet in each level, depending on their age. It also establishes the preparation's indicators of interest in each of the areas, sectors and events.

The pyramid, comprising sports schools that until recently were arranged in four steps or levels, sits above the municipal sports areas. These areas, unlike the schools, have a mass participation nature. National and provincial commissions govern entry to and progression in the sport schools.

The first step refers to the Sports Initiation Schools (EIDE), where the best talents of each province are grouped, with children from 12 to 15-16 years old. The wide, multilateral and demanding preparation that takes place in these schools is essentially addressed to mastering the athletics techniques, and also to creating a basis of motor performance for later specialisation.

This motor performance specialisation takes place at the second level, the Provincial Junior Higher Schools for the Formation of High Performance Athletes (ESFA), which is for athletes from 17 to 19 years old. At the provincial level we also have Academies, whose admission category is more open. Thus, at the Academies, we could also have adult athletes.

The third step includes the National Junior ESFA, where the most outstanding athletes of the country are enrolled. The National High-Performance School Games are the most important events for the selection of athletes. This competition is the top event for the athletes trained at the EIDE.

The National Senior ESFA is the fourth and culminating point of the pyramid. Here, the best athletes from the junior category are enrolled; these athletes must meet the minimum requirements demanded.

This has been the formation structure underlying the athletic development process over many years. However, in 2010, because of an economic rationalisation, changes were introduced in the EIDE. Now these schools include athletes until the age of 18, and the Provincial Junior Higher Schools ESFA have been eliminated.

In this pyramid, the aims and the programme for training, the choice of the best athletes, the objectives and the attendance to competitions, the analysis on the performance's evolution and the usefulness of the specialised technical strength potential, constitute elements that are regulated, controlled and updated according to national and provincial sport guidelines – to guarantee efficiency and efficacy all over the training and preparation process.
**Timely Specialisation**

Timely specialisation is a key element in the process. The choice of the right moment and procedure to determine the definite specialisation of talented athletes is regulated by elements whose basis relies on the pragmatic vision of the methodological and technical action of coaches.

Nevertheless, a problem that affects Cuban athletics, like athletics in any part of the world, is the control in the application of the ideal training loads by ages. Specialisation in early ages is a phenomenon still to be accurately defined in Cuban athletics. For this reason, methodological strategies have been implemented in order to address the work to the most important objectives, depending on the athletes’ stage of development.

This conception must be improved, because studies (MUNIZ SANABRIA, 1995, 1998, 2005) show that in some disciplines adequate organisation for efficiently achieving the pyramidal approach to athletic development, which could lead to the production of world top athletes, is missing. Unlike the more technical disciplines (jumps, throws, hurdles, combined events), the sprints and endurance races in Cuba have not reach the best development because of the bad use of the pyramidal structure and inappropriate specialisation in a long-term process.

For example, MUNIZ SANABRIA (1998) shows that 16 (72.7%) out of the 22 best Cuban middle- and long-distance runners started practicing athletics only in the last period of the school category (15-16 years old) and only six (27.3%) of them studied at EIDE schools. The data also show us that just a few of those taking part in all the pyramidal stages are included among the best middle- and long-distance Cuban runners of all times. So, it is important to consider “the champion tendency” as an essential element to be changed by endurance runners. This tendency is the result of an intensive specialisation performed at an early age, which opposes the objectives of the long-term development.

**Methodologies of Success**

Those athletes who enrol immediately after childhood in the high performance pyramid represent the success of the Cuban model and its comprehensive conception for producing top-level athletes. The performances of these athletes are the result of training methodologies validated by a practical-experimental process and applied to young people and adults for many years. These methodologies are always improved, like those implemented for the throwing events, long jump and 110m hurdles, where the results have been four Olympic champions and two world record holders.

We focus here on the training methodology for 800m, where the event is viewed as a sprint based on the principle of simultaneous or basic complementation specialisation in 400m. Throughout the years, the most important representatives of this approach have been Blas Beato (1980-1990) and Amarilis Hernández (1990-2000). Unlike the methodology normally applied for middle- and long-distances, this methodology has been more effective and has characterised the process that has allowed Cuban 800m runners to be among the world’s elite. The main examples of athletes whose results come from this methodology are:

1) Alberto Juantorena Danger, double Olympic champion (400m and 800m) in the 1976 Olympic Games and winner at the 1977 World Cup;


3) Norberto Téllez, Pan-American champion (400m) in Mar del Plata 1995 (45.38) 4th place (800m) in Atlanta 1996 and silver medal (800m) in the 1997 World Championships in Athletics.
Table 1: Summary of the competitive activity of Alberto Juantorena, Anna Fidelia Quirot and Norberto Téllez

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Years competed in</td>
<td>9</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>The 400m and 800m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>400m races</td>
<td>134</td>
<td>237</td>
<td>152</td>
</tr>
<tr>
<td>800m races</td>
<td>72</td>
<td>174</td>
<td>113</td>
</tr>
<tr>
<td>Race proportion</td>
<td>53.7% - 46.3%</td>
<td>63.3% - 36.7%</td>
<td>57.4% - 42.6%</td>
</tr>
<tr>
<td>4x400m races</td>
<td>34</td>
<td>68</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 2: Comparison of the training of Alberto Juantorena and Norberto Téllez in Olympic seasons

<table>
<thead>
<tr>
<th>Indicators</th>
<th>A. Juantorena, 1976</th>
<th>Norberto Téllez, 1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning of the macro-cycle</td>
<td>November 3rd, 1975</td>
<td>September 18th, 1996</td>
</tr>
<tr>
<td>First competition</td>
<td>April 16th, 1976 (800m)</td>
<td>March 1st, 1996 (800m)</td>
</tr>
<tr>
<td></td>
<td>April 17th, 1976 (400m)</td>
<td>March 2nd, 1996 (400m)</td>
</tr>
<tr>
<td>400m competitions</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>400m races</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>800m competitions</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>800m races</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>4x400m races</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Olympic Final</td>
<td>July 25th, 1:43.50 (1st)</td>
<td>July 31st, 1:42.85 (4th)</td>
</tr>
</tbody>
</table>

Table 3: Athletic development and progression of Yoelvis Quesada

<table>
<thead>
<tr>
<th>Age</th>
<th>School</th>
<th>Performance</th>
<th>Competitive Achievements</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 (86)</td>
<td>Sports Initiation School</td>
<td>60m (8.5), Long Jump (4.91m), High Jump (1.30m), 80 c/v (14.0), Pole Vault (1.90m), 1000m (3:19)</td>
<td>– Participation at the High Performance School National Games (JENAR, Spanish abbreviation)</td>
</tr>
<tr>
<td>15 (88)</td>
<td></td>
<td>14.77m</td>
<td>– Champion of the JENAR</td>
</tr>
<tr>
<td>16 (89)</td>
<td>National Junior Higher School for Athletes Formation</td>
<td>16.11m</td>
<td>– Champion of the JENAR (15.73m), World Junior Runner-up</td>
</tr>
<tr>
<td>17 (90)</td>
<td></td>
<td>16.68m</td>
<td>– Junior and Senior Pan-American Champion.</td>
</tr>
<tr>
<td>18 (91)</td>
<td></td>
<td>17.13m</td>
<td>– World Championship Finalist</td>
</tr>
<tr>
<td>19 (92)</td>
<td></td>
<td>17.23m</td>
<td>– World Junior Champion and World Cup Champion. Olympic Finalist</td>
</tr>
<tr>
<td>20 (93)</td>
<td>National Senior Higher School for Athletes Formation</td>
<td>17.68m</td>
<td>– World Championship Finalist</td>
</tr>
<tr>
<td>21 (94)</td>
<td></td>
<td>17.61m</td>
<td>– World Cup Champion</td>
</tr>
<tr>
<td>22 (95)</td>
<td></td>
<td>17.67m</td>
<td>– World Runner-up</td>
</tr>
<tr>
<td>23 (96)</td>
<td></td>
<td>17.75m</td>
<td>– Olympic Bronze Medallist</td>
</tr>
<tr>
<td>24 (97)</td>
<td></td>
<td>17.85m</td>
<td>– World Champion</td>
</tr>
</tbody>
</table>

Another methodology of specialised high-performance success is addressed to bringing triple jumpers into the world elite. In this event, Cuba has had champions at all competitive levels, as well as two world record-holders: Pedro Pérez Dueñas, 17.40m in 1971 and Alicer Urrutia, 17.83m (indoor) in 1997.

The methodology’s efficiency has been proved as 20 male athletes have exceeded 17m and 15 female athletes have gone over 14m.

We also have to mention that in four world championships we have seen two Cuban athletes placed among the medallists:

- at the 1997 World Indoor Championship in Paris, Yoel García (17.30m) and Alicer Urrutia (17.27m) became champion and runner-up respectively;
- at the 1997 IAAF World Championship in Athletics in Athens, Yoelvis Quesada (17.85m) became the champion and Alicer Urrutia (17.64m) obtained a bronze medal;
• at the 2009 World Championships in Athletics in Berlin, Yargelis Savigne (14.95m) and Mabel Gay (14.61m) were the athletes who climbed to the top of the podium at the awards ceremony;
• at the 2010 World Indoor Championships in Doha, Yoandri Betanzos (17.69m) and Arnie David Girat (17.36m) obtained the silver and bronze medals respectively.

In this event, the 1997 world champion Yoelvis Quesada is an example of the superior model, which shows the formation of a champion starting from the organizational and methodological bases ruling the Cuban athletes’ long-term process.

Conclusions

1. The sustained development of Cuban athletes in the training of champions is based, among other aspects, on the comprehensive pyramidal approach linked to the preparation of talented athletes, consistent with the long-term preparation objectives. With this approach, timely specialisation is essential for the athletic development of the talented athletes, in order to improve their performances and goals in the different age categories.

2. Appropriate specialisation at each step of the athlete’s development are essential to reach the culminating point in the training and preparation process. The use of authentic methodologies leads to results that guarantee the inclusion of athletes in the world elite. This has been the basis of the outstanding results by Cuban athletes across a variety of disciplines in the world’s top athletics competitions.

BIBLIOGRAPHY


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The Evolution of the Combined Events: Is a One-Day Decathlon Possible?

By Anatoliy Fatieiev

ABSTRACT

One of the most difficult problems of the combined events is that the dynamics of the competition are clear to specialists but not so to the average fan or television broadcasters, are not interested to follow the full competition. This is hardly surprising as in a decathlon held in accordance with the current regulations, each athlete spends eight to nine minutes directly performing during a programme that can run up to 10 hours per day for two days. The aim of this article is to draw specialists and non-specialists into a discussion about the future of the event. After listing examples of innovative formats that have been tried in recent years, the author outlines a model that drastically reduces the time required for the jumping and throwing disciplines and calculates that a decathlon with 15-20 competitors could be completed in 10 hours. After considering the organisational challenges of staging the event in this way, he concludes that a one-day decathlon is possible.

AUTHOR

Anatoliy Fatieiev is currently an Associate Professor in the Institute of Physical Education and Sport at the Luhansk National University in Ukraine. He has coached combined events for more than 35 years, held national coaching positions in Oman, India and Saudi Arabia, and has been recognised as an Honoured Coach of Ukraine. A number of his athletes have participated in the Olympic Games and major championships, including Lev Lobodin, who won a bronze medal at the 1994 European Athletics Championships IAAF High Performance Centre in Havana.

The combined events are among the most prestigious competitions in modern athletics. They represent a very specific challenge with unique features. Although the IAAF set the key competition regulations for the decathlon, including the order of the ten disciplines, at its 1914 Congress, it is well known that since then there have been many alterations to both the men’s and women’s combined events. Changes include the scoring systems and temporal characteristics of the competitions, while in the case of...
the women’s event there has been an addition to the number of disciplines. These changes have mainly been aimed at making the competitions more interesting for the athletes and more entertaining for the fans.

But times continue to change. The social situation, the psychologies of both spectators and athletes, and approaches to sport training have all developed. And what is more, other events have become more dynamic.

One of the most difficult problems of the combined events is that the dynamics of the competition are clear to specialists but not so to the average fan. The long duration (two days) requires much attention and cannot be compared with other events, which have opposite temporal and dynamic characteristics. In a decathlon held in accordance with the current regulations, each athlete spends eight to nine minutes directly performing the competitive disciplines during a programme that runs from six to eight, sometimes 10, hours per day. Television broadcasters are not interested in covering the full competition and the bulk of information is televised fragmentarily – only parts of some disciplines and only at the most important meetings.

It is hardly surprising that there are difficulties in arousing the interest of the spectators, mass media audiences, sponsors and advertisers. Some sports journalists have even proposed excluding the combined events from the Olympic Games. Coupled with a general discussion about reducing the Olympic programme, this should be an alarm signal for the IAAF.

It seems that more dynamic approaches are called for in the 21st century. This is not lost on people in sport. For many years, specialists have been discussing the question of the temporal parameters in the combined events and we have seen how other sports, including volleyball, rugby, cricket and even football, have successfully created new models of their events that are both shorter and more attractive for spectators and media.

In this context, I would like to discuss a proposal for change in the combined events. The main aim is to invite specialists and non-specialists to contribute, study and systemise ideas that could give a new impulse to development in this area. The focus of my proposal is on considerably shortening the competition time, which to my mind will positively affect the dynamics of the competitions, require less financial means for conducting the competitions, make the work of the competition officials easier and better arouse the interest of the mass media, television in particular. I have analysed the facts and modelled a variant format, the one-day decathlon, which meets the demands of the current situation.

It should be noted that enthusiasts have been experimenting with different formats of short-time combined events competitions for many years. These have been staged using regulations approved by the organising committees. Athletes from my own training groups have taken part in some such competitions:

2) 45 Minutes Pentathlon (1998, Prague, Czech; Director – Jiri Jon).
3) 1 Hour Decathlon (1992-1994, Ostrava, Czech; Director – Robert Zmelik).
4) 1 Hour Decathlon (1995-1997, Salzburg, Austria; Directors – Karin Juriga + Dietmar Juriga).
5) 2 Hours Decathlon (1995, Prague, Czech; Director – Robert Zmelik).
6) 1 Hour Women’s Decathlon / experiment (1997, Linz, Austria)

The best result recorded for the 1 Hour Decathlon, 7897 points, was by the Robert Zmelik (CZE) just a few weeks after his Olympic win in 1992.
Taking into account the fact that the IAAF has officially recognised the women’s decathlon (at the 2001 Congress in Edmonton, Canada) and several countries have already held championships for the event, my proposal concerns both men’s and women’s decathlon. It should be mentioned that several women athletes have already tried short-time decathlons and the best known result is by Mona Steigauf (GER), who scored 7351 points in a 1 Hour Decathlon in 1997.

My analysis of the preparation, organisation and process of such competitions leads to the conclusion that a one-day decathlon is both possible and precisely the variant transformation of the combined events that would be least difficult achieve and have all the positive effects required.

As I said above, my aim with this article is to draw people into a discussion and stimulate development of the combined events. Any contributions and ideas would be most appreciated and should be sent directly to my e-mail address.

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10thlon51@gmail.com.

It is obvious that competitions organised using my model would initially present challenges for both the competition officials and organisers, but there is no doubt that the new dynamics of the competition would bring excitement and keen competition between the athletes. Moreover, competitions organised according to such rules would heighten the interest of spectators and television as everything happens during one day: in the morning the participants are introduced before the first event and in the evening everybody sees the winners on the podium.

My analysis of the preparation, organisation and process of such competitions leads to the conclusion that a one-day decathlon is both possible and precisely the variant transformation of the combined events that would be least difficult achieve and have all the positive effects required.

As I said above, my aim with this article is to draw people into a discussion and stimulate development of the combined events. Any contributions and ideas would be most appreciated and should be sent directly to my e-mail address.

The Evolution of the Combined Events: Is a One-Day Decathlon Possible?
Documentation

contents

- Selected and Annotated Bibliography
- Book review
- Technology Report
- Abstracts
- Preview
No. 92: The Sprint Events

By Jürgen Schiffer

Introduction

The sprints are the most extensively covered events by NSA bibliographies, which underlines the immense interest in sprint research and training-oriented literature.

This is the sixth bibliography about sprint training. The first was published in the very first issue of NSA (1/1986) and contained 87 sources published between 1981 and 1985. The second was published in issues 1 and 2 of 1991 and included 74 sources published between 1986 and 1991. The third appeared in issue 1 of 1995 and included 116 documents. The fourth was published in issue 2+3/1996 and contained a total of 73 documents, most of which were from the years 1994 to 1996. The fifth appeared in issues 4/2006 (part 1) and 1/2007 (part 2) and contained 260 articles, books and book chapters from the years 1990 until the end of 2006.

The following bibliography contains 80 articles and books about the sprints from the years 2007 until 2011. The publications deal with both the short and long sprints. The following items deserve particular attention:

An informative overview of the historical development of sprinting technique and training is presented by BERNHART (2010, 2011). He deals, among other things, with the question whether sprinters are born or made or whether it is talent or hard work that counts. Additional aspects covered are technique training, the importance of training volume and intensity and the role of the speed barrier. The focus of the second part of the article is on the sprinting technique in the different movement phases. Bernhart arrives at the conclusion that the modern sprinting technique (exemplified by Usain Bolt) differs from the technique of the past (Valeriy Borsov) by a greater emphasis on the reaching movement prior to the touchdown of the front foot. Since the 1970s and 80s, the forward support phase has been considered almost equally important as the rear support phase for propulsion. This change of the point of view has also led to attributing more importance to the muscles that are responsible for the extension of the hip. Today, the efficient technical execution of the swing and support-pull phase as well as the strengthening of the muscles responsible for his action are regarded as the main factors for achieving a high running velocity in the “free sprint”.

The question whether a constant sprint-to-rest ratio allows full performance recovery between repeated sprints over different distances and also whether active recovery enhances sprint performance is dealt with by ABT et al. (2011). The authors used three repeated sprint protocols (22 × 15, 13 × 30, and 8 × 50 m), each having an active and passive recovery. Each trial was conducted with an initial sprint-to-rest ratio of 1:10. Repeated sprints were analysed by comparing the first sprint to the last sprint. Taken as a whole, the results demonstrate that a 1:10 sprint-to-rest ratio allows full performance recovery between 15m sprints, but not between sprints of 30m or 50
and that recovery mode did not influence repeated performance.

Resisted sprint running is a common training method for improving sprint-specific strength, but it is sometimes controversial. This discussion focuses on, among other aspects, the specificity of this training method. It is a common point of view that, for maximum specificity of training, the athlete’s movement patterns during the training exercise should closely resemble those used when performing the sport. Against this background, the purpose of the study conducted by ALCARAZ et al. (2008) was to compare the kinematics of sprinting at maximum velocity to the kinematics of sprinting when using three types of resisted sprint training devices (sled, parachute, and weight belt). Eleven men and 7 women participated in the study. The authors found that the three types of resisted sprint training devices are appropriate devices for training the maximum velocity phase in sprinting. These devices exerted a substantial overload on the athlete, as indicated by reductions in stride length and running velocity, but induced only minor changes in the athlete’s running technique. When training with resisted sprint training devices, the coach should use a high resistance so that the athlete experiences a large training stimulus, but not so high that the device induces substantial changes in sprinting technique. The authors recommend using a video overlay system to visually compare the movement patterns of the athlete in unloaded sprinting to sprinting with the training device. In particular, the coach should look for changes in the athlete’s forward lean and changes in the angles of the support leg during the ground contact phase of the stride.

The influence of parachute-resisted sprinting on running mechanics in collegiate track athletes was examined by PAULSON & BRAUN (2011). They compared the acute effects of parachute-resisted (PR) sprinting on selected kinematic variables. Twelve collegiate sprinters ran a 40 yards under two conditions: PR sprint and sprint without a parachute (NC) that were recorded on a video computer system (60 Hz). Sagittal plane kinematics of the right side of the body was digitized to calculate joint angles at initial ground contact (IGC) and end ground contact (EGC), ground contact (GC) time, stride rate (SR), stride length (SL), and the times of the 40-yd dashes. The authors found that while sprinting with the parachute, the athlete’s movement patterns resembled their mechanics during the unloaded condition. This indicates the external load caused by PR did not substantially overload the runner, and only caused a minor change in the shoulder during push-off. The parachute used in this study can therefore be called a sports-specific training apparatus which may provide coaches with another method for training athletes in a sports-specific manner without causing acute changes to running mechanics.

Another topical question often dealt with in the context of resisted runs is whether this training method should be used with children. This question is dealt with by MÄDE (2007). He states that especially in the young age classes until the completion of puberty training-induced improvements in performance are overlapped by purely growth-related changes. Therefore, the effects of training can be estimated only with difficulty. Against this background, training exercises with resistive runs in sprint training that transform the running training into a special strength training should be treated with great caution. According to MÄDE, with young athletes, general and simple stress stimuli are sufficient to achieve performance improvements and only later are more specific and more complex load stimuli necessary. From a training-methodological point of view, resistive loads in speed training should be reserved for athletes of 16 years of age and older.

The opposite of resisted runs are pull-assisted runs to help the athlete achieve supramaximal velocities. Here, too, the question of specificity is crucial. This topic is dealt with by CLARK et al. (2009). The purpose of their study was to determine the influence of towing force magnitude on the kinematics of supramaximal sprinting. Ten high school and college-age track and field athletes (6 men, 4 women) ran...
60m maximal sprints under five different conditions: Nontowed, Tow A (2.0% body weight [BW]), Tow B (2.8% BW), Tow C (3.8% BW), and Tow D (4.7% BW). The authors arrive at the conclusion that towing force magnitude does influence the kinematics of supramaximal running and that potentially negative training effects may arise from towing individuals with a force in excess of 3.8% BW. It is therefore suggested that coaches and practitioners adjust towing force magnitude for each individual and avoid using towing forces in excess of 3.8% of the athlete’s BW.

It is clear that at least since the 2008 Olympic Games the phenomenal sprint records set by Usain Bolt have made researchers curious what the reasons for these performances might be. The question how fast Bolt might run in the future is dealt with by LOCATELLI (2009) on the basis of a section analysis of Bolt’s 100m world record race in Beijing. LOCATELLI made his own simulation of the 10m splits although he does not present it as a scientific work. His approach, after having contacted the IAAF’s broadcast partners, is based on analysis of the video produced by the RAI (the Italian broadcaster) using “Dartfish software”. Of particular interest is the split for the last 10m. The author calculated 0.89 sec. It is not unreasonable to say that if Bolt had continued to run without any showmanship he could have covered the last 10m in around 0.86 sec, which would have given a time of 9.66 sec.

The question “What is it that makes the Jamaican athletes so fast?” is also focused on in the article by SCHRADER, MÜLLER & KILLING (2008). The following three hypotheses are examined: 1. The Jamaicans have a genetic predisposition to sprinting in the form of a disproportionate great muscle-fibre concentration of A actines, which supports the fast “twitching” of their muscle fibres. However, there is no exact scientific evidence to support this theory. What is certain is only that Jamaicans have other muscle fibres than Europeans. 2. Athletics is the most popular sport in Jamaica. An athletics career is a possible way out of poverty. 3. The climate in Jamaica is tropical and characterised by northeast trade winds. Also, due to the small temperature differences in the course of the year the training conditions are very good. The following especially applies to Usain Bolt: Bolt’s strength is his active touch-down in the front support phase, which is initiated by the rapid and strong heel kick in the swing phase. The touchdown takes place almost directly under his CG, which means that strong braking effects are avoided. Like Borsov in the 1980s, Bolt demonstrates a marked extension of the rear support leg. The authors arrive at the conclusion that because of his technique, ideal physical conditions (including a body height of 1.93 m) and his speed endurance abilities (he ran the second 100 metres in the 200m victory in Beijing in 9.32 sec), Bolt might be able to increase his 200m performance and that, perhaps, he might also be able to break the 400m world record one day.

VONSTEIN (2010) holds that the long-term training buildup already at young age creates accents that are responsible for the Jamaican sprinters’ superiority at least to a certain extent. This means that speed is developed and accentuated rather early and much value is attributed to general athletic development. There is an early and comprehensive coordinative and technical training in order to target important movements. In high-performance training itself, the relationship between loading and unloading is meticulously respected. Jamaican sprinters also try to not move too far from the intensity level of the target performance even in the preparatory phases (in top athletes about 1.5%). However, VONSTEIN also says that doping might be an explanation for the considerable performance differences between European and Jamaican sprinters.

Observations of Usain Bolt at the 2009 IAAF World Championships in Berlin made by MAY (2009) show that instead of the classic warm-up jogging, Usain Bolt prefers a warm-up procedure with mobilisation by a physiotherapist. Such a warming-up procedure may be useful in the case of high temperatures or when there are several qualifying rounds. MAY also observed that because of his strength abilities,
Bolt is in a position to keep his upper body quiet and to do without any evasive movements. Bolt seems to have a very pronounced trunk stability, which enables him to translate his active leg and arm actions into maximum speed. During the front support phase, Bolt’s touchdown is active and almost under his centre of gravity (CG). He brings his swing leg very close to his buttocks and moves it forward very fast. Using a pronounced front swing phase, he gets into the support actively and produces only slight braking effects. What is particularly impressive about Bolt’s performance is that in spite of his speed he remains very relaxed.

Particularly against the background of the recent IAAF World Championships in Athletics in Daegu, where for the first time a physically disabled athlete was allowed to compete against non-disabled world-class 400m runners, the article by POTTHAST & BRÜGGE-MANN (2010) is very interesting reading. They analysed Oscar Pistorius’ sprint mechanics in the phase of maximum running speed compared to 400m sprinters with no disability and similar levels of performance. The most notable finding of the study was the large differences in the energetic contributions from knee and ankle on both sides between Pistorius and the athletes without disabilities in the control group (CG). In the CG participants, the relative contributions of knee and ankle were more evenly distributed than in Pistorius, whose knee joint provided no significant energetic contribution to the phase of maximum velocity. Here, almost the entire contribution of the lower limb resulted from the work done in the artificial ankle. Since in the competition prosthesis there is an energy dissipation of about 5%, which means that about 95% of the energy stored in the first phase are returned, the prosthesis acts almost like an ideal elastic spring. In the ankle of athletes without disabilities, however, almost half (46%) of the absorbed energy is not returned. This means that Pistorius, as soon as he has reached a certain speed and thus kinetic energy, is able to store a significant proportion of his energy in the first half of the support phase in the prosthesis in the form of deformation energy, and that in the second half of the support phase, he is returned almost the entire amount of energy purely passively. This movement strategy, which can be described as almost ideal elastic “cushioning” or “bouncing”, differs markedly from the motion of all athletes in the control group. The generation of joint energy in athletes without a disability is always done in connection with muscular work. This also becomes clear from the significantly higher external knee extension moments of the control athletes. These external moments must essentially be counteracted by muscle force. Apparently, Pistorius’ strategy enables a sprinting action with a lower vertical movement of the CG (reduced vertical reaction force impulses) and with reduced braking impulses. It is noted that Pistorius’ mechanics of movement while sprinting in the phase of maximum velocity is fundamentally different from the mechanism of control sprinters of similar performance class. This applies both to the CG-related parameters including the energetic contributions of the joints of the lower extremity.

This bibliography has been compiled by using
- SPOLIT, the sports literature database of the Federal Institute of Sport Science (BISp) in Cologne, Germany (www.bisp-datenbanken.de, free access), and
- SPORTdiscus, the database of the Sport Research and Information Centre in Ottawa, Canada (www.sirc.ca, no free access).

In addition, some of the articles were found by a “free search” in the Central Library of Sports Science at the German Sports University in Cologne and others are from the private library of the author.

Readers interested in obtaining one or more articles from this bibliography should contact:
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As always, this bibliography, though extensive, does not claim to be complete.
The purpose of this study was to compare the kinematics of sprinting at maximum velocity to the kinematics of sprinting when using three types of resisted sprint training devices (sled, parachute, and weight belt). Eleven men and 7 women participated in the study. Flying sprints greater than 30 m were recorded by video and digitized with the use of biomechanical analysis software. The test conditions were compared using a 2-way analysis of variance with a post-hoc Tukey test of honestly significant differences. We found that the 3 types of resisted sprint training devices are appropriate devices for training the maximum velocity phase in sprinting. These devices exerted a substantial overload on the athlete, as indicated by reductions in stride length and running velocity, but induced only minor changes in the athlete’s running technique. When training with resisted sprint training devices, the coach should use a high resistance so that the athlete experiences a large training stimulus, but not so high that the device induces substantial changes in sprinting technique. We recommend using a video overlay system to visually compare the movement patterns of the athlete in unloaded sprinting to sprinting with the training device. In particular, the coach should look for changes in the athlete’s forward lean and changes in the angles of the support leg during the ground contact phase of the stride.


The 400m is generally considered to be a highly anaerobic race, but the findings of various researchers on the percentage contributions of anaerobic and aerobic energy mechanisms are not consistent. Drawing on a selection of publications, this article looks at how the energetic characteristics of the event are studied and explains the reasons behind the variation in findings. It considers 1) differences between men and women athletes, 2) differences between sprinter and endurance type athletes, 3) the influence of different methodologies and 4) differences caused by the performance level of the athletes studied. The authors find that performance capacity represents the most impor-

Bibliography


It is unclear if a constant sprint-to-rest ratio allows full performance recovery between repeated sprints over different distances. This is important for the development of sprint-training programs. Additionally, there is conflicting evidence on whether active recovery enhances sprint performance. Three repeated sprint protocols were used (22 × 15, 13 × 30, and 8 × 50 m), with each having an active and passive recovery. Each trial was conducted with an initial sprint-to-rest ratio of 1:10. Repeated sprints were analyzed by comparing the first sprint to the last sprint. For the 15-m trials, there were no significant main effects for recovery or time and no significant interaction. For the 30-m trials, there was no main effect for recovery, but a main effect for time \( F[1,10] = 15.995, p = 0.003; \) mean difference = 0.20 seconds, 95% confidence interval \( \text{CI} = 0.09-0.31 \text{ seconds, } d = 1.4 \) [large effect]. There was no interaction of recovery and time in the 30-m trials. For the 50-m trials, there was no main effect for recovery, but a main effect for time (\( F[1,10] = 34.225, p = 0.0002; \) mean difference = 0.39 seconds, 95% \( \text{CI} = 0.24-0.55 \text{ seconds, } d = 1.3 \) [large effect]). There was no interaction of recovery and time in the 50-m trials. The results demonstrate that a 1:10 sprint-to-rest ratio allows full performance recovery between 15-m sprints, but not between sprints of 30 or 50 m, and that recovery mode did not influence repeated sprint performance.


Resisted sprint running is a common training method for improving sprint-specific strength. For maximum specificity of training, the athlete’s movement patterns during the training exercise should closely resemble those used when performing the sport.


The 400m is generally considered to be a highly anaerobic race, but the findings of various researchers on the percentage contributions of anaerobic and aerobic energy mechanisms are not consistent. Drawing on a selection of publications, this article looks at how the energetic characteristics of the event are studied and explains the reasons behind the variation in findings. It considers 1) differences between men and women athletes, 2) differences between sprinter and endurance type athletes, 3) the influence of different methodologies and 4) differences caused by the performance level of the athletes studied. The authors find that performance capacity represents the most impor-
tant quantitative factor for explaining the different percentages of intervention of the energy mechanisms. They also look at oxygen consumption and suggest an increase in pH level in the first 150-200m inhibits Type II muscle fibres from using the aerobic mechanism in the later stages of the race.

Askling, C.; Thorstensson, A.
Hamstring muscle strain in sprinters
Hamstring muscle strains are common in athletics, especially in the sprints and jumping events, and often cause extended absences from training and competition. At present, there are no studies systematically following acute hamstring strains over time with repetitive clinical examinations and correlating the findings with the actual time to return to sport. Magnetic Resonance Imaging (MRI) offers a means of non-invasively determining the location and extent of a hamstring strain. Since MRI investigations are both expensive and demand expert evaluation, simpler clinical assessment methods would be preferable. Such methods have, however, to be validated with parallel MRI-investigations. The aim of this study was to systematically follow the first six weeks after acute first-time hamstring strains in sprinters, with respect to an injury situation, injury location and extent of the injury, recovery of strength, flexibility and function, as well as possible relationships between clinical and MRI findings and time to return to sport during a follow-up period of two years. This project was named the overall winner in the 2008 European Athletics Innovation Awards.

Babic, V.; Delalijah, A.
Reaction time trends in the women's sprint and hurdle events at the 2004 Olympic Games
New Studies in Athletics, 24, (2009), 1, pp. 49-57
Reaction time values, though very small, can differentiate overall performance results in sprint races, where the margin of victory is often measured in thousandths of a second. The purpose of this research was to study the reaction time characteristics for the athletes competing in the women's sprint and hurdles events at the 2004 Olympic Games in Athens and to determine differences between events and between the competitive levels of the athletes. The sample of 250 female athletes was selected from the list of competitors and divided by event and by how far the athletes advanced in their competitions (qualification rounds, semi-finals and finals), which defined their competitive level. The results showed statistically significant differences between the events, confirming the findings of earlier studies. Although no statistically significant differences between the competitive levels were found in most of the events, certain differences were established in the 100m, 400m and 100m hurdles. In the 100m and 400m, the differences showed a negative trend, while the 100m hurdles showed a positive trend. Based on these findings, reaction time can be considered as one of the possible determinants of athletes’ competitive quality. In a separate article, the results presented here are compared to those of the male participants at the Games.

Babic, V.; Delalijah, A.
Reaction time trends in the sprint and hurdle events at the 2004 Olympic Games: differences between male and female athletes
New Studies in Athletics, 24, (2009), 1, pp. 59-68
Reaction time values, though very small, can differentiate overall performance in sprint races, where the margin of victory is often measured in thousandths of a second. This study, the second from a project examining the sprint and hurdle events at the 2004 Olympic Games in Athens, aimed to determine the differences in reaction times between male and female athletes. The results confirm previous findings that mean reaction time values are less for men than for women. However, unlike with the women, statistically significant differences for different competitive levels (defined by how far the athlete advanced in the competition) within the analysed events were not found for the men and, therefore, it was not possible to use reaction time as a parameter for drawing conclusions about competitive quality. It was found that men had significantly better mean reaction time values at all levels in three events: 100m, 110m hurdles and 400m hurdles. Interestingly, men had better reaction times only at the lower competitive levels of some events (first and second rounds) while the men and women finalists in most events did not differ significantly in reaction time. In the 200m men and women did not differ in reaction time at any level.
The main aim of the crouch start is to create optimally large horizontal components of accelerating forces in the shortest possible time and to maintain the frequency of the applied forces after leaving the block. Starting from this fact, the author describes the technique of the crouch start: 1. “On Your Marks” position, 2. “Set” position, and 3. starting action – „Gun“.

Böttcher, J.
Messung der Schrittgestaltung im Maximalsprint mit Optojump [Measurement of the stride pattern using Optojump]
Zeitschrift für angewandte Trainingswissenschaft, Aachen, 16, (2009), 2, 100-110
One Optojump measuring system has been applied for sprint and jump tests as part of talent diagnosis. Ground contact time was considered to deliver hints for talent diagnosis. But it turned out that without a consideration of body height and speed of the athlete no assessment of contact time was possible. Because ground contact depends on the kinematic relation between distance and speed, and speed was measured, only the path/distance remained variable. Here the course of the centre of gravity starting from frontal support to push-off is described as angular path. It strongly depends on support technique and body height. The relation between body height and angular path is significant. Thus for a mean support technique an angular path of 57 % of the body height can be expected. Based on the angular path that (in per cent) depends from body height the measured speed a prognostic ground contact time can be calculated. The difference between prognostic and real ground contact time proved whether an athlete performed with a relatively short or long contact time. Since the individual relative ground contact time was caused by the design of support technique we had to study in which way support technique could be trained. Thus performance factors of track sprinters and bobsleigh athletes have been compared.

Barrett, P.
Sprint start
Modern Athlete and Coach, Adelaide, 48, (2010), 1, pp. 10-12
The main aim of the crouch start is to create optimally large horizontal components of accelerating forces in the shortest possible time and to maintain the frequency of the applied forces after leaving the block. Starting from this fact, the author describes the technique of the crouch start: 1. “On Your Marks” position, 2. “Set” position, and 3. starting action – „Gun“.

Beckmann, H.
Starten wie ein Champion oder wie’s am schnellsten ist? Den Tiefstart pädagogisch interpretieren [Starting like a champion or starting as fast as possible. The crouch start interpreted from a pedagogical point of view]
From a biomechanical point of view, the goal of the sprint crouch start is getting the sprinter into an optimal position for a fast and explosive start. In the crouch start the sprinter’s centre of gravity is far in front of his or her feet so that he or she can produce an optimally long acceleration phase by pushing off forcefully from the blocks. Based on a picture sequence, the author shows which prerequisites pupils between 14 and 16 years of age should fulfil so that the crouch start really leads to a faster starting action.

Bernhart, J.
Die Entwicklung des Sprints [The development of the sprint]
The following aspects of the sprint are dealt with in the first part: 1. Historical development of the sprint; 2. the training of the 100m sprinter: Are sprinters born or made?; Talent vs. hard work; Technique training; Training volume and intensity; Speed barrier. The focus of the second part of the article is on the sprinting technique in the different movement phases. The author arrives at the conclusion that the modern sprinting technique (Usain Bolt) differs from the technique of the past (Valeriy Borsov) by a greater emphasis on the reaching movement prior to the touch-down of the front foot. Since the seventies and eighties it is not only the rear support phase which is regarded as responsible for propulsion but the forward support phase is regarded as almost equally important. This change of the point of view has also led to attributing more importance to the muscles that are responsible for the extension of the hip. Today, the efficient technical execution of the swing and support-pull phase as well as the strengthening of the muscles responsible for his action are regarded as the main factors for achieving a high running velocity in the “free sprint”.

Böttcher, J.
Messung der Schrittgestaltung im Maximalsprint mit Optojump [Measurement of the stride pattern using Optojump]
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Motor control plays a vital role in sprinting, and can greatly affect the outcome of a race when it comes down to sprinters’ differing reaction times to the starter’s gun. The processes within the CNS, including the regions of the brain that contribute to smooth, accurate and continual movement of limbs are all responsible for the responses seen within a sprinter. Sensory inputs, which may be auditory, visual or proprioceptive, are interpreted by the brain and the effectiveness of the motor neurons in relaying these messages to the sprinter’s muscles during the race are fundamental to their success. The nervous system also determines a sprinter’s feedback throughout the race, enabling the Sprinter to constantly assess his position and performance. Perhaps the most important aspect of motor control with regards to the 100m sprint is reaction timeethe phases of which (premotor and motor time) are affected hugely by the sprinter’s neuromuscular conditioning. Speed and resistance training, along with practicing reaction time drills can all help to improve a sprinter’s reaction time. Motor control and the relative anatomical, neurological and physiological processes that occur in the human body are therefore essential for both elite and aspiring athletes when it comes to a race such as the 100m sprint.

Browne, J.
Motor control in sprinting
Track Coach, Mountain View, (2010), 191, pp. 6111-6113

Motor control plays a vital role in sprinting, and can greatly affect the outcome of a race when it comes down to sprinters’ differing reaction times to the starter’s gun. The processes within the CNS, including the regions of the brain that contribute to smooth, accurate and continual movement of limbs are all responsible for the responses seen within a sprinter. Sensory inputs, which may be auditory, visual or proprioceptive, are interpreted by the brain and the effectiveness of the motor neurons in relaying these messages to the sprinter’s muscles during the race are fundamental to their success. The nervous system also determines a sprinter’s feedback throughout the race, enabling the Sprinter to constantly assess his position and performance. Perhaps the most important aspect of motor control with regards to the 100m sprint is reaction timeethe phases of which (premotor and motor time) are affected hugely by the sprinter’s neuromuscular conditioning. Speed and resistance training, along with practicing reaction time drills can all help to improve a sprinter’s reaction time. Motor control and the relative anatomical, neurological and physiological processes that occur in the human body are therefore essential for both elite and aspiring athletes when it comes to a race such as the 100m sprint.

Cissik, J. M.
Sprinters : physical preparation in the early off-season

The following are principles to help guide the training of sprinters during the early off-season:
1. Fitness is not assumed, it will be developed: This is the phase of training where the athlete is getting in shape. The athlete’s entire fitness base needs to be addressed during this phase, this helps them to have the foundation to be successful and also prevents the development of training-related injuries. 2. Link the training together: The athlete does more than just lift weights, all of this training interacts and this has to be planned for and taken into account. It is best to sync up training by qualities, explosiveness, energy system, etc. This maximizes the effectiveness of each training session, allows them to complement each other, and maximizes recovery time so that the same qualities aren’t overtrained (see Cissik (2) for more details). 3. Train one thing at a time: In track training, it is advisable to focus on training one quality in each training session (acceleration or maximum velocity or speed endurance). This should be true of other modes of exercise as well. This maximizes the effectiveness of the training session, ensures that we don’t confuse the athlete, and helps with recovery. 4. The athlete needs time to recover: While developing the athlete’s fitness base during this phase, the athlete needs time to adjust to the training. This means putting in adequate recovery time for the athlete and reducing that time gradually as the year progresses. 5. Be progressive: Strength and conditioning should be developed in a process where each training session, each week, each month, and each year builds upon the foundation that the previous one developed. This means focusing on fundamental exercises before getting to advanced ones, starting with lighter weights before getting to heavier ones, lower volume before greater volume, etc. 6. Develop strength and power from the beginning: Sprinters need to have great strength (to a point) and need to express it quickly. These are not qualities that should be developed right before competition, they must be emphasized and developed from the beginning of training. 7. Balance hypertrophy training: Most training models involve a long period of hypertrophy (muscle growth) training during the beginning of a training year. This is fine when it is needed, but care must be taken. First, sprinters have to be able to run with any additional mass. Second, hypertrophy training can change the angle of the muscle fibers to make them contract less quickly, potentially having a detrimental effect on speed. 8. Keep training in perspective: Sprinters are not Olympic weightlifters, they are not powerlifters, and they are not bodybuilders. This means that strength training needs to be kept in perspective, it is a means to an end and not the end itself. Strength training sessions should be short, focused, and productive.
Clark, D. A.; Sabick, M. B.; Pfeiffer, R. P.; Kuhlman, S. M.; Knigge, N. A.; Shea, K. G.

Influence of towing force magnitude on the kinematics of supramaximal sprinting


The purpose of this study was to determine the influence of towing force magnitude on the kinematics of supramaximal sprinting. Ten high school and college-age track and field athletes (6 men, 4 women) ran 60-m maximal sprints under 5 different conditions: Nontowed, Tow A (2.0% body weight [BW]), Tow B (2.8% BW), Tow C (3.8% BW), and Tow D (4.7% BW). Three-dimensional kinematics of a 4-segment model of the right side of the body were collected starting at the 35-m point of the trial using high-speed (250 Hz) optical cameras. Significant differences (p < 0.05) were observed in stride length and horizontal velocity of the center of mass during Tow C and Tow D. For Tow D, a significant increase (p = 0.046) in the distance from the center of mass to the foot at touchdown was also observed. Contact time decreased significantly in all towing conditions (p < 0.01), whereas stride rate increased only slightly (<2.0%) under towed conditions. There were no significant changes in joint or segment angles at touchdown, with the exception of a significant decrease (p = 0.044) in the flexion/extension angle at the hip during the Tow D condition. We conclude that towing force magnitude does influence the kinematics of supramaximal running and that potentially negative training effects may arise from towing individuals with a force in excess of 3.8% BW. Therefore, we suggest that coaches and practitioners adjust towing force magnitude for each individual and avoid using towing forces in excess of 3.8% of the athlete's BW.

Coh, M.; Bracic, M.

Kinematic, dynamic and EMG factors of a sprint start


An efficient start is one of the crucial factors of competitive performance in the Sprints. Some of the studies conducted so far, most of which were partial biomechanical studies, have identi-
New Studies in Athletics · no. 1/2.2011

studies, have identified the following parameters for a good start: reaction time; optimal position of the starting blocks in relation to the starting line; height of the sprinter’s centre of mass (CM) in the set position and the block velocity, which is mainly a result of the force impulse on both the rear and front starting blocks. These parameters are interdependent and each is conditional on the central movement regulation processes, biomotor abilities, energetic processes and morphological characteristics of the athlete. The start and transition to the acceleration phase of a sprint race is a very complex movement sequence, requiring high muscle activation and effective integration of acyclic and cyclic movements. The purpose of this study was to understand the mechanisms of the start and facilitate the development of appropriate training methods for one athlete, a female hurdler with a best time of 13.19. The aim was to measure the major kinematic and dynamic parameters as well as the EMG activation of muscles in the start. The focus was an 1) the block velocity in a dependent relationship with the development of force in the rear and front blocks, 2) the block acceleration in the first two steps and 3) the EMG activity of seven key muscles. The results of the study include data on 15 start-related parameters and analysis of the EMG activity in both legs during the start.

Cronin, J. B.; Green, J. P.; Levin, Gr. T.; Brughelli, M. E.; Frost, D. M. 
Effect of starting stance on initial sprint performance 

The effect of different starting stances from a standing position on short sprint times and the subsequent variability in times was investigated in this study. A dual-beam timing light system was used to measure 5- and 10-m times for 3 different standing starts commonly found in the sporting environment: parallel (feet parallel to the start line), split (lead left foot on start line, right leg back), and false (initial parallel start, right leg drops back to split start when movement initiated). The parallel start was found to be significantly ([alpha] < 0.05) slower than the other 2 stands for both the 5- (~8.3%) and the 10-m (~5.9%) distances. Within the trial, variation of the

Coh, M.; Peharec, S.; Bacic, P. 
The sprint start: Biomechanical analysis of kinematic, dynamic and electromyographic parameters 

An efficient start is crucial for a competitive performance in sprint races. Studies conducted to date, most of which were partial biomechanical
In this project, kinematic characteristics of sprints and bounding runs in different training periods as well as during double periodisation were examined. Bounding runs were also examined, depending on the approach speed. The basic thesis of the project was as follows: “In the sprint and jumps those athletes have a greater developmental potential who with identical running speed and multiple jump distance demonstrate shorter support times.” Because of the training periodisation an increase of the sprinting velocities with simultaneous shortening of the ground contact times as well as an increased jumping velocity and/or jumping-stride length from the general preparation period through the special preparation period up to the competition period was to be expected. In the case of double periodisation, this cycle is performed twice and should be reflected in the kinematic parameters although there will be individual variations. In bounding runs the increase of the approach velocity results in takeoffs that resemble competition takeoffs. These should be reflected in changed jumping-stride velocities, lengths and ground contact times.

Drawer, S.
Real time ‘speed’ tracking for the sprints
The author gives an introduction to the possibilities of the “Inmotio” system for real-time velocity measurement (www.inmotio.eu). The system, which was developed for football and speed skating, is particularly suitable for velocity measurement in the 400m run, among other things to answer the question whether the 400m winner is really the one who ‘slows’ down the least.

Drawer, S.
Technology for supporting the coaching of the sprints
New Studies in Athletics, Aachen, 24 (2009), 1, pp. 123-125
Sprinting velocity is the product of two factors: stride length and stride frequency. Both of these are influenced by a number of physical, physiological and mechanical factors. Measuring the length, frequency and other aspects of an athlete’s stride in training provides the coach with important information about the effectiveness of
the running technique and it can give an indication of the success, or otherwise, of the training programme. The author presents two modern methods for measuring stride length and stride rate: 1. Optojump (www.optojump.com), which is an optical measurement system consisting of transmitting and receiving lights. The system detects any interruptions in communication between the Bars and calculates their duration. This makes it possible to measure flight and contact times during the performance of a series of jumps with an accuracy of 1/1000 of a second from anything to 2m to 100m. 2. e-AR (www.sensixa.com), which is a miniature ear-worn accelerometer based sensor. Supported by laser based sensors at nominated known distances, the system has the capability of providing alternatives to many other current methods with distinct advantages in cost, portability, availability, and the number of athletes that can be tracked at any one time.

Eynon, N.; Alves, A. J.; Yamin, C.; Sagiv, M.; Duarte, J. A.; Oliveira, J.; Ayalon, M.; Goldhammer, E.; Meckel, Y.

Is there an ACE ID – ACTN3 R577X polymorphisms interaction that influences sprint performance?

*International journal of sports medicine, Stuttgart, 30, (2009), 12, pp. 888-891*

Functional R577X (rs.1815739) and ID (rs.5186) polymorphisms in the α-actinin-3 (ACTN3) and the angiotensin converting enzyme (ACE) genes, respectively, have been associated with sprint performance. The aim of this study was to determine their effect on sprint performance among 81 Israeli sprinters and 240 healthy controls. Results revealed that the ACE II genotype+ACTN3 R allele (P=0.003 for sprinters vs. controls), and the ACTN3 RR genotype+ACE I allele (P=0.001 for sprinters vs. controls) might be the genotype for sprinters. In the whole cohort the probability of ACTN3 RR genotype+ ACE I allele being a sprinter (odds ratio 2.67, 95% confidence interval 1.45-4.93) and of ACE II genotype+ACTN3 R allele being a sprinter (odds ratio 3.57, 95% confidence interval 1.78-7.15) was significantly higher than that in the controls. In conclusion, the above data suggest that ACE ID/ACTN3 R577X genotype combination is associated with sprint ability. However, ACE ID/ACTN3 R577X genotype combination is not related to the level of performance.

Fortune, P.

Womens 400metre: Moving forward with the event in Australia


How does the coach of a current 200m athlete who shows the mental and physical signs that they may evolve to 400m go about planning the transition? The author’s view is first and foremost: Do not lose the focus on speed in an attempt to build in the strength required for 400m. Longer rep sessions can be scheduled in blocks of training or combined carefully with speed development in a comprehensive complex training program. 400m athletes coming from a sprint background need not stray too far from the speed endurance work that will develop them for the 200m. In fact, the fatigue factor in 200m running is quite similar to 400m and often underestimated. Catherine Freeman did not run longer than 500m on the track in training and then only in one or two reps. The majority of her specific training was in multiples of 150m-300m throughout the training year. Her talent and application enabled her to remain world class at 200m throughout her career. Melinda Gains ford-Taylor despite focusing competitively at 100/200m was always able to contribute very well when running 400m especially in relays. This approach seems to be valid for speed based women. The author believes that following a suitable preparation period the athlete needs to get used to being challenged on recovery between reps and in volume when appropriate. As well as tolerating the increased training load physiologically, the coach will need to develop their athlete’s ability to psychologically accept the discomfort of 400m racing and training, and importantly develop the skills to run very fast in a relaxed manner. Athletes excelling in 400m have the following characteristics: High ability to produce energy through the lactic system; excellent sprinting ability; excellent anaerobic capacity; high anaerobic power; efficient running technique and relaxation; optimal body composition.

Frost, D. M.; Cronin, J. B.; Levin, G.

Stepping backwards can improve sprint performance over short distance

The use of a backward (false) step to initiate forward movement has been regarded as an inferior starting technique and detrimental to sprinting performance over short distances as it requires additional time to be completed, but little evidence exists to support or refute this claim. Therefore, we recruited 27 men to examine the temporal differences among three standing starts that employed either a step forward (F) or a step backward (B) to initiate movement. An audio cue was used to mark the commencement of each start and to activate the subsequent timing gates. Three trials of each starting style were performed, and movement (0 m), 2.5 m, and 5 m times were recorded. Despite similar performances to the first timing gate (0.80 and 0.81 s for F and B, respectively), utilizing a step forward to initiate movement resulted in significantly slower sprint times to both 2.5 and 5 m (6.4% and 5.3%, respectively). Furthermore, when the movement times were removed and performances were compared between gates 1 and 2, and 2 and 3, all significant differences were seen before reaching a distance of only 2.5 m. The results from this investigation question the advocacy of removing the false step to improve an athlete’s sprint performance over short distances. In fact, if the distance to be traveled is as little as 0.5 m in the forward direction, adopting a starting technique in which a step backward is employed may result in superior performance.

Gajer, B.; Hanon, C.; Thepaut-Mathieu, C. Velocity and stride parameters in the 400 metres

Success in the 400 m requires the athlete to preserve the optimal technical characteristics of his/her stride despite intense fatigue. Using 50 m intervals, the time courses of velocity and stride parameters (length and frequency) were evaluated for races of three groups of athletes: world-class, national level and regional level. The better athletes were able to achieve higher absolute and relative velocities (% of their best performance over 200 m). These were reached by way of both significantly greater stride length and stride frequency. It is notable that peak values for the two parameters were observed in different parts of the race: between 50 and 100 m for stride frequency and between 100 and 150 m for stride length. In general, length rather than frequency is the stride parameter distinguishing the groups from each other. As the morphological characteristics of the subjects were similar, this could indicate greater maximal strength levels for the better athletes.

Gittoes, M. J. R.; Wilson, C. Intralimb joint coordination patterns of the lower extremity in maximal velocity phase sprint running
Journal of Applied Biomechanics, Champaign, 26, (2010), 2, pp. 188–195

This study aimed to develop insight into the lower extremity joint coupling motions used in the maximal velocity phase of sprint running. Two-dimensional coordinate data were used to derive sagittal plane joint angle profiles of sprint running trials. Intralimb joint coupling motions were examined using a continuous relative phase (CRP) analysis. The knee-ankle (KA) coupling was more out of phase compared with the hip-knee (HK) coupling across the step phase (mean CRP: KA 89.9°; HK 34.2°) and produced a lower within-athlete CRP variability (VCRP) in stance. Touchdown (TD) produced more out-of-phase motions and a larger VCRP than toe-off. A destabilization of the lower extremity coordination pattern was considered necessary at TD to allow for the swing-to-stance transition. The key role that the KA joint motion has in the movement patterns used by healthy athletes in the maximal velocity phase of sprint running was highlighted.

Goodwin, J. E.; Glaister, M.; Howatson, G.; Lockey, R. A.; McInnes, G. Effect of preperformance lower-limb massage on thirty-meter sprint running

Massage is a commonly utilized therapy within sports, frequently intended as an ergogenic aid prior to performance. However, evidence as to the efficacy of massage in this respect is lacking, and massage may in some instances reduce force production. The aim of this study was to investigate the effect of massage on subsequent 30-m sprint running performance. Male university level repeat sprint sports players volunteered...
**New Studies in Athletics · no. 1/2.2011**

**Grandys, M.; Majerczak, J.; Zapart-Bukowska, J.; Kulpa, J.; Zoladz, J. A.**

**Gonadal hormone status in highly trained sprinters and in untrained men**


It is a common view that strength and sprint trained athletes are characterized by high plasma/serum testosterone (T) concentration, which is believed to be partly responsible for their performance level. This opinion, however, has poor scientific background. The aim of this study was to give evidence-based information on this issue. We examined gonadal hormone status at rest after overnight fasting in high and top-class track and field sprinters (n = 16) and in untrained men (n = 15). It was shown that basal T, free testosterone (FT), bioavailable testosterone (bio-T), and sex hormone-binding globulin concentrations were not significantly different (p > 0.05) in sprinters vs. untrained subjects. Further comparison of the results of the basal serum T concentration in 8 sprinters showed its significant changes during an annual training period. Significantly higher T concentration during a low-intensity training period (beginning of December) than during heavy sprint specific training period (end of March) was observed in these athletes (n = 8) (mean ± SD; 23.37 ± 5.28 vs. 20.99 ± 4.74 nmol/L, respectively, p = 0.04). We have concluded that basal gonadal hormone concentration in high and top-class athletes (sprinters and jumpers) did not appear to be significantly different when compared with untrained subjects. Moreover, basal T concentration in sprinters can differ significantly during an annual training period. This fact should be taken into consideration when interpreting the results of gonadal hormone status in athletes at varied training stages.

**Headly, D.; Baum, J.; Megson, P.**

**Top-speed practice drills for sprinters: Benefits and insights**

*Track Coach, Mountain View (Calif.) (Winter 2011), 194, pp. 6185-6190, 6210*

As a sprint coach, how do you motivate your athletes to run “really fast” in any given practice drill that is supposed to be performed at full speed? Does telling a novice athlete to “run fast!” or “go all out on this one” work well? Do you ever ask runners to do the first few trials at, say, 80% of their max speed and wonder if their speeds are really anywhere near 80%? How many consecutive trials can sprinters perform running a short distance at maximum effort, before they start to significantly drop in the top speed achieved, hence signaling the end of a productive workout? Working at the high school level, questions like these present significant challenges to the Track Coach in planning a good speed workout for a large number of runners with a wide range of abilities. Two high school seniors, as part of their year-end senior project, were enlisted to help try to answer some of these questions through a nonrigorous experiment. Using middle and high school volunteers, a series of electronically timed ten-meter Sprints were performed, using a spreadsheet analysis of the data at a later date. Our informal results are not to be considered in any way the final word on this subject; they do, however, indicate that this type of conditioning drill has some unique training benefits and that additional, more in-depth studies are warranted. The analysis shows that, in a short sprint, the top speed that can be achieved in a given practice session can be maintained over...
a surprisingly large number of trials, even after perceived fatigue on the part of the athlete sets in. The study was done without a guided warm-up period, which could explain why some of the runners continued to improve their speeds over the first few trials; however just as many runners started to slow down immediately after the first attempt. The acceleration phase was shorter than it realistically should be, especially for the faster athletes, which implies that our data is conservative in its estimate of the top-end speeds. There was great variability between successive trials, but overall a fairly consistent top speed by the tenth or higher effort (compared with the first trial) for the majority of students tested, both trained and untrained as sprinters. An important question as a result of this study is the following: How would these results compare on the day of a track meet? If a runner consistently shows in timed practice sessions to be able to increase his /her top speed achieved over the first few trials (or even more), should that sprinter warm up for the official race by doing several all-out sprints just prior to (as dose as possible to) the race? Consider a sprinter who can maintain a top speed of about 10.0 m/s for 20 meters during a 100m race. A five percent change in that speed over just the 20-meter stretch produces a 0.10-second change in race time – no small effect! After the testing was done many students kept asking about their results – the curiosity generated by this method can make a practice session a lot more fun for the kids, and provide very practical knowledge for the coach. You can take the top speed overall for a student from a test like this, divide it into 100m (distance divided by running speed = time), and provide a theoretical “fastest possible time in the 100 meters” for a particular runner (as a split in a 4 x 100 relay) and watch their surprised reaction. The fact that such a top speed may only be maintained for as little as 10 to 15 meters is beside the point-giving the students an idea of what they can approach as their “personal best ever” can for some young athletes really provide a strong motivator to develop further. A timed 10-meter sprint workout can work well as an addition to a sprint coach’s repertoire. The test motivates the athletes to perform at their best during practice, and it has the ability to quantitatively isolate progress in raw speed for a runner over the course of a season, as opposed to monitoring race times from each meet which are affected also by starting block efficiency, acceleration strategies, and the ability to maintain top speed as long as possible during a race.

Reliability and accuracy of handheld stopwatches compared with electronic timing in measuring sprint performance 

This study assessed reliability of split times obtained by handheld stopwatches (HHSs) compared with electronic timing (ET) during a 200-m sprint. Two HHS timing methods were compared with ET: single-split timers (SST) and multiple-split timers (MST). Twenty-six timers without previous experience were given instruction and completed practice trials until good agreement was achieved between ET and HHS. Trained runners (8 males, 10 females) were timed for each 25-m interval on a standard 200-m course. Repeated-measures analysis of variance and intraclass correlation models were used to determine reliability. A total of 248 split times were analyzed. No significant differences were found between the three timing methods (p > 0.99), and calculated intraclass correlation values were high (0.988). Mean error between SST, MST, and ET (-0.04 ± 0.24 and -0.05 ± 0.24 seconds, respectively) indicated faster HHS times, though not significantly. However, absolute errors were considerably larger (0.15 ± 0.20 and 0.16 ± 0.19 between SST, MST, and ET, respectively). The HHS-recorded splits were faster than ET in 67.3% of splits and slower in 29.4%. The distribution of errors made the development of a reliable correction factor to convert HHS to ET impossible. It was concluded that on the basis of the small mean error and high intraclass correlation values, the use of HHSs may be a viable alternative to ET in collecting group data. However, on the basis of the absolute error between HHS and ET, when high degrees of precision are required, ET should be used, and reliable correction of HHS to ET values is not possible. It was further concluded that HHS times should be reported without attempting correction and interpreted in light of the shortcomings of the HHS method.
Hoffmann, T.
**Untersuchung der Schnelligkeitsausdauerleistung im leichtathletischen Sprintlauf mit Hilfe einer (mobilen) Lichtschrankenanlage**
[Examination of the speed endurance performance in athletics sprint races using a (mobile) light barrier system]


As part of a study project, the Institute for Sports Science at the Otto-von-Guericke-University Magdeburg, conducted a pilot study to investigate the speed endurance. The main focus was on the constancy and repeatability of cyclical acceleration performances. In the present study, the goal was to examine the speed endurance in the athletics sprint race from both a sport- and event-specific point of view. The cyclical acceleration in sprint is closely tied to the speed-strength, movement frequency and the technical-economic movement execution. The running times were measured using a light barrier system. The data obtained (run times and velocities) were evaluated qualitatively and quantitatively. This should lead to findings on the stability of the cyclical acceleration performance with multiple repetitions. The main focus of the study was on more frequent than random losses of speed and disturbances of the acceleration behaviour. Within this complex cyclic speed performance the pilot study produced information about possible fatigue. It should be examined whether the influence of the cyclic ultra-short-time endurance (sprint speed endurance) has an effect on coordination and/or on physical condition.

Hücklekemkes, J.
**So organisieren Sie Ihr Hallentraining** [This is how you organise your indoor training]

Leichtathletiktraining, Münster, 21, (2010), 9+10, pp. 6-12 (part 1); 11, pp. 14-22 (part 2); 12, pp. 31-35 (part 3)
The author gives hints on how to organise indoor sprint, hurdles and running training during the autumn and winter season.

Hommel, H.
**Sprinttechnik beobachten und analysieren!** [Observance and analysis of sprinting technique]

Leichtathletiktraining, Münster, 18, (2007), 2/3, pp. 62-71

The nature and extent of visual perception are highly dependent on the coach’s training and experience in motion vision. The more experienced the “coach’s vision” is, the better will be the quality of his perceptions – but in any case they are subjective and selective. The advantage of the “coach's eye”, however, is its constant availability – regardless of technology. It is the basis for immediate feedback after the movement execution. In addition to the assessment of key technical positions, the assessment of the harmony of the entire movement process is important (running or hurdle rhythm). Video-based monitoring has the disadvantage that even if the coach makes the recording himself it is not possible for him to draw upon his “coach's eye”. Therefore, it is advisable to use the camcorder only selectively in training or to entrust another person with the recordings. Against this background, the author uses diagrams to give an overview of the main observation points in the sprint start, sprint, relay, short and long hurdles. The contribution also includes tips on buying a camcorder.

Ito, A.; Fukuda, K.; Kijima, K.
**Mid-phase movements of Tyson Gay and Asafa Powell in the 100 metres at the 2007 World Championships in Athletics**


This study examines the running movements of two of the fastest sprinters in history, Tyson Gay (USA) and former 100m world record holder Asafa Powell (JAM). They were filmed at the 60m mark in the 100m final at the 2007 IAAF World Championships in Athletics, where they placed first (9.85) and third (9.96) respectively. The data obtained were analysed and compared to post data in order to determine the characteristics of
both sprinters and identify points of advice for aspiring athletes and coaches. The parameters covered are step frequency and step length, recovery leg movement and support leg movement. The landing distance for Gay and Powell is comparable to 11 sec 100m performers and both continue to bend the knee of the support leg during the support phase. The authors’ suggestions include that training guidance instructing sprinters to actively extend the knee and ankle joints of the support leg should be re-evaluated.

Jakobs, K.
Faszination Schnelligkeit [Fascination speed]
Leichtathletiktraining, Münster, 18, (2007), 2/3, pp. 4-8

To run fast, the athlete must be able to react and start well. The transitions between the individual phases until reaching maximum speed are also important. They should be fluid, i.e., there should be no interruptions between them. Running speed is the product of step frequency and step length. While the latter depends on leg length, push-off force and running technique, stride frequency depends to a great extent on neural processes (speed of activation and relaxation and nervous coordination between the involved muscles). These neural processes should be addressed particularly at a young age. Apart from the coordinative and technical aspects, the energy supply of the involved muscles is also important for the design of training. Therefore, the following principles should be considered in speed training: 1. The training should focus primarily on the alactic metabolism. 2. The acceleration and cyclical (locomotor) speed capability should be the main focus in training. 3. In addition to a “clean” sprint technique and coordination it is necessary to train a well-developed relaxation and switching ability. 4. Maximal intensities require a good command of submaximal intensity. In addition to the classic sprint-specific means of training varied exercise forms should also be used. Against this backdrop, the author summarizes the criteria for a good sprint technique and the components of speed (acyclic speed, acceleration capacity, cyclic speed, speed endurance and reaction speed. The principle facts of speed training are 1. that athletes get fast only by doing maximally fast movements, exercises, or actions, 2. that high load volumes and appropriate fatigue conditions should be avoided, and 3. that a high activation state of the CNS, i.e., an above-average concentration and optimal motivation, is also required.

Kale, M.; Asçi, A.; Bayrak, C.; Açikada, C.
Relationships among jumping performances and sprint parameters during maximum speed phase in sprinters

The purpose of this study was to investigate the relationships among jumping performances and speed parameters during maximum speed phase in sprinters. Twenty-one men sprinters volunteered to participate at the beginning of the preparation training phase. All tests-including 100-m sprint running, squat jump (SJ), countermovement jump (CMJ), drop jump (DJ), 60-second repetitive jump (RJ), standing long jump (SLJ), standing triple jump (STJ), standing quintuple jump (SQJ), and standing 10-stride jump (STENJ)-were done on switching mats. Flight (FT) and contact times (CT) during the vertical jump tests and 10-m split times during 100-m sprint running were measured by a 2-channel precision timing system (PTS) connected to the mats. The trace marking method was used for measuring the stride length (SL) through 60 m in 100-m sprint running. Stride frequency (SF), maximum velocity (Vmax), jump height for all vertical jumps, and lower-body power in DJ and RJ were calculated. Statistical analysis showed that the highest significant correlation was found between Vmax and DJ height (r = 0.69; p < 0.05). However, the lowest significant correlation coefficient was found between SL at maximum velocity phase of sprint running and SJ (r = 0.39; p < 0.05). In con-
bean and North American sprinters is highlighted. They replace the classic warm-up jogging by 5-10 sprints or starts at low intensity (60-70%). The sprint lengths vary widely, ranging from 50 to 100 meters. The runs are performed with walk breaks. The goal of this "warm-up sprinting" is according to the coach only to "hit" oneself and to run with little effort. Following these warm-up sprints dynamic stretching and mobilisation exercises are very common. These are either done by the athletes themselves with the help of bands or tubes or they are done by a physiotherapist. In some cases one can even see static stretching exercises with swinging movements. If sprint drills are carried out by, they are done in a relaxed way. Coordination and frequency drills are clearly structured, with the frequency drills coming normally after the coordination drills. Accelerations are done from "long and loose" to "short and fast". When doing crouch starts and starting accelerations, the focus is first on a powerful knee extension (0-20 meters), followed by hip extension (20-40 meters), and finally lifting the head (40-60 meters). The focus is on the frequency during the first steps and on a slow lifting of the head. Spikes are only put on when the runs should be very fast. In general, there is a slight tendency to a more "economical" warm-up. This is consistent with recent findings that say that the body does not have to be warmed up considerably in order to provide maximum performance and that a strenuous warm-up before competition is counterproductive. During normal temperatures, it is sufficient to only warm up slightly and do a few muscle mobilisation exercises. Only in the case of low temperatures should the warm-up programme be intensified.

**Komi, P. V.; Ishikawa, M.; Salmi, J.**

**IAAF sprint start research project: Is the 100 ms limit still valid?**

*New Studies in Athletics, 24, (2009), 1, pp. 37-47*

The current false start criterion used by the IAAF is based on an assumed minimum auditory reaction time. If an athlete moves sooner than 100 ms after the start signal, he/she is deemed to have false-started. The purpose of this study, which was commissioned by the IAAF, was to examine neuromuscular reaction to the auditory signal used in the sprint start and to determine whether the 100 ms limit is correct. Seven nationallevet Finnish...
sprinters took part. A comprehensive approach was used to study force reaction at the blocks, the movements of the arms and the activation profiles of several muscles. The authors found great variation in individual reaction times and confirmed previous reports of simple auditory reactions as fast as 80 ms. They recommend that the 100 ms limit be lowered to 80 or 85 ms and that the IAAF urgently examines possibilities for detecting false starts kinematically, so that judges’ decisions are based on the first visible movement regardless of the body part. This can be done with a system of high-speed cameras, which gives views of all the athletes on the start line. With such a system, it would be possible to change the start rule so that no false starts are permitted.

Korn, M.; Böttcher, J.; Killing, W.; Mattes, K. Kinematische Parameter von Sprints und Mehrfachsprüngen verschiedener Altersklassen [Kinematic parameters of sprints and multiple jumps in different age groups]


Currently, the collection of core exercises, athletic training, the sprints and horizontal multiple jumps is undifferentiated. In both aptitude testing as well as high performance training only sprint times and total jump distances are available. Support, flight times and the stride or jump lengths and derived parameters (stride rate and velocity) for the individual movement cycles can neither be used for aptitude testing nor for regular training control in high-performance sport. Thus, both analytical and control instruments are severely limited in their effect. As part of BiSp project “sprints and horizontal multiple jumps for aptitude testing and training management for athletics jumping disciplines,” a cross-sectional analysis of young athletes took place was conducted throughout the Federal Republic with the aim of analysing and discussing the above parameters as criteria for aptitude testing. Thus, the focus was on the conspicuous performancees of young athletes, which were collected using the track and field sprint and jumping core exercises of sprints and jumps in the form of sprint times and jump distances. In doing so, the individual structure of the performance was examined more deeply using the kinematic stride and jump characteristics and their concrete realisation. For the first time the Optojump measurement system was used for diagnosis to a great extent. This then leads to the question, of course, what are the benefits of the use of this measurement system compared to traditional testing methods.

Korn, M.; Böttcher, J.; Müller, E. Zugunterstützung im Sprinttraining: der Einfluss eines zusätzlichen Attraktors auf ausgewählte kinematische und neuromuskuläre Parameter [Pull-support in sprint training: the influence of an additional attractor on selected kinematic and neuromuscular parameters]


The short sprint in athletics is possibly the event which is to the greatest extent dependent on the respective athlete’s genetic prerequisites. However, this does not change the fact that better training stimuli lead to better results. A popular training means in sprint training are pull-supported runs, although some results of scientific studies contradict the coaches’ intentions. This is the starting point of this study intended to show which factors are decisive for the successful application of pull-supported runs in sprint training.

Kusy, K.; Zielinski, J.; Osik, T. Die Belastungsgestaltung im leichtathletischen Sprint: Trainingsprofil des besten polnischen 200m-Sprinters [The load structure of athletics sprinting – the organisation of load in athletics sprint – the training profile of the best Polish 200m sprinter]

In: D. Lühnenschloß & P. Wastl, Quo vadis olympische Leichtathletik? Probleme, Bilanzen, Perspektiven ; Symposium der dvs-Kommission Leichtathletik vom

The load structure of athletic training is always a topical problem of sports science and sports practice. Consciously or unconsciously, every coach is constantly on the lookout for optimizing the design of athletic loads. Training documentation and analysis is one of the essential prerequisites for effective training control, including the planning and implementation of training, based on precisely repeatable measurement data, according to the respective training cycle: prognosis – program/plan – analysis/diagnosis – conclusion/recommendation. The research group of the athletics department of Poznan Sport University has been working for several years with the training of high-performance sprinters. In this paper, the general contents of the training of a sprinter of international top-level class, who was educated and trained in the “Pozna Sprint School”, is presented. In doing so, the characteristics of this athlete, the yearly structure of his training, the load documentation, and the structure of his training load are presented with regard to motor character and energy expenditure.

Locatelli, E.
A closer look at 9.69

New Studies in Athletics, Monaco, 24, (2009), 1, pp. 3‐4

Usain Bolt’s world record of 9.69 sec for the 100 metres at the 2008 Olympic Games in Beijing was one of the great highlights of the year in athletics and has excited renewed interest around the world in the sprint events. Remarkably, Bolt’s performance was achieved without any wind assistance (wind = 0.0m/sec) and with a noticeable deceleration in the last 10m. Predictably, there has been a lot written about how fast different sections of the race were, how fast the last 10m might have been without the early celebrations and, of course, how fast Bolt might run in the future. Many reports, both in the press and online, were produced without the information necessary to make accurate statements about the split times, as has been possible about 100m races at IAAF World Championships in Athletics in the past. The reality is the following: 1. Omega, the official timing company, did not place photocells on the track. 2. No one made the pre-race calibrations necessary for serious research (and to be precise, a calibration should be made for each lane, in order to avoid errors when comparing athletes running in different lanes). 3. No one correctly positioned or synchronised high-speed video cameras to record the race (the only videos available are those produced by the Host Broadcaster and private videos recorded from the stands). Under these circumstances, it is possible to accurately measure only the first 10m and the last 10m of the race. This is because of the existing, accurately measured and visible lines on the track (for the exchange zone of the 4x100m, which is at 10m of the 100m straight,
The aim of this study was to investigate the variability of stride length and stride frequency between athletes of different performance levels in the 100m and then verify the influence of these kinematic parameters on the phases of the race and technical efficiency. Data from a group of 8 average male sprinters (mean performance 11.18) and the men’s 100m finalists in 1991 IAAF World Championships in Athletics were compared. Based on statistical analysis of the kinematic parameters, the author identifies different phase structures for the races of the two groups. The results suggest that stride length contributes much more to the velocity curve of the 100m than stride frequency, which can no longer be considered the most important performance-determining factor in either average- or high-level performers.

MacLennan, A.; Francis, S.
Stephen Francis: an interview
Recently at the Sydney International Track and Field meet, coaches and athletes had the opportunity to listen to and ask questions of Stephen Francis, Jamaican coach. Francis is the controversial coach of Asafa Powell, who was this time last year known as the World’s fastest man’. Francis is also the coach of 100m hurdles gold medallist Melaine Walker, Shelly-Ann Fraser’s silver in the 100 metres, Shericka Williams’ silver in the 400 metres and Sherone Simpson’s silver in the Women’s 100m. Other athletes whose careers he has influenced include Michael Frater, Ainsley Waugh, Winston Smith, Kenneth Sylvester, Oral Thompson, Ryan James and Olympic high jump silver medallist Germaine Mason (who competes for Great Britain). Francis works on technical skills, physical conditioning and, if this does not bring about improvement, “we move to the mental”. In this interview Stephen Francis gives answers to the following questions: 1. Do your hurdlers do sprints too? 2. Why do you have your athletes running the 400m early in their competitive program? 3. When do your athletes start training on the track? 4. What is done in the 4th week and for the exchange zone of the 4x400m, which is at 90m of the 100m straight). Any times one may have read for the other splits in the race are problematic. Looking at the first 10m and last 10m, the author to be considered most credible is Jimson Lee (www.speedendurance.com) who was honest from the start in declaring that his splits were extracted from a high-speed video analysis and not official data. The author has made his own simulation of the 10m splits, but, for the reasons mentioned above, he does not present it as a scientific work. His approach, after having contacted the IAAF’s broadcast partners, is based on analysis of the video produced by the RAI (the Italian broadcaster) using “Dartfish software”. His findings are slightly different from those of Mr Lee for six out of the 10 segments. Of great interest is the split for the last 10m. The author calculated 0.89 sec while Lee and some other authors found it to be 0.90 sec. It is not unreasonable to say that if Bolt had continued to run without any showmanship he could have covered the last 10m in around 0.86 sec, which would have given a time of 9.66 sec.

MacLennan, A.; Francis, S.
Changes in accumulated oxygen deficit and energy cost of running 400 metres
The aim of this study was to compare the accumulated oxygen deficit (AOD), the energetic cost of running and the anaerobic fraction of energy elicited during all-out 400m track runs in the off-season and summer preparation phases of a season. Five trained 400m runners with an average best time of 47.72 took part in the tests. The authors found that the subjects’ performance improved significantly between the two tests but this improvement was not matched by significant changes in AOD. They did find that the performance improvement was matched by significant decreases in the energy cost of running and oxygen uptake during the run and a significant increase in the anaerobic fraction of energy used. These results suggest that improving high-speed running economy is a key to better performance in the 400m.

Mackala, K.
Optimisation of performance through kinematic analysis of the different phases of the 100 metres
New Studies in Athletics, Aachen, 22, (2007), 2, pp. 7-16
The aim of this study was to investigate the variability of stride length and stride frequency between athletes of different performance levels in the 100m and then verify the influence of these kinematic parameters on the phases of the race and technical efficiency. Data from a group of 8 average male sprinters (mean performance 11.18) and the men’s 100m finalists in 1991 IAAF World Championships in Athletics were compared. Based on statistical analysis of the kinematic parameters, the author identifies different phase structures for the races of the two groups. The results suggest that stride length contributes much more to the velocity curve of the 100m than stride frequency, which can no longer be considered the most important performance-determining factor in either average- or high-level performers.
changes to block start and early acceleration sprint kinematics with resisted sled towing. Ten male sprinters performed 12 sprints (four each of unresisted and approximately 10 and 20% body mass [BM]) for 10 m from a block start. Two-dimensional high-speed video footage (250 Hz) of the starting action and the first three steps of each sprint were recorded to enable the sagittal sprinting kinematic parameters to be obtained using APAS motion analysis software. The overall results of this study indicated that early acceleration sprint performance from starting blocks decreases with increasing load during resisted sled towing. A load of approximately 10% BM had no “negative” effect on sprint start technique or step kinematic variables measured in this study (with the exception of one variable) and was also within the “no greater than 10% decrease in speed” limits suggested by Jakalski. Towing a load of approximately 20% BM increased the time spent in the starting blocks and induced a more horizontal position during the push-off (drive) phase. The approximately 20% BM load also caused the sprinters to shorten their initial strides (length), which may have resulted from the decreased flight distances. Such results suggest that the kinematic changes produced by the 10% BM load may be more beneficial than those of the 20% BM load. Future training studies will, however, need to investigate how these acute changes in sprinting technique impact on long-term adaptations in sprinting performance from resisted sprinting.

May, R.
'Ich bin ein Berlino': Sprintass Usain Bolt gewann in Berlin dreimal Gold ['I am a Berlino': sprint star Usain Bolt won three gold medals in Berlin]
Leichtathletiktraining, Münster, 20, (2009), 10+11, pp. 36-43
An observation of Usain Bolt at the 2009 IAAF World Championships in Berlin leads to the following conclusion: 1. Instead of the classic warm-up jogging, Usain Bolt prefers a warm-up procedure with mobilisation by a physiotherapist. Such a warming-up procedure may be useful in the case of high temperatures or when there are several qualifying rounds. 2. Because of his strength abilities, Bolt is in a position to keep his upper body quiet, and there are hardly any evasive movements. He seems to have a very pronounced trunk
stability, which enables him to translate his active leg and arm actions into maximum speed. 3. In the 100-meter final in Berlin Bolt reached a very high speed earlier than at the Beijing Olympics. For metabolic reasons, acceleration to the highest possible speed within a short time is of great importance. 4. During the front support phase, Bolt’s touchdown is active and almost under his CG. He brings his swing leg very close to his buttocks and moves it forward very fast. Using a pronounced front swing phase, he actively gets into the support and his touchdown is close to the projection point of his CG. This technique produces only slight braking effects. 5. What is particularly impressive about Bolt’s performance is that he is able to sprint fast in a very relaxed manner.

Mills, G.  
**NSA interview: Glen Mills [NSA-Interview mit Glen Mills]**

*New Studies in Athletics, 24, (2009), 1, pp. 29-34*

Glen Mills has guided Usain Bolt’s career since 2004. His coaching education included courses staged by the IMF Regional Development Centre in Puerto Rico and the International Olympic Committee. He has led Jamaican teams to international competitions, coached a number of top sprinters from the Caribbean, including 1987 world championships 100m silver medallist Ray Stewart (JAM) and 2003 world 100m champion Kim Collins (SKN), and he is currently the main coach at the IAAF HPTC in Kingston. But with the success of Beijing, Mills’ own story is becoming more widely known and recognition has followed. Among his most recent awards was the “Coach of the Year” presented by his colleagues in the North American, Central American and Caribbean Track and Field Coaches Association (NACACTFCA) in October 2008. The credentials and reputation of Mills, who has been coaching since the age of 14, were already well established before he hooked up with Bolt. Insight into Mills’ thorough approach and his relationship with Bolt is provided by this interview.

**Effect of competitiveness on forty-yard dash performance in college men and women**


The objective of this study was to determine performance differences between individual and competitive trials of the 40-yard dash. Physically active college men (n = 25) and women (n = 29) performed an individual 40-yard dash, followed by completion of the Sports Competition Trait Inventory (SCTI) before performing a paired 40-yard dash against a time-matched competitor. All sprints were performed on an indoor rubberized track using photoelectric gates to start and stop a digital timer. In addition, 3 timers used hand-held stopwatches to record the individual sprint time. There was no significant difference (p < 0.10) between men (120.3 ± 16.6) and women (111.7 ± 20.3) on the SCTI. There was no significant difference between individual and competitive 40-yard dash times for either men (5.21 ± 0.24 and 5.19 ± 0.23 seconds, respectively) or women (6.12 ± 0.31 and 6.11 ± 0.32 seconds, respectively). The correlation between SCTI and both individual and competitive 40-yard dashes was significant (p < 0.05) for women (r = -0.45 and = 0.44, respectively) but not for men (r = -0.10 and 0.10, respectively). Electronic times (5.70 ± 0.54 seconds) were not significantly different from 1 hand-timer (5.71 ± 0.56 seconds) but were significantly faster than the other 2 timers (5.80 ± 0.58 and 5.82 ± 0.57 seconds). Averaging the 3 hand times (5.78 ± 0.56 seconds) for comparison with the electronic timing (5.70 ± 0.54 seconds) produced a high correlation (r = 0.96) but a significantly slower time (p < 0.05). A competitive environment does not appear to improve short sprint times in either men or women. In addition, hand timing may not always produce faster times compared to electronic timing.

**Predictors of sprint start speed: the effects of resistive ground-based vs. inclined treadmill training**


There is currently no consensus with regard to the most effective method to train for improved acceleration, or with regard to which kinematic variable provides the greatest opportunity for improvement in this important performance
characteristic. The purpose of this study was to determine the effects of resistive ground-based speed training and incline treadmill speed training on speed-related kinematic measures and sprint start speed. The hypothesis tested was that incline treadmill training would improve sprint start time, while the ground-based resistive training would not. Corollary hypotheses were that treadmill training would increase stride frequency and ground-based training would not affect kinematics during the sprint start. Thirty-one high school female soccer players (15.7 ± 0.5 years) were assigned to either treadmill (n = 17) or ground-based (n = 14) training groups and trained 2 times a week for 6 weeks. The treadmill group utilized incline speed training on a treadmill, while the ground-based group utilized partner band resistance ground-based techniques. Three-dimensional motion analysis was used (4.5 m mark) before and after training to quantify kinematics during the fastest of 3 recorded sprint starts (9.1 m). Both groups increased average sprint start time from 1.75 ± 0.12 to 1.68 ± 0.08 seconds (p > 0.001). Training increased stride frequency (p = 0.030) but not stride length. After training, total vertical pelvic displacement and stride length accounted for 62% of the variance in sprint start time for the resistive ground-based group, while stride length and stride frequency accounted for 67% prediction of the variance in sprint start time for the treadmill group. The results of this study indicate that both incline treadmill and resistive ground-based training are effective at improving sprint start speed, although they potentially do so through differing mechanisms.

Nunn-Cearns, G.  
**Training for young athletes**  
*Modern Athlete and Coach, Ashmore City (Austr.)*, 48, (2010), 4, pp. 9-11

In this article, the author explains her thoughts on the development of young athletes in sprinting and the importance of an overall development. It is emphasised that, at an early age, it is extremely important to have a large variety of activities to help develop an athlete’s coordination and a multi-sided development in their general physical capabilities. During this introduction to Track and Field, athletes from the age of 10 to 15 years need a multi-sided development of their general physical characteristics. Activities used during this initial stage could include uphill runs, stair running and hopping, runs in the sand and runs over small hurdles alternated with sessions under normal conditions. All are great activities for developing a general fitness level and tend to guide the coach as to the deficiencies of the young athlete — whether it be stability, basic body strength or flexibility to name a few. The young athletes should also be introduced to learning the basic elements of relays and minor games that ask the athlete to change their running speed and direction continually. Drills encouraging basic movement patterns and stability should also be kept in mind. The MUSTs in the development of sprinters are: 1. Functional strength – not necessarily the weight an athlete can lift, but the amount of strength the athlete uses in the execution of their activity. 2. Structural stability – the ability for the body to move efficiently as a series of levers. 3. Structural Flexibility – ability to take advantage of range of motion. Longer, stronger muscles will produce force and stabilise joint actions which will allow the athlete to support technical development. Activities should follow the following guidelines: 1. Static to dynamic, 2. Slow to fast, 3. Simple to complex, 4. Unloaded to loaded. Training should reflect the maturation level of the athlete with frequency of competition also included. Quality of performance will always ensure the athlete stays in the sport for longer. Development of movement speed and ability must be preceded by improvement of physical competencies.

Paulson, S.; Braun, W. A.  
**The influence of parachute-resisted sprinting on running mechanics in collegiate track athletes**  

The influence of parachute-resisted sprinting on running mechanics in collegiate track athletes. The aim of this investigation was to compare the acute effects of parachute-resisted (PR) sprinting on selected kinematic variables. Twelve collegiate sprinters (mean age 19.58 ± 1.44 years, mass 69.32 ± 14.38 kg, height 1.71 ± 9.86 m) ran a 40-yd dash under 2 conditions: PR sprint and sprint without a parachute (NC) that were recorded on a video computer system (60 Hz). Sagittal plane kinematics of the right side of the body was digi-
tized to calculate joint angles at initial ground contact (IGC) and end ground contact (EGC), ground contact (GC) time, stride rate (SR), stride length (SL), and the times of the 40-yd dashes. The NC 40-yd dash time was significantly faster than the PR trial (p < 0.05). The shoulder angle at EGC significantly increased from 34.10 to 42.10° during the PR trial (p < 0.05). There were no significant differences in GC time, SR, SL, or the other joint angles between the 2 trials (p > 0.05). This study suggests that PR sprinting does not acutely affect GC time, SR, SL and upper extremity or lower extremity joint angles during weight acceptance (IGC) in collegiate sprinters. However, PR sprinting increased shoulder flexion by 23.5% at push-off and decreased speed by 4.4%. While sprinting with the parachute, the athlete’s movement patterns resembled their mechanics during the unloaded condition. This indicates the external load caused by PR did not substantially overload the runner, and only caused a minor change in the shoulder during push-off. This sports-specific training apparatus may provide coaches with another method for training athletes in a sports-specific manner without causing acute changes to running mechanics.

Potthast, W.; Brüggemann, Gert-Peter
Regel 144.2: Sprintmechanik eines beidseitig unterschenkelamputierten Athleten

Because of a genetic defect, both feet and parts of the lower legs of the South African sprinter Oscar Pistorius (OP), who today is 24 years old, had to be amputated. From then on, he learned to walk with the aid of leg prostheses and to play sports exercise, at that time mainly team sports. During the rehabilitation phase after a knee injury, Pistorius began to sprint with specially made prostheses (blades). In the same year (2004) he participated in the Paralympic Summer Games and won the bronze medal over 100m and the gold medal in the 200m (T44 class). In the following years, he broke world records in his class over the 100m, 200m and 400m distances. His personal best is currently at 46.25 s over 400 m. Pistorius aimed to compete at the 2008 Olympic Games with athletes with no disabilities. Sprinting with prostheses, however, could contradict rule 144.2 of the IAAF (International Association of Athletics Federations), according to which no athlete is allowed to use springs, wheels or any other element that gives him an advantage over another athlete who does not use this tool. In the late summer of 2007, the IAAF commissioned the Institute of Biomechanics and Orthopaedics at the German Sports University in Cologne (DSHS) to analyse Oscar Pistorius’ sprint mechanics in the phase of maximum running speed compared to 400-meter sprinters with no disability and similar levels of performance. The method of investigation and results are described in this article. The most notable finding of the study was the large differences in the energetic contributions from knee and ankle on both sides between OP and the athletes without disabilities in the control group (CG). In the participants in the CG, the relative contributions of knee and ankle were more evenly distributed than in OP, whose knee joint provided no significant energetic contribution to the phase of maximum velocity. Here, almost the entire contribution of the lower limb resulted from the work done in the artificial ankle. It should be emphasised that in the competition prosthesis there is an energy dissipation of about 5%, which means that about 95% of the energy stored in the first phase are returned. The prosthesis acts almost like an ideal elastic spring. In the ankle of athletes without disabilities, however, almost half (46%) of the absorbed energy is not returned. This means that about 0.5% of the energy stored in the first phase are returned. The prosthesis acts almost like an ideal elastic spring. In the ankle of athletes without disabilities, however, almost half (46%) of the absorbed energy is not returned. The generation of joint energy in athletes without a disability is always done in connection with muscular work. This also becomes clear from the significantly higher external knee extension moments of the control athletes. These external moments must essentially be counteracted by muscle force. Apparently, OP’s strategy enables a sprinting ac-
The results also suggest that practitioners may wish to consider improving a relative 1-repetition maximum back squat in already trained adolescent athletes in order to improve maximal sprinting speed. Our data also suggests that there might be at least positive time saving benefits in performing HRE prior to sprinting over multiple sets utilising the protocols provided.

Rossbach, A. 
Der kurze Bodenkontakt ist entscheidend  
[The short ground contact is decisive]

Leichtathletiktraining, Münster, 18, (2007), 11, pp. 30-37

From a biomechanical point of view, the following factors determine the sprinting performance: 1. Stride length, 2. stride frequency, 3. ground contact time, 4. the position of the CG, 5. the joint angles, and 6. the cooperation of the swinging elements. Velocity is calculated from the distance traveled and the time taken. The sprinter’s speed can only change when he has contact with the ground with the horizontal and vertical forces being of particular interest. If a sprinter has reached his maximum speed, the horizontal forces are only low, whereas the vertical force component is substantially higher. At the moment of touch-down, the Sprinter must absorb the downward movement of the flight phase, and his own body weight on one leg, while at the same time producing the highest possible speed for the next stride. For this he needs a force of about 1600 Newtons (160 kg). This force must be produced in the shortest possible time, i.e., with short ground contact times. In particular, this is a crucial factor in sprint performance. Against this background and on the basis of picture sequences, the author analyses the technique of the German sprinter Julian Reus (10.28 sec), who won the 100m gold medal and 200m silver medal at the U20 European Championships 2007, and of the German sprinter Cathleen Tschirch, who in 2007 ran for the first time under 23 sec over 200m, was German champion, an is at the top of the 2007 German yearly list of best athletes.

Rotter, D. 
Sprinten richtig vorbereiten  
[Preparing for the sprint correctly]

Leichtathletiktraining, Münster, 18, (2007), 2/3, pp. 20-27
For the sprint-specific warm-up the improvement of the neural control processes is especially important: the conduction velocity must be increased, the receptors must respond faster, and the muscle tone, the contraction and relaxation skills need to be optimised. This way, the inter- and intra-muscular coordination is improved. Basically, the following aspects should be considered when warming up for the sprint: 1. The warm-up must include a competition-like movement technique. 2. During the warm-up, intensive exercise types should be carried out with the highest concentration. Only then can a state of optimal motivation be created.

Saunders, R.
**Stride pattern of the ‘sprint drive’ technique**
*Modern Athlete and Coach, 46 (2008), 2, pp. 22-23*

The discrete components of the 100m performance, in the required order of execution, are: a fast, reactive response to a given stimulus; an efficient block clearance; the powerful drive to full acceleration; maintenance of horizontal velocity; and, reluctant but relaxed deceleration. The powerful drive to achieve full acceleration in a 100m sprint is accomplished through a learned technique which Dick (1991) among others, has identified as the Sprint Drive. The Sprint Drive technique should be regarded primarily as a vehicle through which the athlete is enabled to achieve full horizontal velocity in the execution of a technically competent sprint performance. The Sprint Drive component of the 100m sprint performance commences as the athlete is moving out of a “pike” body position, rough a powerful horizontal thrust from the starting blocks. At this initial point in the driving phase, the back is flat and the centre of mass is low in order to overcome friction and inertial forces in the initial strides of the sprint performance. The head is in line with the 93 and the eyes are looking down at the track in order to prevent the driving athlete from rising too soon to an upright position. The arms are driven back through a full range of movement in a vigorous pumping action that reflects the powerful driving action of the legs. The elbows should be held at an approximate angle of 90 degrees as they are driven back to a position high behind the torso to counterbalance the low, forward position of the head and shoulders. An emphasis should be placed on work performed behind the body, with the powerful, backward sweep of the arms more pronounced as the hands pass behind the hips and the legs driving to full hip, knee, and ankle extension behind and below the torso before the completion of each foot contact with the track. Accordingly, the duration of each foot-strike will be comparatively long in the opening strides of the Sprint Drive phase, as the athlete strives to increase the rate of acceleration towards maximum attainable velocity. According to the author, there is one major point relevant to the teaching of the Sprint Drive technique to novice sprinters which is frequently overlooked by the inexperienced coach. This concerns the relationship between stride rate and stride length during the Sprint Drive phase of the 100m performance in what McFarlane (2000) has described as a stride pattern of pure acceleration. In order to attain full horizontal speed as quickly as possible, it is crucial that, in the early strides of the Sprint Drive as much flight as possible is eliminated from the sprinting action. The initial stride should be as short as practicable, with the athlete aiming to make an initial foot contact with the track within 50cm of the start line. Each subsequent stride should then be increased in length by approximately 10cm until optimal stride length is reached as the athlete rises to an upright posture and approaches maximum horizontal velocity.

In contrast to the elite sprinter, who may still be accelerating between the 50-60m points of the 100m performance, the developing sprinter is likely to reach maximum horizontal velocity between 35-45m, depending on ability and experience. Accordingly, the stride pattern of the more accomplished and more powerful powerful elite sprinter is likely to be based on an increasing stride length of 15cm, with the initial strides measuring 60cm, 75cm, 90cm etc up to an optimal stride length of perhaps 2.50m. It is imperative to the development of the athlete, then, that the coach emphasises the value of the stride pattern of pure acceleration as a vehicle by which the athlete is enabled to increase the potential for maximal horizontal velocity in the performance of the 100m sprint in training and in competition.

Schiffer, J.
**Overview: The sprints**
*New Studies in Athletics, 24, (2009), 1, pp. 7-17*
Schiffer, J.  
Selected and annotated bibliography No. 83: The 400 metres  
*New Studies in Athletics, Aachen, 23, (2008), 2, pp. 81-102*  
Although the 400 metres is regarded as a “prolonged sprint” it is an event apart from the other sprints, with its own special demands in the areas of physiology, biomechanics and tactics. For example, success in the 400m is highly dependent upon the athlete’s ability to produce energy via anaerobic glycolysis, with the accompanying acidosis. Training for the event must, therefore, have a strong emphasis on increasing the athlete’s alactate anaerobic power and capacity and his or her lactacid anaerobic capacity. Also important are how the running technique and pacing strategies used in the 400m differ from the other sprints. Therefore, the coach must be aware of both biomechanical aspects and the ideal distribution of energy in order to prepare his/her athlete for success. The purpose of this bibliography, the first in NSA dealing exclusively with the 400m, is to provide coaches, athletes and others interested in the event with abstracts of a structured list of publications from the available literature, selected for their relevance to the special demands of the event. As it must fit within the space constraints of a printed Journal, it is meant to provide overviews of the items chosen by the author rather than an exhaustive list of articles that might touch the topic. The aim, in other words, is to give readers a service that is more personalised, focused and immediately informative than a simple list of publications or an internet search. This bibliography contains 113 articles and books from the years 1976 to the present. It is divided into six sections. The first three deal with the key training demands for the 400m as outlined above. In making the selections, two other subtopics stood out as being of special interest to the target group of readers: the first is the specific sport medicine aspects of the 400m and the second is the event’s dose relationship with the 4x400m relay. These are covered in sections 4 and 5. A small selection of items that were not readily assigned to the first five sections has been included as section 6. The sections are as follows: 1) Publications with an emphasis on training aspects of the 400m (49 documents); 2) Publications about the biomechanics and technique of 400m running (7 documents); 3) Publications dealing with tactics and speed distribution in the 400m (9 documents); 4) Publications dealing with medical aspects of the 400 metres (34 documents); 5) Publications about the 4x400m relay (3 documents); 6) Various publications about the 400m (11 documents).

Schiffer, J.  
Selected and annotated bibliography No. 86: The sprint start  
*New Studies in Athletics, Aachen, 24 (2009), 1, pp. 97-119*  
A good start contributes more to a sprint race than merely reducing the block clearance time, which accounts for approximately 5% of the total time of a 100m race. The way the sprinter is positioned in the blocks at the set command and the mechanics of leaving the blocks have great effects on the acceleration in the first portion of the race. In general, high performance levels over 100m correlate with correspondingly high performance levels in the block start and the acceleration phase of a sprint.
race. The crouch start replaced the standing start in 1887. Scientific study of starting dates back to 1927, when BRESNAHAN investigated the difference between starting from holes dug in the ground and starting from blocks. Research has examined many factors affecting the start, including the angle of the blocks, block spacing, the forces exerted against the blocks, and the body position during the set phase. These are only some of the aspects covered by the publications included in this bibliography, which is the first exclusively dealing with the sprint start in NSA. It includes 81 articles and books from the years 1934 to 2008 and is divided into the following chapters: 1. Publications dealing with the technique and biomechanics of the sprint start (56); 2. Articles on the coaching and training of the sprint start (8); 3. Publications about the teaching of the sprint start to schoolchildren (7); 4. Articles dealing with reaction time aspects (10).

Schiffer, J.  
**The 400 metres**

*New Studies in Athletics, Aachen, 23, (2008), 2, pp. 7-13*

Although once classified among middle distance events, the 400 metres is now regarded as a “prolonged sprint”. This term appears to be appropriate, especially when one considers that Michael Johnson’s 1999 world record of 43.18 is the equivalent of four consecutive 100m in 10.795 seconds. Sometimes the 400m is also referred to as the “killer event” because, being just beyond the limit through which a well-trained runner can maintain his or her maximum speed, a huge stress is placed on the organism with the body invariably fatiguing, “rigging” or “tying up”, especially in the closing stage. As early as in 1888, this led Montague Shearman, the most famous observer of athletics in the 19th century, to refer to 440 yard runners as “runners who run themselves blind before reaching the tape”. The purpose of this overview is to give a brief history of the event and summarise the current consensus thinking on the following points: 1. Types and characteristics of 400m runners; 2. Energy and speed distribution in the 400m; 3. Mental makeup of successful 400m runners; 4. Characteristics of the 400M and commonalities with sprinting; 5. Biomechanical aspects; 6. Training principles; 7. Training methodology.

Schrader, A.  
**’Kleine’ Übungen mit großer Bedeutung**

*Leichtathletiktraining, Münster, 21, (2010), 4, pp. 4-13*

The author presents a number of so-called ABC exercises, i.e., small exercises that can be used to improve the technical aspects of the sprint.

Schrader, A.  
**Schnelle Füße und ’saubere’ Technik [Quick feet and ‘clean’ technique]**

*Leichtathletiktraining, Münster, 19, (2008), 8, pp. 4-11*

The author presents a number of speed drills that can be used to improve the foot position as well as the feet and leg movements that are necessary for correct sprint technique.

Schrader, A.; Müller, F.; Killing, W.  
**Jamaikas ’Lightning Bolt’** [Jamaica’s ‘Lightning Bolt’]

*Leichtathletiktraining, Münster, 19, (2008), 12, pp. 4-11*

At the Olympic Games in Beijing, the track and field sprint events were the domain of the Jamaicans. All of the 11 medals the Jamaican athletes won were won in the sprint events. The most outstanding sprinter was Usain Bolt, who set new world records ran in both the 100 and 200m and also won the gold medal with the Jamaican relay team in world record time. The focus of this article is therefore on the question: What is it that makes the Jamaican athletes so fast? The following three hypotheses are examined: 1. The Jamaicans have a genetic predisposition to sprinting in the form of a disproportionate great muscle-fibre concentration of A actines, which supports the fast “twitching” of their muscle fibres. However, there is no exact scientific evidence to support this theory. What is certain is only that Jamaicans have other muscle fibres than Europeans. As the Jamaicans, with respect to their muscle structure, also differ from their African ancestors, who mainly tend to the long distances, there is the argument that slavery led to the selection of the fittest. As part of the “triangular trade” that started in the 16th century, only the strongest people, especially from West Africa, were selected by the Europeans and transported to the Caribbean. Only few of the slaves did survive the crossing. Then, the extremely hard physical labor allegedly led to a further selection. 2. Athletics is the most popular sport in Jamaica. An athlet-
ics career is a possible way out of poverty. 3. The climate in Jamaica is tropical and characterised by northeast trade winds. Also, due to the small temperature differences in the course of the year the training conditions are very good. The following especially applies to Usain Bolt: Bolt’s strength is his active touchdown in the front support phase, which is initiated by the rapid and strong heel kick in the swing phase. The touchdown takes place almost directly under the CG, which means that strong braking effects are avoided. Like Borsov in the 1980s, Bolt demonstrates a marked extension of the rear support leg. Because of his technique, ideal physical conditions (including a body height of 1.93 m) and his speed endurance abilities (he ran the second 100 metres in the 200m victory in Beijing in 9.32 sec), Bolt should be even able to increase his 200m performance. Perhaps, he will even be able to break the 400m world record.

Seager, A. Erfolgreiche Teamarbeit [Successful teamwork]
Leichtathletiktraining, Münster, 22, (2011), 1, pp. 4-9
In the last few years, the German women sprinters have always demonstrated good to very good performances at international junior championships. Against this background, the sprinters set themselves a clear 4 x 100 m relay target for the year 2010: Place four to six at the U20 World Championships in a time of 44.40 to 44.60 sec. Eventually, the relay team, with Nadja Bahl (first leg), Leena Günther (second leg), Tatiana Pinto (third leg), and Stefanie Pähler (fourth leg), won the silver medal in 43.74 sec behind the U.S. relay team. The author describes the initial situation, the selection of the positions, the preparatory training measures, the preparatory competition (U20 Gala in Mannheim), and the course of the U20 World Cup in Moncton itself. In addition, the first exchange during the heat at the U20 World Championships is analysed in detail based on a picture sequence.

Shepherd, J. Conditioning sprint acceleration: recent research
Track Coach, Mountain View, (2010), 193, pp. 6177-6180
Researchers from New Zealand studied the ground reaction forces (GRF) involved in the acceleration sprint phase (1). Thirty-six athletes performed maximal-effort sprints from which video and GRF data were collected at the 16m mark. The team discovered that the faster accelerating sprinters displayed less vertical impulse in their acceleration phase, i.e., more force was directed horizontally, thus pushing them forward. The sprinters with the fastest acceleration also had fastest ground contact times. Although acceleration requires increased foot/ground contact times when compared to top speed sprinting (to impart sufficient force to overcome inertia and push the sprinter forward), the research indicates that the fastest accelerators also have the quickest track contact reactions. This is a crucial factor to be borne in mind by sprint coach and athlete when
selecting appropriate acceleration conditioning methods. For Optimum acceleration the sprinter needs to incline the trunk forward and drive the ground back behind him (this contrasts with the flat-out phase when work is done “in front of the body”). The arms should be pumped vigorously backwards and forwards as the sprinter drives from the blocks to gain momentum. Coaches vary in the way they teach the leg movement; some will argue for a driving back action, while others advocate bringing the thighs to the chest in a piston-like manner. In both cases the body should remain inclined. Around the 15m mark the athlete’s torso will increasingly move into an upright position. Research also shows that concentric (not plyometric) force development is critical to sprint start performance and accordingly maximal concentric jump power is related to sprint acceleration. This is in contrast to the subsequent sprinting strides that benefit from the increased plyometric power opportunities provided. This occurs when the eccentric priming of the subsequent concentric contraction increases power potential, in the muscles of the calves, thighs and hips. It’s a little like stretching out a spring to its full extent (the eccentric contraction) and then letting it go. An immense amount of power will be released in the split second the spring recoils (the concentric contraction). Another research team discovered that 1) a hopping test was the best predictor of performance over the last two phases of the 100m race and 2) that sprinters who had the greatest leg stiffness produced the highest rates of acceleration between the first and the second phases – not the first. The 100m sprint was divided into a 0-30m acceleration phase, a 30-60m secondary acceleration to maximum speed phase and a 60-100m speed maintenance phase. So why is leg stiffness less important for acceleration? The answer is as indicated previously more than likely a response to the fact that concentric muscular strength expression is a key acceleration determinant, while plyometric power – which is enhanced by greater leg stiffness – becomes more relevant to sprinters when they are at maximum velocities and can use a fast eccentric pre-stretching muscular contraction to enhance the power output of the subsequent concentric contraction. As far as training with weighted sleds is concerned, a team of Greek researchers looked specifically at the validity of towing methods as a way of improving both acceleration and sprint speed (6). Eleven students trained using 5kg weighted sleds (the RS group) and 11 without (the US group). Both followed sprint training programs, which consisted of 4x20m and 4x50m maximal runs. These were performed three times a week for eight weeks. Before and after the training programs the subjects performed a 50m sprint test. The students’ running velocity was measured over 0-20m, 20-40m, 20-50m and 40-50m. In addition stride length and stride frequency were evaluated at the third stride in acceleration and between 42-47m during the maximum speed phase. The researchers discovered that the RS group improved their running velocity over the 0-20m phase, i.e., their acceleration improved. However, the RS groups acceleration improvement had no effect on their flat-out speed. This contrasted with the US group who improved their running velocity over the 20-40m, 40-50m, and 20-50m run sections. This led the researchers to draw the obvious conclusions that, “Sprint training with a 5kg sled for eight weeks improved acceleration, but unresisted sprint training improved performance in the maximum speed phase of non-elite athletes. It appears that each phase of a sprint run demands a specific training approach.”


The purpose of this study was to compare the main kinematic, kinetic, and dynamic parameters of elite and well-trained sprinters during the starting block phase and the 2 subsequent steps. Six elite sprinters (10.06-10.43 s/100 m) and 6 well-trained sprinters (11.01-11.80 s/100 m) equipped with 63 passive reflective markers performed 4 maximal 10 m sprint starts on an indoor track. An opto-electronic motion analysis system consisting of 12 digital cameras (250 Hz) was used to record 3D marker trajectories. At the times “on your marks,” “set,” “clearing the block,” and “landing and toe-off of the first and second step,” the horizontal position of the center of mass (CM), its velocity (XCM and VCM), and the horizontal position of the rear and front hand (XHand_rear and
According to the author, the relatively poor performances of today’s German 400m runners is caused by their relatively poor sprinting speed. In contrast, the German 400m sprinters of the 1970s and 80s were highly efficient even at the shorter distances. They were often in the final of the German championships over 200 metres. It is also important that the effect of the speed requirements is the greater the higher the degree of qualification. With increasing qualification there is a dramatic increase of the impact of the performance ability on the first 200 metres on the final 400m time. As a consequence of this, the speed capabilities in the 400-m-training must be developed as a priority. According to the author, reality shows, however, the neglect of speed development, while there is a simultaneously greater emphasis on speed endurance training. This combination leads to a premature stagnation of performance and reliably prevents the actual development of 400m sprinters. During basic and build-up training, the basic endurance performance is the second elementary performance requirement, in addition to speed. Neither of these capabilities must be neglected in favor of the other one, but they should be rather developed simultaneously. Only after the development of speed and basic endurance should the special endurance training be systematically used at appropriate intensities as a conjunction of these two elementary abilities. Special endurance training represents therefore the real power reserve for peak performances. Only athletes who are fast and have stamina have a final chance to be able to really sprint the 400 meters.

Sniderman, S.
Twitch-ful thinking: How strong is the correlation between type II muscle fiber and elite performance in explosive sport?
*Track Coach, Mountain View (Calif.) (Summer 2010), 192, pp. 6131-6138, 6149*

Many who follow sports take for granted that a high proportion of Type II (or fast-twitch) muscle fiber gives elite athletes an advantage in explosive Sports like sprinting and jumping. They also assume that athletes of West African descent, especially African Americans and Afro-Caribbeans, have that genetic gift which explains, to a great extent, their world-beating performances in track, football, basketball, and other competitions. However, the Personal Bests of decathletes and the national records of various countries, including some from West Africa, indicate that, for an individual or for a population, blazing speed and spectacular jumping ability are probably not products of the same inherited traits, increasing the chances that an explanation of athletic success in explosive sports which involves amount and quality of intense practice is more useful than one based on fast-twitch muscles.
the focus being on the German sprinter Robert Hering (20.58 sec in the 200m sprint) and the Jamaican world record holder Usain Bolt (20.08 sec over 200m). At the end of his analysis the author comes to the conclusion that the significant performance differences between European and Jamaican sprinters can be primarily explained by doping. For example, the long-term training buildup already at young age creates accents that are responsible for the Jamaican sprinters’ superiority at least to a certain extent. This means that speed is developed and accentuated rather early (even in terms of the elementary speed prerequisites) and much value is attributed to general athletic development. There is an early and comprehensive coordinative and technical training in order to target important movements. In high-performance training itself, the relationship between loading and unloading is meticulously respected. Jamaican sprinters also try to not move too far from the intensity level of the target performance even in the preparatory phases (in top athletes about 1.5%). In the second part of this article the author analyses the women’s sprint performance at the IAAF World Championships in 2009 and has a particularly close look at the 4x100m relay team. In relay running good exchange skills can compensate for not so good sprinting abilities. The relatively poor exchange gains of almost all women relay teams during the finals at the IAAF World Championships show that, in general, there is still a considerable performance potential. Through rigorous preparation and subsequently corresponding improvements in exchange difference different nations can be very quickly successful. Due to the specific performance factors, the 4x100m relay should be regarded as a discipline with its own technical elements that need to be developed specifically, systematically and on a long-term base.

Vonstein, W. 
Schnell sein in der Jugend – und später! [Being fast as a young athlete – and later as well!]
Leichtathletiktraining, Münster, 18, (2007), 2/3, pp. 10-19
The build-up training in athletics usually takes place between the ages 15-16 and 18-19 years and is divided into two phases with different objectives and content. Crucial for the transition from one to the next phase of training and also for the duration of each training phase are not the age groups, but the biological age and the current level of general and special performance-determining conditions. The overall objective of the build-up training is to develop targeted, in the first phase still block-specific training and performance fundamentals that create the conditions necessary for the subsequent follow-up and high-performance training. The main goals and tasks of the build-up training in athletics are: 1. Development of a high stress tolerance, 2. priority of speed training, 3. priority of the training of the coordinative abilities, 4. improvement of training quality, 5. increase of the training volume. The goal of the build-up training is not achieving peak performance, but above all, to lay the necessary foundation for maximum performance in a subsequent training and development phase. Only if the content-related tasks are continuously developed together with a systematic load increase and training specification is there a realistic chance to secure a long-term success. The second phase of the build-up training ideally takes place between 17 and 18/19 years and its goal is the specialisation in one discipline (e.g., the 100m distance). The specialization is done by (1) a systematic increase in the volume in the special training, (2) a shift in the proportions of general and specific training for the benefit of special training, (3) a continuous increase in load intensity and (4) a permanent increase in the competitions in the special discipline. The tasks of the second stage of the build-up training should be seen as against this background: 1. Perfection of a high general physical load tolerance and adaptability, 2. achievement of a high level of individual performance in the special discipline or coupling of related special disciplines on the basis of a high load tolerance and a good state of development of the discipline-specific performance requirements, 3. continuation of the technical development of fitness with increasing physical requirements with a focus on effective competition technique, 4. deepening of theoretical knowledge of biomechanics, sports medicine and stress methodological contexts of training, 5. coping with the increased demands on the self-organisation in the face of increasing training and competition requirements, 6. promotion of the mental properties of athletes that are necessary for training and competition.

Vonstein, W. 
Schnell sein in der Jugend – und später! [Being fast as a young athlete – and later as well!]
Leichtathletiktraining, Münster, 18, (2007), 2/3, pp. 10-19

R: 184

...self-confidence, independence, readiness to take risks, etc.), and 7. preparation of the best athletes for an international peak competition for their age group. In terms of the content-related areas of emphasis, especially in the sprint, it is also to be noted that (1) right from the beginning speed must be developed as a coordinative ability, i.e. with the highest precision of the corresponding control mechanisms, (2) the fine form of the sprint, the hurdles, and the relay techniques is developed, (3) speed and acceleration play a key role in training methodology and therefore must be the focus of attention, (4) the most important training exercises must be performed with a good technique and, if possible, must be coupled with the target technique (e.g., bounding runs, squats, etc.). Against this background, the author presents a yearly training plan for young sprinters in the second phase of build-up training. Even sprinters during follow-up training (20-23 years) can base their training on the systematics of the general training plan presented, but their focus should be somewhat shifted.

Wank, V.; Heger, H.; Schwarz, M. Dynamografischer Messplatz zur Tiefstart-Leistungsdiagnose [A dynamographic measuring station for performance diagnosis in the crouch start]


By using the crouch start, sprinters want to reach three objectives: the start action must take place in the shortest possible time, the horizontal velocity should be maximised, with the push-off direction being optimised to the benefit of the subsequent acceleration phase. The assessment of the starting quality can reliably take place based on the fulfillment of these three target criteria. The focus of the project work was therefore initially the development and evaluation of a measuring station for measuring and evaluating the performance-related biomechanical parameters of the crouch start – reaction time, action time, speed when leaving the block, push-off direction, and the separate force components of both legs – as instant information. In the literature, different methods for measuring the reaction forces at the starting block are described, which serve as the basis for the measurement concept. Previously published data indicate that for a comprehensive analysis all points of force impact during the start must be measured in order to draw conclusions concerning the partial movements of the sprinter on the basis complete dynamografic data. This requirement could not be fulfilled by previous studies. The focus of the project was specifically designed to completely capture the leg and arm forces in horizontal and vertical directions.

Young, M. Maximal velocity sprint mechanics Track Coach, Mountain View, (2007), 179, pp. 5723-5729

Sprinting is a complex task that places a high neuromuscular demand on the performer and requires high levels of coordinated movement and appropriate sequencing of muscle activations to perform at peak levels. This paper will examine maximal velocity sprint mechanics with particular focus on the primary factors affecting performance, the mechanics associated with those factors, and the causal relationships that occur as a result of optimal sprinting mechanics. Although it is understood that maximum velocity sprinting mechanics cannot be taken out of the context of either the acceleration that preceded it or the biomotor abilities of a given athlete, this article focuses solely on maximal velocity mechanics for the sake of simplicity. The author arrives at the following conclusion: Sprint performance is maximized when the largest possible forces are applied in appropriate directions over very short periods of time. From a technical standpoint, an athlete should strive to preserve postural stability, minimize braking forces and increase vertical propulsive forces. Generally speaking, all three of these issues can be addressed by running with optimal posture, increasing frontside mechanics, and minimizing backside mechanics. In addition to these technical points, biomotor training with an emphasis on developing strength, power, and elasticity in the gluteal, quadriceps and hamstring musculature, as well as strength and stability in the muscles of the core, will help to enhance an athlete’s maximal velocity.
Zagatto, A. M.; Beck, W. R.; Gobatto, C. A.  
**Validity of the running anaerobic sprint test for assessing anaerobic power and predicting short-distance performances**  
*Journal of Strength and Conditioning Research, Colorado Springs, 23, (2009), 6, pp. 1820-1827*  
The purpose of this study was to investigate the reliability and validity of the running anaerobic sprint test (RAST) in anaerobic assessment and predicting short-distance performance. Forty members of the armed forces were recruited for this study (age 19.78 ± 1.18 years; body mass 70.34 ± 8.10 kg; height 1.76 ± 0.53 m; body fat 15.30 ± 5.65 %). The RAST test was applied to six 35-meter maximal running performances with a 10-second recovery between each run; the peak power, mean power, and the fatigue index were measured. The study was divided in two stages. The first stage investigated the reliability of the RAST using a test-retest method; the second stage aimed to evaluate the validity of the RAST comparing the results with the Wingate test and running performances of 35, 50, 100, 200, and 400 m. There were not significant differences between test-retest scores in the first stage of the study (p > 0.05) and were found significant correlations between these variables (intraclass correlation coefficient [approximately equal to]0.88). The RAST had significant correlations with the Wingate test (peak power r = 0.46; mean power r = 0.53; fatigue index r = 0.63) and 35, 50, 100, 200, and 400 m performances scores (p < 0.05). The advantage of using the RAST for measuring anaerobic power is that it allows for the execution of movements more specific to sporting events that use running as the principal style of locomotion, is easily applied and low cost, and due to its simplicity can easily be incorporated into routine training. We concluded that this procedure is reliable and valid, and can be used to measure running anaerobic power and predict short-distance performances.

Zorn, D.  
**Sprinttraining einmal anders [A somewhat different sprint training]**  
*Leichtathletiktraining, Münster, 19, (2008), 4, pp. 27-29*  
The so-called “Zorn runner” developed by the author is a kind of scooter with big wheels for adults to practice the optimal stride length at the highest possible frequency for the free sprint. The device cannot only be used for technique training but also for the dynamic strengthening of the often neglected muscles of the back of the legs (hamstrings). Due to this muscular training effect, the “Zorn runner” also serves to prevent injury. In addition to optimising the stride rate, the “Zorn runner” can be used to develop a pulling running stride and for learning the optimal hip position for the sprint.
New Studies in Athletics · no. 1/2.2011

The performances of Jamaican sprinters in recent years and particularly Usain Bolt’s phenomenal world records at the 2008 Olympics and 2009 IAAF World Championships in Athletics have attracted international interest and stirred the desire to unravel the secret of the success of the Jamaican athletes.

Against the current background of successes it is sometimes forgotten that already more than 50 years ago there were Jamaican athletes who captured the attention of sports fans worldwide. The sparkle started at a time when Jamaica was not even an independent nation but still a colony of Britain. At the 1948 Olympics in London, Arthur Wint won Jamaica’s first gold medal in the 400m. Four years later at the 1952 Olympics in Helsinki, the quartet of Leslie Laing, Wint, Herb McKenley and George Rhoden edged out the favourite US team in the 4 x 400m relay by a tenth of a second and set a new world record of 3:03.9 seconds. In 1962 Jamaica became independent, and since then its presence at the Olympics under the black, green and gold flag has been remarkable: In 1968, Lennox Miller won silver in the 100m in Mexico City, in 1976, Donald Quarrie joined him in the rank of medallists, winning gold in the 200m and silver in the 100m, Merlene Ottey took the Jamaican women close to the pinnacle in 1980 with a bronze in the 200m in Moscow and other women followed her with silver medals (Grace Jackson, Juliet Cuthbert) until 1996 when Deon Hemmings became the...
The alpha actinin 3 (ACTN3) gene, a gene which is associated with fast-twitch muscle fibres that allow for high velocity or power sprinting. The actinin 3 gene is a performance-related gene, and one must have the strong form 577RR (homozygous) or the weaker form 577RX (heterozygous) to produce the protein alpha actinin 3 associated with power sprinting.

That 75% of the ordinary Jamaicans tested have the 577RR variant shows that Jamaicans are genetically predisposed to be sprinters, because of their shared ancestry with West Africans; however, the gene has to be switched on or off by environmental factors and physical conditioning. If the environment is not conducive, one may have the gene but fail to perform well on the track.

In addition to carrying out DNA analyses on Jamaicans who participated in the 1948 Olympics right through to those who participated in the Games of the twenty-ninth Olympiad, tests were also conducted on one hundred national athletes (those who participated locally and in the Caribbean) and three hundred persons from the Cockpit Country and Trelawny region of Jamaica. The latter cohort was included because many Olympians either have emerged from that area or have links there. Interestingly, the profile of the persons from the Cockpit Country is similar to that of the Olympians.

The persons from the Cockpit Country have a high frequency of 577RR, the ACTN3 variant associated with elite sprinting. The mere having of the 577RR variant of the actinin 3 gene does not explain why Jamaicans dominate in international sprint events. There must be something driving this gene and/or other genes to perform to the full potential. It is postulated that there are special minerals in the Cockpit Country, akin to bauxites, that the plants uptake and Jamaicans eat in yam and other tubers. Many Olympians, such as Usain Bolt, Veronica Campbell-Brown, Donovan Bailey and Deon Hemmings, come from that region. Even more of the parents of Olympians are from the Cockpit Country.
In Chapter 2, “Charting the Ancestry of Elite Jamaican and US Sprinters”, Rachael Irving, shows that the transatlantic slave trade, which started in the early sixteenth century and lasted over three centuries, was instrumental in moving millions of people from Africa to the Americas: an estimated 11 million people from with about one third from West Africa. The mitochondrial DNA (mtDNA) genome of the descendants of these transported people has retained an imprint of the process. A database of thousands of MtDNAs, including MtDNA sequences from Africa, are publicly available and mitochondrial lineages of West African ancestry in the Caribbean and North America have been identified through genomic analyses.

Mitochondrial DNA has been linked to physical performance and trainability, but more important is that mitochondrial DNA markers or haplogroups can be used in the creation of detailed phylogenies or biogeography charts to explore the matrilineal relatedness of people. Mitochondrial haplogroup distributions are sensitive to population history and some studies have looked at haplogroup distributions in the Caribbean. The few studies to date that have included Jamaica have suggested a predominately West African ancestry with few genetic inroads by Europeans and Asians.

There is growing interest in the genetic trace of the ancestry of Caribbean and US elite sprinters because of the disproportionate success of these athletes in international events. Historical records indicate that the current male record-holders for the sprint (100m to 400m) and hurdles events, including the late Florence “Flo-Jo” Griffith-Joyner, women’s world record holder for the 100m and 200m, descended from West Africa. While MtDNA haplogroup distributions in the Caribbean and United States are well researched, the lineage trace of elite Jamaican and US sprinters has never been undertaken before this study.

Researchers from the University of the West Indies, the University of Glasgow and Florida State University collected samples from 107 and 119 elite Jamaican and US athletes respectively. Samples were also collected from 293 Jamaicans and 1,148 African Americans who have not participated in sports at the national level. The first hyperviable region (HVR-1) of MtDNA was sequenced for each participant and samples were haplogrouped according to the comprehensive full mitochondrial DNA genome phylogenetic tree. The haplotypic distribution for the Jamaican and African-American cohorts was evaluated.

The majority of Jamaican athletes (98%) possessed haplogroups characteristic of West Africa or West-Central Africa while the US athletes had mainly haplogroups suggestive of West and West-Central African ancestry, too, but also more haplogroups indicating a greater percentage of European admixture than the Jamaican sprinters (10% versus 2%).

It was found that the athletes from Jamaica and their controls had similar haplogroup distributions predicative of West and West-Central African origin, and although the controls had more admixture with Eurasia and Asia, it was not significant. The study proved that mitochondrial haplogroup distributions in elite Jamaican sprinters and ordinary Jamaicans (controls) are similar and are primarily derived from the same source populations in West and West-Central Africa.

Mitochondrial haplogroups and biogeography frequency charts are based on specific population histories. This lineage research indicates that Jamaican and African-American sprinters are mainly of West or West-Central African ancestry. The greater mitochondrial diversity in African-American sprinters as compared to the Jamaican sprinters indicates that isolation, differences in number and source of Africans imported, and colonisation history may impact population genetics and the performance of US sprinters.

Talking about “Some Biomedical Mechanisms in Athletic Prowess” (Chapter 3), Errol Morrison and Patrick Cooper contend that there is substantial, documented evidence that the success of individuals of West African de-
scent in athletic activities involving speed and power is based on biomechanical and biochemical differences between themselves and white and Asian athletes and biochemical differences between themselves and all other Africans. The essence of the authors' hypothesis is their claim that the biochemical differences – essentially differences in glucose conversion rates – between West African and West African-descended populations and all other groups, including other black Africans, began but did not end with the sickling of the haemoglobin molecule. In the uniquely lethal West African malarial environment, individuals with the sickle-cell trait possessed a significant selective advantage. Although sickling is caused by a single amino acid substitution, valine for glutamic acid, the authors argue that the mutation triggered a series of physiological adjustments, which, incidentally, had favourable athletic consequences.

These adjustments, or compensatory mechanisms, include a higher percentage of fast-twitch muscle fibres, greater activity in the phosphagenic, glycolytic and lactate dehydrogenase metabolic pathways, and greater rate of ventilation, all of which have been scientifically tested and evaluated. These alterations affect the individual's process in storing and utilizing energy for skeletal muscle contraction and enhances the person's ability to build lean muscle mass.

Black athletes, primarily because of a higher ratio of fast-twitch muscle fibre, convert glucose into energy more rapidly than their white counterparts. Energy for muscle contraction, including all physical and athletic activities, is created by the breakdown of glucose by processes which result in the formation of adenosine triphosphate (ATP). The first stage of the process, known as glycolysis (anaerobic metabolism), is cytosolic and produces ATP at a rate more than twice that of the second, intramitochondrial stage (aerobic metabolism). Both black and white athletes will convert glucose to ATP by glycolysis and by mitochondrial metabolism, but in different ratios. This difference in the relative efficiency or effectiveness of these metabolic pathways in the athletes plays a decisive role in performance and is largely responsible for the greater athletic success of African Americans and others of West African descent.

Muscle biopsies have concluded that people of African descent have significantly higher levels of activity in their phosphagenic, glycolytic and lactate dehydrogenase metabolic pathways than their Caucasian counterparts. The production and regeneration of ATP take place in the glycolytic and phosphagenic pathways. Higher levels of activity result, therefore, not just in faster production of ATP but also in its more efficient regeneration. Faster production and increased regeneration of ATP, however, do not fully explain African-American biochemical superiority in athletic events requiring speed and power. There is also considerably greater activity in the lactate dehydrogenase pathway of people of West African descent. A primary function of this pathway is to reduce muscle fatigue by converting lactic acid back to glucose and re-feeding the muscles. This cyclic set of reactions, from muscles to liver and back to muscles, is known as the Cori cycle.

The recycling of waste products, such as lactic acid, by the liver is vital to the proper functioning of the muscular and nervous systems, among others. Consequently, an athlete engaged in fairly prolonged anaerobic activity – sprinting, for example – would be far less effective without a mechanism to increase the supply of glucose. This is what is accomplished during the Cori cycle, the cyclic set of reactions initiated by increased activity in the lactate dehydrogenase pathway.

The authors arrive at the conclusion that it may be this array of somatogenetic variation, exhibited in the muscle-fibre biology, biochemical metabolic pathways and pulmonary physiology of the Afrocentric peoples displaced from West Africa to the New World which is responsible for the athletic prowess of this group of descendants. Not the least of coincidence seems to be the influence of the compensatory sickle-cell gene on oxygen transport and avail-
ability to the tissues. The reduced availability coupled with the reduced myoglobin in the preponderant fast-twitch muscle fibres, which are adapted for rapid energy (ATP) regeneration, all give a net outcome of muscle anatomical and biochemical advantages which proffer a superior performance in athleticism.

In Chapter 4, “White Men Can’t Run: Where Is the Scientific Evidence?”, Robert A. Scott and Yannis Pitsiladis cast a more sceptical light on the hypothesis that the superior sprint performances of the Jamaican sprinters and African Americans in general is a favourable biology concentrated by natural selection over the centuries as individuals were displaced from West Africa to the New World during the slave trade. These authors point out that genetic explanations of the Jamaican sprint supremacy have not been rigorously tested and that they are subject to the same limitations as genetic explanations of the East African running phenomenon, namely diverse genetic pools of founding populations and time constraints for genetic adaptations to occur.

Scott and Pitsiladis also emphasise that in Jamaica there exists an excellent and unique model that focuses on identifying and nurturing athletic talent throughout junior to senior level. They remind the reader of Patrick Robinson’s conclusion made in his book Jamaican Athletics: A Model for the World (2007) that “the real explanation of the outstanding achievements of the system is that all of its actors are moved by a spirit that unifies them to work to ensure that Jamaican athletics lives up to its rich history and tradition of excellence”. According to Scott and Pitsiladis, this theme echoes what is found in Ethiopia and Kenya. Given these unique circumstances, the superior performances of athletes not only from Jamaica but also from Kenya, Ethiopia come as no surprise to those studying closely these amazing athletes.

In Chapter 6, “Jamaican Yams, Athletic Ability and Exploitability”, Helen Asemota examines the value and importance of natural tubers grown in Jamaica for nutrition and medicine. The food value of yams is based on the carbohydrate, protein, amino acid, vitamin and mineral content. The amount of lipids is negligible in terms of food value. Yams are generally thought of as a good source of native starches which have varying functional characteristics and could find some application in the food ingredients industry.

Many people in the mainstream media have begun to attribute the Jamaicans’ sprint success overwhelmingly to yam consumption, because of the athletes’ yam-rich diet. As a result, yam is now dubbed “the speed agent”. The basis of yam being called so is one which is not entirely clear, but several schools of thought prevail. One perspective is based on the fact that a large percentage of Jamaicans top athletes are from the Cockpit region of the country, where yam is widely grown and consumed. Their athletic prowess could, therefore, be attributed to their yam-rich diet. Without scientific proof, this remains just a guess at best. Within this school of thought, however, there lies a more plausible explanation, which is still only a hypothesis. The phytosterols in yams have the potential to stimulate cell growth and as such may be responsible for enhanced stimulation of proteins essential to muscle function, including proteases, lactate dehydrogenase and actinin-3 protein, which are a part of fast-twitch muscle fibres. Activation of these fast-twitch fibres could in turn cause improvements in muscle speed and overall power. The possibility and rate of this happening has yet to be unravelled. Studies have shown that more than 6 per cent of all prescriptions in human medicine are steroidal hormones. Diosgenin, a saponin derivative of yams, is of great interest as it is easily converted into the starting material for synthesis of these steroidal hormones. This could lead to the question whether it could be that the presence of phytosterols in yams may indirectly result in enhanced muscle mass and speed.

These are some of the facts and views presented in five of the six chapters comprising the first section of the book. Chapter 5, “Physical Therapy: Keeping Athletes on the Move” by Sharmella Roopchand-Martín, Carron Gordon,
and Gail Nelson characterizes injury management and different approaches to treatment of sports injuries that are used with Jamaican sprinters. It is coaches who will benefit the most from reading this chapter.


Section 3 is a photographic essay presenting images of Jamaica’s mastery in sprinting.

Section 4 deals with the cultural norms that make Jamaica unique. Aggrey Irons presents “Run for Your Life” (Chapter 11), a portrayal of Jamaicans’ fascination with running. “The Challenge of Teaching Physical Education in Jamaica” is dealt with by Vilma Charlton in Chapter 12, and “The Role of Boys’ and Girls’ Championships in Jamaica’s Track-and-Field Glory” is discussed in an interview between sport historian Bobby Fray, Vilma Charlton, and Fred Green (Chapter 13).

Against the frequently made accusations that the success of Jamaica’s sprinters might not only be caused by a favourable genetic disposition or by eating a lot of yam but might also be caused by doping, it is quite logical that in the last section of the book, entitled “Protection Issues”, Jamaica’s anti-doping policy is described. This is done in two chapters. Chapter 14 is about “Blood Doping in Sports and Detection Strategies” (by Donovan A. McGrowder), and Chapter 15 Rachael Irving stresses the “The Importance of Haematologic Passports” to protect the athlete’s credibility based on sound scientific data. A completely different issue of athlete protection is the topic of the last chapter of the book. This chapter is entitled “Intellectual Property and the Business of Sports” and its author, Kai-Saran Davis, shows what can be done to protect the athletes’ interests in the business of sports. His answer is that one of the major means of doing so is by ensuring that they protect any creation of their mind that may result from their existence as athletes and personality figures. Also of equal importance is that they must ensure the protection of their image. How this can be done is dealt with in detail.

In summary, Jamaican Gold – Jamaican Sprinters by Rachael Irving and Vilma Charlton is the most complete survey of the reasons for and the background of the success of Jamaican sprinters at international championships. Although the authors may not provide all the answers, they provide historical, scientific and cultural information that will help guide impartial analysis of the sprinting prowess of Jamaican athletes. So, the reader is offered sufficient information to form his or her own opinion about the highly topical and controversial issue of Jamaican sprinting success. Jamaican Gold is highly recommended reading to everybody interested in modern track and field and trying to understand some of the factors that make Jamaican athletes truly remarkable.

Reviewed by Jürgen Schiffer
Introduction

Oztrack.com is a website that claims to be “focused on cutting edge training tips for serious athletes and coaches.” While its main purpose is offering e-books, CDs and DVDs for sale, it provides quite a lot of training and coaching information free of charge.

Form

The information mentioned in the introduction to this review is to be found immediately on the site’s entry page (Figure 1). There is no advertising distracting the user’s attention. Neither is there a menu at the side or at the top of the page. Instead, the page must simply be scrolled down to capture its complete contents.

Figure 1: Oztrack entry pag
Contents

Although the site is mainly text-based, it also includes some videos and pictures embedded into the various texts.

When scrolling down the page, the first link offered is a “Coaching Information Blog”. When clicking this link, users will get various articles and videos dealing, for example, with:
- Sprint training;
- Bounding training for runners;
- Recovery ideas to assist improvement in endurance runners;
- Middle-distance speed training ideas;
- Sprinters, nervous system pre-school;
- Developing sprinters – a yearly plan;
- Endurance training: intensity vs volume;

- Planning ideas for 800m and 1500m athletes;
- Sprint training for the developing athlete;
- Speed from strength.

Scrolling further down, one obtains more “Training & Coaching Information”, which is subdivided into three sections:
- Sprinting 100m, 200m und 400m;
- Middle Distance & Distance Running;
- General Training Ideas.

Below each of these headings are four articles whose topics are presented in Figure 2.

Most of these articles are authored by Steve Bennett, the man behind the Oztrack website. Some of the articles include links to additional information or even related full articles.

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Figure 2: Sections and related articles under the “Training & Coaching Information” button
Conclusion

The Oztrack website is an easy to navigate website that features training and coaching information for athletes and coaches in the sprinting and running events. Although basically a website that wants to sell its products online, it includes enough information free of charge to be interesting for users not interested in buying something. Also because of the quality of this information, the Oztrack website can be recommended for serious coaches.

Reviewed by Jürgen Schiffer
Introduction

The development of speed and power in athletes comes from a number of different training inputs. One of these is from the stimuli provided from gym based conditioning. However, without accurate quantification of the gym based work it is hard to understand the transfer of that work to the track, and therefore maximise the benefit of the time spent in the weights room for your athlete.

There are numerous technologies that now exist to assist the coach in this process and to therefore get the best out of the time spent developing basic strength and power through complex movements. These technologies range in price and capability to support the various assessments and insight required to influence future programming.

The aim of this report is to focus on one such measurement system which has become established in both scientific and practical environments.

GymAware (www.kinetic.com.au)

GymAware is a power monitoring training system that can be used to measure a number of key performance indicators with activity from the weights room (see Figure 1). These variables include acceleration, power, velocity, displacement, force and work down.

The basic technology behind the concept relies on some known engineering principles through use of optical encoders. The GymAware sensors calculate all the output parameters based on first principal determination of displacement and a quartz crystal time base. From time and displacement, velocity can be calculated and then acceleration. If weight is entered, force, work and power can be calculated for that athlete.

Importantly, the current commercial system has been validated against known gold standard measures (http://www.kinetic.com.au/lang-en/products/gymaware/faqs/validation) and tested across various dynamic movement patterns.

One of the major strengths of the GymAware system compared to other competitor systems for monitoring strength and power development is the use of wireless internet technology feedback to enhance the feedback loop. Figure
Summary

The effectiveness of any strength conditioning programme on athletic development is dependent on how well this translates to track performance. One of the key methods which can support this understanding is through effective measurement and monitoring. There are a number of commercial systems which currently exist to support this process, e.g. Tendo units (http://www.tendosports.com/TENDO-Units.html); BMS system (http://www.fittech.com.au/).

The aim of this article was to identify one such system in more detail which may support some particular coaching needs based on the development of speed and power.

As a health warning, it is important to recognise that no system is without its limitations so a controlled process with understanding of such limitations is crucial in any interpretation.

Figure 2. Process flow for the use of GymAware in the training environment
Scott Drawer, PhD, is Head of Research & Innovation Unit at UK Sport in Great Britain. He can be contacted at: scott.drawer@uksport.gov.uk

Figure 3. Exemplar data from the GymAware system used for longitudinal tracking

Figure 4. Exemplar data from the GymAware system used for assessment of mean and peak power in the incline press

Please note: the author has no involvement with any of the commercial companies or products mentioned in this report.

Reported by Scott Drawer
Resúmenes

Análisis Biomecánico de las Carreras de Velocidad y con Vallas en el Campeonato Mundial de Atletismo IAAF 2009
por Rolf Graubner, Eberhard Nixdorf

El Campeonato Mundial de Atletismo IAAF 2009 en Berlín presentó a los científicos alemanes del deporte la extraña oportunidad de estudiar a los mejores atletas del mundo en una competencia de alto nivel en un lugar cercano a su hogar. Un equipo de 18 investigadores de seis instituciones del país planificó, organizó y llevó a cabo un gran proyecto de investigación biomecánica en este campeonato, con el apoyo de la federación alemana de atletismo (DLV) y la IAAF. Los objetivos del proyecto incluían la realización de un análisis detallado de las finales de todas las pruebas de carreras de velocidad y vallas tanto de hombres como de mujeres. Se realizaron videograbaciones utilizando videocámaras digitales ubicadas en las tribunas alrededor de la pista, para obtener los tiempos parciales de las carreras y estudiar otros aspectos como la longitud y la frecuencia de la zancada. Además se utilizaron sistemas de medición laser para conseguir las mediciones de velocidad continua en la final de los 100m hombres. Este informe, preparado especialmente para NSA, proporciona análisis y comentario sobre los datos obtenidos por el equipo de trabajo, con secciones sobre cada una de las pruebas. Además, hay un análisis especial de la final 100m hombres basado en los datos de medición laser.

El Fenómeno de Usain Bolt
por Mike Rowbottom

Usain Bolt es el atleta de máximo perfil mundial, una figura conocida internacionalmente a la escala de cualquier jugador de fútbol o estrella de cine. A través de su éxito en las pruebas más populares del atletismo, llevó el deporte, en forma casi individual, a una nueva generación en los lugares donde se lo sigue como también en lugares donde el deporte no era previamente relevante. Su poder de estrella se confirmó con la firma del acuerdo de patrocinio más prolongado que haya realizado un atleta de pista y campo. Este artículo rastrea el desarrollo de Bolt, desde su nacimiento hasta el final de la temporada 2010. Relata el principio de su carrera, su decisión de convertirse en atleta profesional, los ajustes al estilo de vida y los problemas de salud, su aparición en la conciencia deportiva mundial con un record mundial en los 100 a principios de 2008, y sus fantásticos desempeños en los Juegos Olímpicos 2008 y el Campeonato Mundial de Atletismo IAAF 2009. Paralelamente, también se detallan los antecedentes sociales y deportivos que conllevan a la fortaleza de los velocistas de Jamaica, el rol de su entrenador y su equipo de apoyo y el impacto producido sobre todo el atletismo. El artículo concluye afirmando que Bolt no es más grande que el atletismo, pero indudablemente es lo más grande en el deporte.

Persiguiendo a Usain: Configuración de los 100 m por debajo de los 10 segundos utilizando la Ecuación de Movimiento de Newton
por Jeremy Richmond

Después de las hazañas de Usain Bolt en 2008 y 2009, muchos se han preguntado: ¿cómo es posible que un ser humano pueda correr tan rápido? Para los rivales que buscan acortar la brecha, el entrenamiento de fuerza, el elemento central del paradigma del entrenamiento mod-
Aumento de la velocidad máxima de carrera, que es la clave aparente del dominio de Bolt. Este artículo debate estrategias alternadas de entrenamiento. En base a las ecuaciones de movimiento de Newton y a los datos de actuaciones de velocistas de clase mundial, se creó un modelo de fuerzas físicas generado en una carrera de 100m por debajo de los 10 segundos. Demostró que después de los 30m, la fuerza física en dirección horizontal es bastante pequeña, un poco más que el peso corporal. En tan bajo nivel, la influencia de la fuerza máxima disminuye y el índice de desarrollo de la fuerza física se convierte en el factor predominante. El aumento de la velocidad máxima de un velocista requiere mayor producción de fuerza física dentro los mismos tiempos de contacto con el suelo. Esto requiere una mayor especificidad de entrenamiento, con más énfasis en el incremento de la velocidad de movimiento y menos en la producción de fuerza física. El autor sugiere que se pueden obtener mejores resultados a través del entrenamiento de la fuerza explosiva como los ejercicios pliométricos con un énfasis horizontal que se realiza con menor fuerza física, tiempo reducido de contacto con el suelo y una mayor velocidad de las articulaciones.

Ubicación del Pie de los Velocistas de Elite Durante las Carreras en Curvas por Oleg Nemtsev

¿Cuál es la posición más óptima del pie en la carrera de velocidad? ¿Los dedos hacia adelante, hacia adentro o hacia afuera? ¿Y que hay sobre las carreras de velocidad en una curva, qué obliga al corredor a lidiar con la tarea de mantener una alta velocidad de carrera mientras contrarresta los efectos de la fuerza centrífuga? La alteración de la colocación de los pies puede dar lugar a cambios notables en la interacción entre el sistema muscular-esquelético del corredor y su soporte subyacente (el suelo), así como en la eficiencia de la carrera. Generalmente se recomienda que el pie debe estar ubicado con los dedos ligeramente hacia adentro en una curva. El autor analizó la eficiencia de carrera en curva de los finalistas de los 200 m hombres en el Campeonato Mundial de Atletismo IAAF 2009, comparando sus tiempos para los primeros 100m de carrera con sus mejores actuaciones de los 100m de ese año, y luego examinó imágenes televisivas de la carrera. Descubrió que Usain Bolt, que estableció un record mundial de 19.19 seg. en la carrera, no fue mejor que el 5º entre los finalistas en eficiencia de carrera en curva, a pesar de seguir la recomendación sobre la colocación del pie. Entre las conclusiones se destaca que los velocistas de nivel mundial ubican sus pies de manera diferente cuando corren en curvas y que muchos doblan sus dedos hacia afuera sin pérdida visible de eficiencia.

Fenomenología de las Carreras de Velocidad y Resistencia: Hacia un Modelo de Evaluación de Rendimiento Uniforme por Wim Westera

De acuerdo a las tablas de puntaje de la IAAF, el record mundial de los 100m en 9.58 seg. de Usain Bolt equivale a 1374 puntos, mientras que el record mundial de los 10.000m en 26:17.59 de Kenenisa Bekele sólo equivale a 1295 puntos. Esto sugiere una debilidad en la actual metodología de puntuación. Este artículo estudia la relación entre la distancia de carrera y la velocidad de carrera, y propone un método de puntuación alternativo. Primero presenta el modelo de predicción personal (PPM, sigla en inglés). Este modelo utiliza dos de las mejores marcas personales de un atleta para su calibración y luego permite predecir la mejor marca hipotética personal para cualquier otra distancia. La precisión está por debajo del 1% y es así que en gran medida supera los modelos existentes. Segundo, presenta el modelo de puntuación multi-prueba normalizado (NMSM, sigla en inglés). Este modelo dirige su atención hacia las anomalías en las actuales tablas.
de puntajes; demuestra mayor equidad, consistencia y transparencia. El impacto del nuevo modelo se explica utilizando datos empíricos. Respalda la necesidad de revisión de las actuales tablas de puntajes de la IAAF. Aunque la combinación de PPM y NMSM, (siglas en inglés) para derivar una fórmula genérica de puntajes que cubriera cualquier distancia y desempeño no fue factible para uso oficial, se presenta una tabla de puntajes personalizada que utiliza los dos términos para convertir los desempeños individuales a diferentes distancias en un puntaje personal unificado.

Factores biomecánicos del éxito en la competencia con la técnica de rotación en lanzamiento de Bala
por Severin Lipovšek, Branko Škof, Stanko Štuhec, Milan Čoh

El objetivo de este estudio fue determinar los parámetros biomecánicos en la técnica de rotación que tienen el mayor impacto en la distancia lograda y así en el éxito de competencia en el lanzamiento de bala. La muestra consistió de 10 lanzadores de bala de alto nivel que participaron en la Copa Europea de Lanzamiento de Invierno 2008 en Split, Croacia; se eligió el mejor lanzamiento de cada sujeto para el estudio. Se realizó un análisis cinemático en 3D de los registros mediante dos cámaras de alta frecuencia y se utilizó el software APAS para obtener los valores para los parámetros seleccionados. Los resultados confirmaron una alta correlación entre la distancia lograda y los parámetros claves de descarga, es decir, la velocidad de la bala, el ángulo de descarga y la altura de descarga. El análisis también mostró la importancia de los parámetros que consideran la actividad del lanzador de bala en las fases anteriores de movimiento, es decir, colocación del pie al comienzo de la 2ª fase de doble apoyo y los parámetros calculados desde la velocidad angular del hombro, cadera y las articulaciones de la rodilla. Utilizando una regresión lineal, los autores pueden explicar el 94,7% del éxito en la competencia a partir de los parámetros estudiados. Los resultados indican que la velocidad de descarga sola no es suficiente para explicar el proceso efectivo de la aceleración, y que también debe considerarse el momentum del movimiento corporal total.

El Rol Fundamental de la Fuerza y el Equilibrio de la Zona Media en la Prevención de las Lesiones de Columna
por Bob Adams, Frederic Depiesse, Jack Ransone

La estabilidad de la zona media del cuerpo es esencial para los atletas de pista y campo, tanto para maximizar el rendimiento como para reducir la incidencia de lesiones. Los últimos estudios realizados a atletas de elite muestran que aproximadamente un cuarto de sus lesiones involucran el tronco o el muslo, lo que indica problemas con los estabilizadores de la zona media, tanto los generales (como los oblicuos externos, el recto abdominal y los músculos espinales) como los locales (como el transverso del abdomen, los oblicuos internos, los multifidios, los músculos del suelo pélvico y el diafragma). Por lo tanto, el trabajo de equilibrio y estabilidad de la zona media debe estar presente en cualquier programa de entrenamiento o rehabilitación. Con el objetivo de proporcionar antecedentes y consejo general para los entrenadores y los médicos que trabajan con los atletas de elite, este artículo debate la importancia del equilibrio y la estabilidad de la zona media y luego destaca las causas, la evaluación y el tratamiento de las lesiones de columna. Finaliza planteando que el manejo y la prevención de la recurrencia de las lesiones de columna en los atletas, comienza con la comprensión de lo que hacen, cómo lo hacen y la causa de la lesión. Los principios básicos de la prevención son evitar las posiciones extremas o de tensión durante largos períodos, y los ejercicios de prevención/mantenimiento para el rango de movimiento, la flexibilidad muscular, la fuerza y la potencia.
Foco de Desarrollo – Brasil
por Helmut Digel/ traducido del original en alemán por J. Schiffer

Desde el punto de vista de la organización, el desarrollo del atletismo es una historia de éxito global. Europa ha jugado un rol dominante, tanto en términos de gobernabilidad como de resultados de competencias, pero con el fin del colonialismo y, más adelante, la ruptura del imperio soviético, la distribución de los deportistas de alto nivel ha cambiado. El autor, un integrante del Consejo de la IAAF y ex-presidente de la federación nacional, explica el desarrollo positivo de los desempeños y su propagación por todo el mundo. También observa que en muchos aspectos el deporte es todavía un mosaico de historias positivas y negativas. Sin embargo, existe un número de ejemplos brillantes de los que se debería aprender. Uno de ellos es Brasil, donde desde 1987, la federación ha desarrollado sus estructuras de gobierno y de gestión, ha sido un catalizador para la creación de nuevas pistas y otras infraestructuras, ha sido escenario de muchos eventos internacionales y condujo a un enorme aumento en los niveles de rendimiento. Después de detallar los diferentes éxitos del país, el autor expresa el deseo de que la federación siga su camino y se beneficie de la puesta en escena de los Juegos Olímpicos de 2016 en Río de Janeiro.

La Formación de los Campeones Cubanos de Atletismo
por Ariel Muñiz Sanabria

A pesar de tener un población relativamente pequeña, Cuba ha sido sistemáticamente una potencia atlética durante más de medio siglo, y sus atletas han ganado medallas en 26 pruebas en Juegos Olímpicos y Campeonatos Mundiales. El éxito de la nación se ha logrado con el apoyo de un proceso de desarrollo del atleta bien planificado y basado científicamente, que ha hecho que los investigadores, profesionales y especialistas internacionales se preguntan sobre el secreto de Cuba para la producción de campeones. Este estudio de caso proporciona una descripción genérica del sistema de alto rendimiento cubano, con ejemplos concretos de las bases de organización y metodológicas que subyacen en la formación de atletas de elite. Se contemplan tres componentes principales: 1) el enfoque piramidal del proceso de desarrollo atlético; 2) la especialización oportuna de talentos deportivos; y 3) las metodologías para lograr el éxito en el atletismo de alto rendimiento. El autor finaliza precisando que las demandas apropiadas de especialización en cada paso del desarrollo del atleta son esenciales para alcanzar el punto culminante en el proceso de entrenamiento y preparación.

La Evolución de las Pruebas Combinadas: ¿Es Posible el Decatlón de un Día?
por Anatoliy Fatieiev

Uno de los problemas más difíciles de las pruebas combinadas es que la dinámica de la competencia está clara para los especialistas pero no así para el promedio de los fans y los medios televisivos que no están interesados en seguirla a pleno. Esto no es sorprendente ya que en un decatlón realizado de acuerdo con la normativa vigente, cada atleta dedica de ocho a nueve minutos directamente actuando durante un programa que se extiende hasta 10 horas al día. El objetivo de este artículo es involucrar a especialistas y no especialistas en una discusión sobre el futuro de la prueba. Después de dar una lista de ejemplos de formatos innovadores que han sido probados en los últimos años, el autor destaca un modelo que drásticamente reduce el tiempo requerido para las disciplinas de salto y lanzamiento y que calcula que un decatlón con 15-20 competidores podría completarse en 10 horas. Después de considerar los desafíos organizativos para llevar a cabo la prueba de esta manera, finaliza diciendo que el decatlón en un día es posible.
Résumés

Une analyse biomécanique des épreuves de sprints et de haies aux Championnats du monde d’athlétisme de l’IAAF 2009
Par Rolf Graubner, Eberhard Nixdorf

Les Championnats du monde d’athlétisme de l’IAAF 2009 de Berlin ont été pour les scientifiques du sport allemands une opportunité rare de pouvoir étudier, chez eux, les meilleurs athlètes mondiaux évoluer dans une compétition du plus haut niveau international. Une équipe de dix-huit chercheurs éminents, représentant six instituts allemands différents ont saisi cette occasion pour planifier, préparer et mettre en œuvre un projet de recherches biomécanique de grande envergure, avec le soutien de la Fédération allemande d’athlétisme (DLV) et de l’IAAF. Les objectifs du projet comprenaient notamment le fait de procéder à des analyses détaillées des finales de chacune des disciplines du sprint et des haies, tant masculins que féminins. Des enregistrements vidéo ont été réalisés à l’aide de caméras numériques placées dans les tribunes tout autour de la piste afin de pouvoir obtenir des données telles que les temps intermédiaires et étudier l’amplitude et la fréquence des foulées des coureurs. En outre, des systèmes laser ont été utilisés pour l’obtention de mesures de la vitesse tout au long de la finale du 100 m hommes. Ce rapport, préparé spécialement pour la NSA, fournit des analyses et des commentaires sur les données obtenues par l’équipe de recherches, avec des sections consacrées à chaque épreuve. Il comporte également une analyse spéciale de la finale du 100 m hommes qui s’appuie sur les données recueillies grâce aux mesures laser.

Le phénomène Usain Bolt
Par Mike Rowbottom

Usain Bolt est l’athlète le plus célèbre au monde, une personnalité internationale de l’envergure de n’importe quel joueur de football ou star hollywoodienne. Au travers de ses succès remportés dans les épreuves reines de l’athlétisme, il a, presque à lui tout seul, réussi à populariser ce sport auprès d’une nouvelle génération partout où il est suivi, et même dans certaines régions où l’athlétisme demeure relativement peu développé. Son statut de superstar vient d’être encore souligné par le plus important contrat de parrainage jamais signé par un champion de l’athlétisme. Cet article passe en revue le développement de Bolt, depuis son enfance jusqu’à la conclusion de la saison 2010. Il se penche ainsi sur ses débuts sur la piste, sa décision de passer professionnel, les ajustements qu’il a apporté à son style de vie, ses problèmes de santé, son émergence sur le devant de la scène sportive avec son premier record du monde du 100 m au printemps 2008, et ses performances phénoménales des Jeux olympiques de 2008 et des Championnats du monde d’athlétisme de l’IAAF 2009. L’article traite également, en parallèle, du milieu social et sportif jamaïcain, qui réussit visiblement tant au sprint jamaïcain, du rôle de l’entraîneur de Bolt ainsi que de l’équipe qui l’entoure. Il s’attarde sur l’impact d’Usain Bolt sur l’athlétisme dans son intégralité. L’auteur conclut que, même si Bolt ne peut être considéré comme plus important que l’athlétisme, il ne fait aucun doute qu’il est ce que ce sport possède actuellement de plus important.

Dans les traces d’Usain: le modèle d’un 100 m en moins de 10 secondes calculé à l’aide des équations des lois du mouvement de Newton
Par Jeremy Richmond
Suite aux exploits d’Usain Bolt en 2008 et 2009, on a souvent entendu la question de savoir comment il était possible qu’un être humain puisse courir aussi vite. Pour ses adversaires cherchant à se rapprocher de ses performances, il semblerait qu’un travail développant la force soit l’élément principal de la préparation des sprinters modernes. Pourtant, dans les faits, il s’avère que cela n’offre que des avantages prouvés assez limités pour une augmentation de la vitesse de pointe maximale, qui semble être la clé de la domination de Bolt. L’article examine des stratégies alternatives d’entraînement. Une modélisation des forces générées lors d’un 100 m parcouru en moins de dix secondes a été calculée, basée sur les équations des lois du mouvement de Newton et sur des données recueillies lors de compétitions de sprint de niveau mondial. Cette modélisation met en évidence que, passés les premiers trente mètres, la force horizontale est relativement modeste, guère plus élevée que le poids du corps. Avec un niveau aussi peu élevé, l’influence exercée par la force maximum diminue, et c’est le niveau de développement de la force qui devient alors le facteur dominant. Une amélioration de la vitesse maximale d’un athlète requiert une production de force plus élevée avec un temps d’appui au sol identique. Ceci demande un entraînement très particulier, avec l’accent mis davantage sur une augmentation de la vitesse de déplacement que sur la production de force. L’auteur suggère que des résultats probants peuvent être obtenus au travers d’un entraînement privilégiant l’explosivité, faisant appel à des exercices plyométriques, avec l’accent mis sur le développement horizontal. Les exercices demanderont moins de force, un temps de contact au sol diminué et une plus grande vitesse au niveau des articulations.

Le placement du pied chez les sprinters de haut niveau dans les courses en virage
Par Oleg Nemtsev

Quelle est la position optimale du pied pour un sprinter? Les orteils doivent-ils être orientés vers l’avant, vers l’intérieur ou vers l’extérieur? Et qu’en est-il de la course en virage, qui force le coureur à maintenir une vitesse de course élevée tout en contrant les effets de la force centrifuge? Modifier la position du pied peut apporter des changements considérables au niveau de l’interaction entre l’appareil locomoteur du coureur et le terrain sur lequel il se tient (la piste), mais aussi sur l’efficacité de la course. On recommande en général de placer le pied avec les orteils légèrement tournés vers l’intérieur dans le virage. L’auteur a analysé l’efficacité de la course en virage des finalistes du 200 m aux Championnats du monde d’athlétisme de l’IAAF de 2009. Pour cela il a comparé leurs temps sur les cent premiers mètres de la course avec leurs meilleures performances de l’année sur 100 m, puis il a examiné les images vidéo de la course. Il a ainsi découvert qu’Usain Bolt, qui a établi un nouveau record du monde en 19"19 lors de cette course, n’était que cinquième en termes d’efficacité dans la course en virage, bien qu’il applique les recommandations usuelles concernant le placement du pied. Parmi les conclusions, on a découvert que les sprinters de niveau international positionnent leurs pieds différemment lorsqu’ils courent dans les virages, et que nombre d’entre eux orientent leurs orteils vers l’extérieur sans perte visible d’efficacité.

Phénoménologie du sprint et de l’endurance : vers un modèle uniforme d’évaluation des performances
Par Wim Westera

Selon les tables de cotation de l’IAAF, le record du monde du 100 m en 9"58 d’Usain Bolt vaudrait 1374 points, alors que celui de Kenenisa Bekele sur 10 000 m en 26’17”59 ne lui en rapporterait que 1295. Cela démontre bien la faiblesse et l’iniquité inhérentes à la méthode actuelle de calcul des points. Cet article étudie la relation entre la distance et la vitesse de course, et propose une méthode alternative de calcul des points. En premier lieu, il présente le modèle personnel de
prévision (MPP). Ce modèle utilise les deux meilleures performances d’un athlète comme valeur étalon. Il permet ensuite de prédire les records personnels présumés sur n’importe quelle autre distance. L’exactitude des résultats est supérieure à 99% et par conséquent, il surpassé de loin les modèles existants. En second lieu, l’article présente le modèle normalisé de calcul des points pour les épreuves combinées (MNCEC). Ce modèle vient corriger les défauts manifestes des tables de cotation actuelles de l’IAAF, dans le sens où il offre davantage d’équité, de cohérence et de transparence. L’impact du nouveau modèle est expliqué par l’utilisation de données empiriques. Il justifie le besoin de remplacer les tables de cotation existantes de l’IAAF. Associer les deux modèles (MPP et MNCEC) pour constituer des tables de cotation génériques, quelle que soit la distance et la performance, ne pourraient être utilisées officiellement. En revanche, on peut établir une table de cotation personnalisée issue de l’association des deux modèles pour la conversion des performances individuelles sur plusieurs distances.

**Facteurs biomécaniques de l’avantage compétitif de la technique du lancer de poids en rotation**
Par Severin Lipovšek, Branko Škof, Stanko Štuhec, Milan Čoh

L’objectif de cette étude est de déterminer les paramètres biomécaniques de la technique en rotation ayant le plus d’impact sur la distance atteinte et par conséquent sur l’avantage compétitif au lancer du poids. L’échantillon étudié se composait de dix lanceurs de niveau international, en compétition à la Coupe d’Europe hivernale des lanceurs qui s’est tenue à Split en Croatie, en 2008. Le meilleur résultat de chaque concurrent a été retenu pour l’examen. Une analyse cinématique en 3D a été faite à partir des enregistrements réalisés par deux caméras à haute fréquence. Un logiciel APAS (Système d’Analyse des Performances Ariel) a également été utilisé pour obtenir des valeurs pour les paramètres sélectionnés. Les résultats ont confirmé une grande corrélation entre la distance atteinte et les paramètres clés d’éjection, c’est-à-dire la vitesse du lancer ainsi que l’angle et la hauteur au moment du lâcher. L’analyse a également démontré l’importance des paramètres relatifs à l’activité du lanceur lors des phases précédant le mouvement - positionnement du pied au début de la seconde phase en double appui - et des paramètres calculés à partir de la vitesse angulaire des articulations des épaules, des hanches et des genoux du lanceur. Avec l’aide de la régression linéaire, les auteurs sont en mesure d’expliquer 94,7 % de l’avantage compétitif à partir des paramètres analysés. Les résultats indiquent que la vitesse du lâcher seule est insuffisante pour expliquer le processus d’accélération effective et qu’il faut aussi prendre en considération l’élan du mouvement du corps dans son ensemble.

**Le rôle primordial du gainage et de l’équilibre dans la prévention des lésions de la colonne vertébrale**
Par Bob Adams, Frédéric Depiesse, Jack Ransone

La stabilité du tronc est fondamentale pour les sportifs pratiquant l’athlétisme. Non seulement pour améliorer les performances, mais aussi pour réduire la fréquence des blessures. De récentes études sur des athlètes de haut niveau ont démontré qu’environ un quart de leurs blessures sont localisées au niveau du tronc ou des cuisses. Cela dénote un problème avec les muscles stabilisateurs du tronc, que ce soit les stabilisateurs principaux (comme les muscles obliques externes, le muscle droit de l’abdomen et les muscles érecteurs du rachis) ou les stabilisateurs locaux (comme les muscles transverses de l’abdomen, les muscles obliques internes de l’abdomen, les muscles multifides, les muscles du plancher pelvien et le diaphragme). Par conséquent, le travail de l’équilibre et de la stabilité du tronc devrait faire partie de chaque programme d’entraînement ou de rééducation fonctionnelle. L’objectif de cet article est de fournir des informations de base et des conseils d’ordre général à destination des entraîneurs et des médecins travaillant avec des athlètes de haut niveau.
niveau. Il traite de l'importance de l'équilibre et de la stabilité, puis expose brièvement les causes, le diagnostic et le traitement des lésions de la colonne vertébrale. L'article se termine sur la conclusion suivante : la gestion et la prévention de la récurrence des blessures au dos chez les athlètes commencent par une bonne compréhension de ce qu'ils font, de la façon dont ils le font et des causes de ces blessures. Les principes fondamentaux de la prévention sont d'éviter les positions extrêmes ou le stress pendant des périodes prolongées, mais aussi de pratiquer des exercices préventifs et d'entretien de l'amplitude, de la flexibilité des muscles, de la force et de la puissance.

**Gros plan sur le développement – le Brésil**
Par Helmut Digel / Traduit de l'allemand vers l'anglais par J. Schiffer

D'un point de vue organisationnel, le développement de l'athlétisme est un succès international. L'Europe a longtemps joué un rôle dominateur, tant en termes de gouvernance que de résultats accomplis lors des grandes compétitions, mais la fin de l'ère de la colonisation ainsi que, plus tard, le démantèlement du bloc soviétique, ont contribué à une modification au niveau des nations dominantes. L'auteur de cet article, un membre du Conseil de l'IAAF et un ancien président de fédération nationale, décrit le développement positif des performances et la manière dont elles sont réparties au travers du monde. Il note également que, par bien des aspects, le sport de l'athlétisme présente encore un certain nombre d'histoires négatives, aux côtés de celles qui sont positives. Il existe toutefois quelques exemples qui peuvent servir de modèles. Ainsi, celui du Brésil où, depuis 1987, la fédération a développé ses structures de gouvernance et de gestion, servi de catalyseur pour la construction de nouvelles pistes et d'installations diverses, organisé un grand nombre de manifestations internationales, et a connu une amélioration phénoménale des niveaux de performances. Après avoir passé en revue les différents succès de cette nation, l'auteur exprime l'espoir que la fédération brésilienne va poursuivre dans cette voie, et bénéficier de l'organisation par Rio de Janeiro des Jeux olympiques de 2016.

**Étude de cas La formation des champions d'athlétisme cubains**
Par Ariel Muñiz Sanabria

Bien que ne possédant qu'une population relativement modeste, cela fait plus de cinquante ans que Cuba joue les premiers rôles au niveau de l'athlétisme mondial. Ses représentants ont en effet remporté des médailles olympiques et mondiales dans 26 disciplines différentes. Les succès de cette nation sont le fruit, notamment, d'un processus de développement de l'athlétisme planifié avec soin et de manière scientifique. Les résultats de cette méthodologie sont tels que bon nombre de parties prenantes de l'athlétisme international (chercheurs, professionnels et spécialistes divers) se sont souvent interrogés sur le secret cubain pouvant expliquer la production de tant de champions. Cette étude de cas offre une description générale du système cubain de haute performances, avec des exemples concrets des fondations logistiques et méthodologiques qui sous-tendent la formation des athlètes de haut niveau. Trois aspects principaux sont passés en revue: 1) l'approche pyramidale du processus de développement des athlètes; 2) l'orientation relativement rapide vers une spécialisation du sportif sur une discipline précise; 3) les méthodologies employées pour atteindre le succès au plus haut niveau. L'auteur conclut en expliquant qu'une spécialisation appropriée à chacune des étapes du développement de l'athlète est vitale pour atteindre le meilleur niveau possible d'entraînement et de préparation.
L’évolution des Épreuves combinées: L’organisation d’un décathlon sur une seule journée est-elle envisageable?
Par Anatoliy Fatieiev

Une des difficultés majeures auxquelles doivent faire face les compétitions d’Épreuves combinées est que si le déroulement de l’action est clair pour les spectateurs avertis, il n’en est pas de même pour la majorité du public, et les diffuseurs ne voient pas d’intérêt à retransmettre une compétition dans son intégralité. Rien là de très surprenant, car, sous les règles actuelles, sur la durée d’un décathlon, chaque athlète va être en activité effective pendant une durée comprise entre huit et neuf minutes, et ce dans le cadre d’un programme qui peut durer jusqu’à dix heures par jour. L’objectif de cet article est de générer un débat entre spécialistes et non-spécialistes portant sur l’avenir de la discipline. Après avoir décrit plusieurs formats innovants testés ces dernières années, l’auteur présente un modèle qui réduit de manière dramatique le temps requis pour les épreuves de lancer et de saut. Il calcule, sur cette base, qu’un décathlon rassemblant entre quinze et vingt compétiteurs pourrait être complété en un total de dix heures. Après avoir passé en revue les difficultés logistiques liées à la mise sur pied d’une telle épreuve, il conclut que la tenue d’un décathlon sur une seule journée est une possibilité.

Аннотация

Биомеханический анализ спринтерского и барьерного бега на чемпионате мира по легкой атлетике 2009 года
Рольф Граубнер, Эберхард Никсдорф

На чемпионате мира по легкой атлетике 2009 года представителям спортивной науки Германии было поручено осуществлять биомеханические исследования. Команда из 18 ученых, представляющих шесть институтов, проводила наблюдения за выдающимися спортсменами по поручению Федерации легкой атлетики Германии (DLV) и ИААФ. Согласно плану исследований проводился анализ выступлений спортсменов в финалах спринтерского и барьерного бега у мужчин и женщин. Видео камеры, расположенные на трибунах вокруг всего стадиона, позволяли фиксировать промежуточные временные интервалы и другие параметры бега, такие как частота и длина беговых шагов. Дополнительно были зафиксированы данные динамики скорости в мужском финальном забеге на 100 метров. В данном сообщении, подготовленным специально для журнала Легкоатлетический вестник ИААФ, приводятся данные наблюдений и их анализ в различных видах спринтерского и барьерного бега. Дополнительно проводится анализ финала бега на 100 метров у мужчин, где в исследованиях были применены специальные лазерные приборы.

Феномен Usain Bolt
Майк Роуботтон

Usain Bolt один из самых известных спортсменов в мире, который разделяет славу наряду с актерами и игроками в футбол. Благодаря его достижениям в самом популярном виде легкой атлетики, он принес в спорт интерес молодого поколения. Его слава позволила ему заключить невиданные спонсорские контракты. Автор статьи прослеживает жизненный
путь атleta с момента рождения до конца сезона 2010 года. В сообщении рассказывается о спортивном пути атleta от ранней карьеры до установления феноменальных рекордов на Олимпийских играх и Чемпионатах мира. М. Роуботтон рассматривает социальный и спортивный фон спринтеров Ямайки, роль тренеров и команды поддержки, а также влияние достижений спортсменов на общее развитие спорта. Автор заключает, что U.Bolt является лишь частью легкой атлетики, но он самая значимая фигура в ней.

Пример Усейна: Создание модели бега быстрее 10 секунд с использованием уравнений движения Ньютона
Джереми Ричмонд

После результатов Usain Bolt в 2008 и 2009 годах, многие спросили: как возможно, для человека бежать столь быстро? Для спортсменов, стремящихся показывать аналогичные результаты, кажется, что основной элемент подготовки в спринте это развитие силы, которая позволяет бежать быстрее. В данном сообщении приводится обобщенная модель стратегии подготовки в спринте. Автор предлагает уравнение движения, рассчитанное на бег быстрее 10 секунд, на основании критериев разработанных Ньютоном. Показано, что после 30 метров дистанции сила, приложенная в горизонтальном направлении, является незначительной и лишь слегка превышающей вес спортсмена. Таким образом, влияние силы уменьшается и развитие максимальных ее значений не является необходимым. Развитие максимальной скорости бега в большей степени связано с проявлением силовых качеств в ограниченные промежутки времени. Автор считает, что лучшие результаты могут быть достигнуты через взрывную силу, и в тренировке должны быть представлены в большей мере плиометрические упражнения.

Постановка стоп во время спринтерского бега по повороту
Олег Немцев


Изучение соотношения скорости и выносливости: путь к единой оценке результатов с помощью эффективной модели
Вим Вистера

В соответствии с таблицей оценок ИААФ, мировой рекорд в беге на 100 м Usain Bolt 9.58 сек равен 1374 очку, в то время как мировой рекорд Kenenisa Bekele на 10.000м
26:17.59 составляет только 1295 очков. Это указывает на слабость текущей рейтинговой методологии. В работе исследуется связь между дистанцией и скоростью бега и предлагается альтернативный метод оценки. Во-первых, он представляет персональную модель (PPM). Эта модель использует два личных рекорда спортсмена для калибровки, а затем позволяет прогнозировать гипотетические личные рекорды на любой другой дистанции. Точность намного ниже 1%, что тем самым значительно превосходит существующие модели. Во-вторых, он представляет нормализованную модель для других видов легкоатлетики (НМСМ). Данная модель предлагает удалить аномалии в текущей таблице оценок и демонстрирует большую справедливость и прозрачность. Достоинство новой модели объясняется использованием эмпирических данных. Таким образом, обосновывается необходимость пересмотра существующих таблиц оценок ИААФ. Объединение PPM и НМСМ позволяет получить формулу оценки, которая будет охватывать любые дистанции и возможна для официального пользования. Представлены также перспективные результаты на любых дистанциях на основе оценки достижений на двух дистанциях отдельного спортсмена.

Биомеханические факторы спортивного результата в толкании ядра методом вращения
Северин Липовчек, Бранко Шкоф, Станко Стухеч, Милан Кох

Задачей исследования было изучить биомеханические факторы спортивного результата в толкании ядра методом вращения и определить важнейшие параметры, влияющие на спортивный результат. Исследования проводились во время Зимнего Кубка Европы 2008 года в Сплите, Хорватия. Анализировались лучшие попытки десяти спортсменов в толкании ядра. Использовался трехмерный анализ с помощью синхронизированных видеокамер. В результате были получены высокие значения корреляции между результатом и параметрами скорости выпуска снаряда, угла и высоты выпуска ядра. Было выявлено, что на результат влияют такие параметры разгона, как расположение ног перед началом двупорной фазы, а также угловые скорости оси бедер и плеч. Авторы считают, что на основании линейной регрессии, в которую входят исследуемые параметры, можно предсказать результат в толкании ядра с точностью до 97%. Предполагается, что скорость выпуска не полностью объясняет эффективность развития ускорения ядра, поскольку необходимо рассматривать еще и момент инерции всего тела метателя.

Влияние силы верхней части тела и способности к равновесию на развитие травм позвоночника
Боб Адамс, Фредерик Депесси, Джек Рансон

Стабильность верхней части тела является важной в предотвращении травм позвоночника у легкоатлетов. Современные исследования показывают, что одна четверть полученных травм у спортсменов высокого класса фиксируется в верхней части тела или бедер, что определяет важность изучения стабильности положения верхней части тела, которая определяется уровнем развития определенных мышечных групп (external obliques, rectus abdominis и the erector spinae). Таким образом, совершенствование развития силы этих мышц должно являться основой программ тренировки и восстановления после травм. Авторы предлагают тренировочные программы, которые необходимо использовать в повседневной практике. С целью предотвращения травм необходимо совершенствовать силу мышц, подвижность в суставах и гибкость.
Развитие спорта – Бразилия
Хельмут Дигель / Перевод с немецкого Д.Шиффер

С точки зрения развития и организации легкой атлетики Европа имеет доминирующую роль. На этом континенте проводится большинство важнейших соревнований, где показываются выдающиеся результаты. В последнее время после разрушения колониальной системы и империи СССР распределение стран, активно прогрессирующих в развитии спорта, претерпело изменения. В своей статье член Совета ИААФ и в прошлом президент национальной федерации легкой атлетики рассматривает проблему развития спортивных результатов во всем мире. Автор отмечает, что развитие спорта в последнее время имеет как позитивные, так и негативные тенденции, но лучше остановиться на самых впечатляющих достижениях. Такие успехи произошли в Бразилии, где, начиная с 1987 года, национальная федерация легкой атлетики стала проводить активную политику. Были построены новые стадионы, развилась структура управления и проведены многочисленные международные соревнования. Указывая на достижения в развитии спорта в этой стране, автор уверен в успехе проведения Олимпийских игр в 2016 году в Рио де Жанейро.

Формирования системы подготовки спортсменов по легкой атлетике на Кубе
Ариель Мунитс Санабрия

Несмотря на небольшое количество населения, Куба в течение полувека демонстрирует высокие спортивные достижения на международных соревнованиях. Легкоатлеты этой страны завоевали 26 медалей на Олимпийских играх и Чемпионатах мира. Такой успех был достигнут благодаря хорошо спланированной и научно обоснованной программе развития спорта на Кубе. В статье представлены конкретные примеры организации и методологических основ подготовки спортсменов самого высокого класса. Определены три основных компонента успеха развития спорта на Кубе: 1. Стратегия подготовки всех уровней спортсменов; 2. Поиск и начальная подготовка талантливых атлетов; 3. Методология подготовки спортсменов высокого класса. Автор останавливается на этих основных аспектах развития легкой атлетики в своей стране.

Развитие многоборий: Возможно ли проведение соревнований в один день
Анатолий Фатеев

Одной из проблем многоборий является тот факт, что для специалистов динамика выступлений спортсменов достаточно ясна, но для зрителей и телевизионщиков, из-за длительности проведения этих соревнований, интерес к ним незначителен. Как показывают наблюдения за спортсменами в десятиборье в течение программы, которая занимает 10 часов каждый день, спортсмен соревнуется только восемь-девять минут. Основная цель данного сообщения привлечь внимание специалистов для разработки планов развития многоборья в будущем. Автор подсчитал, что при участии 15-20 спортсменов всю программу десятиборья можно завершить за 10 часов, совершенствуя правила в прыжках и метаниях.

Аннотация
摘要

2009年国际田联世界田径锦标赛短跑和跨栏项目的生物力学分析

摘要

在柏林举行的2009年国际田联世界田径锦标赛为德国运动科学专家们提供了一个难得的机会，在家门口的顶级比赛现场来研究世界最高水平的运动员们。在德国田径协会和国际田联的支持下，来自全国6个院所的由18名研究人员组成的团队在比赛过程中规划、组织和实施了一系列重要的生物力学研究项目。这个研究项目的目的包括，为男子和女子短跑和跨栏比赛中，所有进入决赛的个人运动员进行详细的分析。为了获得各个赛次的分段时间以及其他研究内容，如步长和步频，使用置于跑道四周看台的数架便携式数字摄像机进行摄像记录。另外，使用激光测量系统获得男子100米决赛的持续速度数据。本报告是为《田径运动新研究》专门准备的，提供了研究项目团队对于在每个比赛项目中所获得数据的分析和评论。此外，根据激光测量数据，对于男子100米决赛也进行了专门分析。

优赛因·博尔特现象
麦克·罗波托姆

摘要

优赛因·博尔特是世界最高水平的运动员，其国际知名度达到了任何一位美国橄榄球运动员或电影明星的程度。通过他在田径运动最流行项目中获得的成功，他几乎独自将我们这个运动带入了一个新世代，随之而来的是，以前在这个项目中实力并不强的一些地方也大有起色。他的明星效应，已经通过取得有史以来田径运动员收到的最大赞助而得到证实。本文追溯了博尔特从出生，到2010年赛季结束的发展过程。文章叙述了特的他的早期生涯、他决定成为一名职业运动员的情况、他在生活方式上的调整及健康问题、2008年打破100米世界纪录他被全球运动界所瞩目，以及在2008年奥运会和2009年世界田径锦标赛上他所取得的优异成绩。文章内容还包括牙买加短跑运动员们所处的社会和运动背景，对于他们实力的促进，教练员和支持团队的作用，以及他本人对于整个田径运动的影响。在文章结束部分，提出了博尔特的影响虽然不会超出田径运动本身，但无可否认的是，他创造了田径
追赶尤赛因：使用牛顿运动方程模拟10秒以内100米成绩  
杰瑞米 • 里士满

摘要
在2008年和2009年尤赛因 • 博尔特取得的运动成绩壮举之后，许多人提出问题：一个人怎么可能跑这么快？就那些正在寻求缩小差距的竞争者、力量训练、短跑运动员们现代训练理念的核心要素而言，证据表明增加最大进速度只能提供有限的益处，而显然这却是博尔特登上主宰地位的关键。本文讨论了不同的训练策略。根据牛顿运动方程和世界级短跑成绩数据，制作了10秒以内100米成绩的力学模型。这个力学模型表明，在30米之后，水平方向的力相当小，只比体重略大一点。在这么小力的情况下，最大力量的影响减弱，而力量速率的发展成为主导因素。短跑运动员最大速度的发展，需要在相同的每次接触地面时间内产生更大的力量。这就要求更高的训练针对性，把重点更多地放在增加动作速度，而较少地放在产生力量上。作者建议，可以通过爆发力量训练，如强调水平方向用力、致力于以较小力量完成动作、减少接触地面的时间和更大关节速度的各种快速伸缩复合练习，来取得更好的成绩。

优秀短跑运动员弯道跑中脚的放置  
奥利格 • 涅姆谢夫

摘要
什么是短跑中脚的最佳放置姿势？脚趾向前、向内还是向外？弯道跑迫使运动员在完成保持高速跑任务的情况下，还要对抗离心力效应。改变脚的放置姿势，对于改变运动员肌肉骨骼系统、它的基础支撑（地面）和跑进效率，都能够产生明显的变化。一般来说，建议脚应该以稍微指向弯道内侧的姿势放置。作者通过比较2009年国际田联世界田径锦标赛男子200米决赛运动员前100米比赛的时间和当年跑这100米距离的最好成绩，然后研究比赛的电视画面，分析他们的弯道效率。他发现，在比赛中创造19.19秒世界纪录的尤赛因 • 博尔特，就弯道效率而言，在该赛次弯道跑的决赛运动员中不会优于第五名的水平，并不遵从以上提出的脚部放置姿势的建议。作者在文章的结束部分提出，世界级短跑运动员弯道跑的脚部放置姿势存在着很大差别，许多人将他们的脚趾向外转，并没有明显降低跑的效率。

短跑和耐力的现象论：朝着一个统一的成绩评价模式  
维姆 • 韦斯特拉

摘要
按照国际田联积分表，尤赛因 • 博尔特的9.58秒100米世界纪录相当于1374分，而肯尼 • 贝克勒的26分17.59秒的10000米世界纪录只相当于1296分。这表明目前采用的积分方法存在着一个弱点。本文研究了跑进距离和速度的关系，并提出一个不同的积分方法。首先，它提供了一种个人预测模型。这个模型使用一名运动员的两次个人最好成绩进行定标，然后它能够预测一名运动员在任何其它距离上的假设个人最好成绩。其精度误差小于1%，因此使用效果极大地优于存在的各个现行模型。第二，它提供了一个正常化的多项目积分模型。这个模型说明了各种现行积分表所表现出的异常现象，而且它表现出更大的公平性、一致性和透明性。新模型的影响采用实验数据来解释，它证实了修订现行国际田联各个积分表的需要。虽然将个人预测模型和正常化的多项目积分模型结合起来，可推导出一个一般化的积分公式，而这个能够包括任何距离和任何成绩的公式，还不能被正式使用，但已经提出一个使用这两个模型将一个人在任何距离上的成绩转化成一个单一的个人得分的方法。
旋转推铅球技术比赛成功的生物力学因素

西沃林·利普夫谢克，布兰科·斯科夫，斯坦科·斯图海克，米兰·科

摘要

本研究的目的是确定旋转推铅球技术中那些对于投掷距离、以及推铅球比赛取得成功、能够产生最大影响的生物力学参数。受试样本由在2008年欧洲杯冬季克罗地亚斯普利特掷铅球比赛中10名顶级水平的铅球运动员组成，选出每名受试者的最佳一次掷铅球进行研究。采用两台高速摄影机和艾尔利三维运动解析系统对摄像结果进行三维运动学分析，来获得所选参数的各项数值。结果证实了在投掷距离和关键的出手参数，如铅球速度、出手角度和出手高度之间，存在着高度的相关性。分析还表明了，那些在铅球运动员运动中较早各个动作阶段参数的重要性，如第二次双腿支撑开始时脚的放置，以及肩、髋、膝关节角度等计算出的参数。采用线性回归方法，作者从研究的参数中，能够解释94.7%比赛成功率。这些结果说明，出手速度本身不足以说明加速的有效过程，还必须考虑到全身动作的动量。

核心力量和平衡在预防脊柱损伤中的关键性作用

鲍勃·亚当斯，弗莱德里克·蒂皮瑟，杰克·兰松尼

摘要

人体核心稳定性对于田径运动员来说是必需的，它能够最大程度地提高运动成绩和减少损伤的发生率。最近对于优秀运动员的研究表明，他们之中大约四分之三的损伤都涉及到躯干和背部，指出核心稳定肌群的问题，包括核心稳定肌群（如腹外斜肌、腹直肌和竖脊肌）和局部稳定肌群（腹横肌、腹内斜肌、多裂肌、骨盆底肌和横隔膜）。因此，平衡和核心稳定性练习应该是任何训练或康复计划的组成部分。为了对教练员和与优秀运动员一起工作的医务人员们提供背景信息和一般建议，本文讨论了平衡和核心稳定性的重要性，然后重点说明了各种脊柱损伤的原因、评价和治疗方法。在文章的结束部分，阐明了运动员控制和预防背部损伤的复发，开始于他们对于做什么、怎样做和损伤原因的理解。基本的预防原则是，避免各种极端姿势或长时间承受压力，进行运动范围的各种预防性且保持性练习，提高肌肉柔韧性、力量和功率。

发展公众注意焦点-巴西

赫尔穆特·迪格尔

由J·西弗尔译自德文

摘要

从组织的观点来看，田径运动的发展是一个全球性的成功史。欧洲在管理和比赛成绩两方面都发挥了主导作用，但随着殖民化的结束，而后是苏维埃帝国的崩溃，顶级运动员的分布也已经发生了变化。作者是一名国际田联理事，也是一名国家协会的前主席，他概括了各项运动成绩的积极发展，以及它们在全球的分布情况。他还注意到，在许多方面这项运动仍然是一个交织着正面与负面故事的混合体。然而，仍然存在着许多值得学习的闪光事例。其中之一便是巴西，自从1987年以来，那里的协会已经发展出它的各种支配和管理结构，成为创造许多新道路和其它基础设施的催化剂。协会还主办了许多国际比赛，并且带来了运动成绩水平显著的提高。在详细说明了这个国家的各个成功之处后，在结束部分作者希望协会沿着这个路线继续前行，并且从主办2016年里约热内卢奥运会中获得更大的利益。
抽象

古巴田径冠军的形成
艾利尔・穆尼兹・萨那布里亚

摘要
虽然它只有一个相对较小的人口基础，半个多世纪以来古巴不断地成为一只田径运动力量，它的运动员在26个项目中赢得了奥运会和世界锦标赛奖牌。国家取得的成功，依赖于良好的计划和具有科学基础运动员培养过程的支持，这使国际研究人员、专业人员和专家都知道古巴培养冠军的秘密。这个案例研究，通过许多具体的和构成优秀运动员形成基础的组织和方法学事例，提供了一个分类说明的古巴高水平成绩系统。其中包括三个主要组成部分：（1）运动员发展过程的金字塔方法；（2）运动天才的即时专门化；（3）高水平田径运动在取得成功的方法学。作者在结束部分阐述了，在运动员培养每个步骤的适宜专门化需求，对于达到训练和准备过程的顶点都是必要的。

全能项目的演变
一天完成十项全能比赛可能吗？
阿纳托利・法迪耶夫

摘要
全能项目最困难的问题之一是，比赛的动态性虽然对于专家们清楚，但对于普通爱好者和电视直播者来说则不然，他们没有兴趣完整地跟踪下来。所以人们也不会惊讶，在按照现行规则进行的十项全能比赛中，虽然每名运动员只用8至10分钟来直接进行计划中的项目，而完成计划中的比赛项目却需要达到每天10小时。本文的目的是引起专家和非专家们进行一场关于这个项目未来的讨论。在列举了近年来曾经尝试的一些创新形式事例之后，作者概括了一个能够显著减少跳跃和投掷项目所需时间的模式，并计算出一场由15至20名运动员参加的十项全能比赛，可以在10小时之内完成。在考虑了以这种方式举行比赛所面临组织上的各种挑战之后，在结束部分作者认为举行一场一天的十项全能比赛是可能的。
تحليل بيوكيتاني لمباقم العدو والحاجز في بطولة العالم لألعاب القوى عام 2009

ملخص

قدمت بطولة العالم لألعاب القوى التي أقيمت عام 2009 في برلين عالمية رياضية رائعة والذين تمت معها برلمة نادرة للدراسة أفضل اللاعبين على مستوى العالم في منافسات ذات مستوى عالٍ في مكان قريب من الوطن. وقام فريق مكون من 18 لاعباً من ست معايير من جميع أنحاء الدولة بتخطيط مشروع بحث في مجال الرياضيات التخطيطية وتفتيظ نقاط في البطولات ونجز كل من الأنداد الآلي لألعاب القوى. وتضمنت أهداف المشروع عمل تحليلاً تفصيلياً للمنافسات جميع مباقم العدو والحاجز الرقمية لكل من الرجال والسيدات. وقد تم تمليل الفيديو باستخدام كاميرات فيديو رقمية مثبتة في المدرجات حول المجمهر وذلك للحصول على أزمة منفصلة للسياقات ودراسة الجوانب الأخرى مثل طول الحمولة وترددها. بالإضافة إلى ذلك، فقد تم استخدام نظام قياس الزور للحصول على فئات مستمرة للسرعة في نهائي سياق 100م للرجال. وقد قام هذا التقرير - الذي تم إعداده خصيصاً لجامعة بدقة في عالم الفوقي - تحليلاً وتفصيلاً على البيانات التي حصل عليها في مشروع في الخلايا. مع وجد قسم لكل مباقم من المباقم. بالإضافة إلى ذلك، فهناك تحليلاً خاصاً للخليفة سياق 100م للرجال معتمداً على البيانات التي تم الحصول عليها من خلال الفيديو البليز.

ظاهرة بويسبن بوتل

يقل بامي بروتوت

ملخص

بويسن بوتل هو اللاعب ذو الشخصية المرموقة الأعلى في العالم وهو شخصية بإرادة مروية. دواليب مثله مثل أي لاعب كرة قدم أو نجم سينمائي، وقد نجح في المسابقات الأكبر معه في ألعاب القوى، وقد قام بشكل فريد بتقييم فريق الرياضة إلى جبل جديد متابعة في مكان، فضلاً عن بعض الأمكّن التي لم تكن قوية في المسباق. وقد تم تأكيد سلطته من خلال التوجيه على أكثر تصفي رياضية في أي وقت مضى للاعب مضمار مديد. تفتيج هذه المقالة تطور بوتل منذ ولادته وحتى نهاية موسم 2010. فهي تبرز بداية حياته المهنية وقراره ليصحيح لأنا متحفنا والتغييرات التي حدثت على نموه حياته والمشكّلات الصحية التي أواجهها وبرزت في الابتكار الرياضي العالمي بتحديات الرقم القياسي العالمي في سباق 100م في بداية عام 2008. وتأدية الابتكارات في دور الانساني لألعاب القوى عام 2008 وبطولة العالم لألعاب القوى عام 2009. و في موازات تطهير القافلة الاجتماعية والرياضية وقوة الهدايا البارزة، فقد تم تمكين娃娃 دير مريج عرف طموح وفرقة العمر وتأثر على رياضة الألعاب القوى ككل. وتنهى المقالة بأن بوتل ليس أعظم من ألعاب القوى، ولكنه ما نقص هو أعظم شيء في هذه الرياضة.

تعزب بويسبن: نموذج تحقيق أقل من 10 ثواني في 100م باستخدام معدات نيوتن للحركة

يقل جيروي ريشموند

ملخص

بعد الأفكار التي حققتها بوتل في عامي 2008 و2009، فقد سال الابتكارين: كيف يمكن أن يجري الأمر هذه السريعة؟ وقد بالنسبة لمناخه الذين يعانون من سد الفجوة فإن تذوب القوى هو عصر رئيسى لموجات التدريب الحديثة للعداءين، فهو لا يقتصر سوى فوات محدودة مؤداة زيادة السرعة القصوى للجري، وذلك هو ما يجب من نفاذ الهيمنة. من هنا، تناول هذه المقالة استراتيجيات
تتغريدة التدريب المغتفي. وقد تم ابتكار نموذج لتوليد القوة لطعع 100 م في أقل من 10 ثوان. هكذا على معيادات نموذج للحركة والبيانات الخاصة بآداء سياق العدوى على المستوى العالمي. فهو يعرض إنه بعد 30 م يكون القوة في الائحة الأقوي شفقة جدا، و يكون أكثر قليلا من وزن الجسم. و هو عدد هذا المستوى من خصائص يقل تأثير القوة الفستوى ويصبح معرق نتيجة القوة هو العامل المسلط. يتطلب تحسين السرعة الفصوية لداء النتائج المحدود من القوة داخل نفس أزمة الاتصال بالأرض. وذلك يعتمد إلى الميدان من التدريب الخاص مع التركيز بشكل أكبر على زيادة سرعة الحركة وشكل أقل على الاتصال القوة. و يقترح الكاتب أنه يمكن تحقيق أفضل النتائج من خلال تدريب لقوة الإنجازية مثل تدريب اليوتوتريمك مع التركيز العمودي واستخدام قوة أقل والذي يؤدي إلى انخفاض زمن الاتصال بالأرض وسرعة أكبر للمفصل.

وضعية قدم عدائي النخبة خلال جري المنحنى

بقد أولىً نيسايف

ملخص

ما هو أطول وضع القدم في العدو؟ مشتر لبلج للأسمان أم للدرو ملء المنحنى، الذي يعبر العاء على التنافس مع مهارة المحاذ في السرعة العالمية لحيرة في حين مواجهة الآثار المتربية على القوة الطارة المركبة. يمكن أن يؤدي تغيير وضع القدم إلى تغييرات متحوية للнатج بين الجهاز المشكل للدرو ودعمه الأساسي (الرض) وكذلك في كفاءة الحري. و عموماً يوصي أن يكون وضع القدم للمد خلا عن المنحنى. وملع الكتبكة جرى المنحنى في نهائيات ساب 200 م للدرو في بطولة العالم لأعمال القوة عام 2009 من خلال مقتارة إمتدام لأول 100 م من السباق مع أفضل أما سوي ل 100 م ثم قاد دراسة صور تليفزونية للسبي. وقد وجد أن يوسي بول (الذي سهل لغة بيقاس عاملا 19.99 بث في السباق) بالنسبة للكمية إعداده في المنحنى لم يكن أفضل من الخسائر في النهائيات، على الرغم من المزاح التوصية الخاصة بوضع القدم. ومن بين الاستنتاجات أن المدعى على السوقي العالمي يكون وضع أقدامه بشكل مختلف عند العدو حول المنحنى وأن الكثير منهم يكون وضع تدريض قيده للدرو بدون فقد مرن للكلام.

الطواهر الخاصة بالعدو والتحمل: نحو نموذج تقييم موحد للكداء

بقد ويم وسترا

ملخص

وفقا لجدول إحساس النقاط للكأس العالم للدروي، يساوي الرقم العالمي الذي حققه يوسي بول في سباق 100 م وهو 9.58 ثانية 1373 نقطة في حين الرق الزيالي الذي حققه بيدو يوسي بيكيلي في سابق 200 م وهو 17.59 منح فقط 1295 نقطة. ويشير ذلك إلى وجود ضعف في المنهجية الخاصة للاستفادة من نقاط هذه الأوراق لدراسة العلاقة بين سلالة أخرى وسرعة الجرى كما قدمت طريقة بديلة لإحساس النقاط في بادي الأمر قدمت نموذج التبشير الشخصي (PPM). استخدم هذا النموذج أفضل رهن شخصين لا يعبر من أجل ميزانيتهم. ثم سمح بعد ذلك بالبنزين يوما أفضل لدرو للاستخدام مثل مساحة أخرى. تكون النتائج دقيقة عند أقل من 1% و بذلك تكون كلية عن النتائج الموجودة. ثانياً، القدر المدمج الطبيعي لإحساس النقاط للمباريات المعتد (NMSM) يفاق هذا النموذج بعض الأهم الشاذ المعادة في الجدول الحالية للاستطاعة القوة؛ فإنها تبرز المزيد من الوضع والتفاصيل والشفافية. وقد أثر النظر من النموذج
النهاية باستخدام البيانات التجريبية. فإنها تجد الحاجة إلى مراجعة الجدول الحالية لإحصاء النقاط للأحداث الدولية للألعاب القوى. وعلى الرغم من أن الجم بين NMSM وPPM عالية، فإن صيغة معالجة النتائج المبكرة للعبة التي يشتهر بها UEFA يعتذر أي مسافة مما يجعل أي من الممكن استخدامته لنتائج النتائج يستخدم النتائج لتحويل الأداء الفعلي للنسبة المثلثة إلى رقم شعبي موحد.

العوامل البيوميكانيكية لنجاح التنافس مع استخدام تقنيات دفع الجري بطريقة الدوران

فلم سيفرين ليبوسكي وبرانكو سوكوف وسانكو ستورك وميلان كور

ملخص

الهدف من هذه الدراسة هو تحديد المحددات البيوميكانيكية في تكيلد الدوران الذي له أثر كبير على المسافة التي تحتفل بالناج للاجتاع التفاصيلي في دفع الجري. تكون معدة من أضعاف 10 أعيان من درجة المبكرة في بطولات الكأس الإقليمية لعام 2008 التي أقيمت في سيليزيا بكراتانيا، فقد تم اختيار أفضل سمات عن كل لاعب من اللاعبين المشاركين في كل البحث. وقد أجروا تحقيق ثلاثي الأبعاد من التحليلات من كلاً من الرياضيين ذات تردود على برنامج أطيل. لتشمل الأداء المتحول على قيم المحددات المختارة. وقد أدى النتائج وجود ارتباط كبير بين المسافة التي تحتفل بالناج والتحديات الرئيسية لمرحلة التذوق من الأداء مثل سرعة الجري وزاوية التذوق من الأداء وارتفاع الرمي. كما أوضحت التحليل أيضاً أن المحددات التي تعتبر نشاط لاعب الرمي في المرحل التفاصيلي للحركة مثل وضع القدم في بداية مرحلة الإ cinéمثوت الثانوية والمحددات التي تحلب من سرعة زاوية مفاصلك الكتف الفخذ والركبة. ومع استخدام الاعتداد الخطي، يمكن للملوكن تصنيف 94.7% من نجاح التنافس من المحددات التي تم دراستها. وتظهر النتائج إلى أن سرعة النزول من الأداء وحدها لا تكفي لشرح العملية الفعالة لزيادة السرعة لأنه ينبغي الأخذ في الاعتبار القوة الدافعة لحركة الجسم باكمله.

الإفلاس الضوئ على التنمية - البرازيل

فلم هيلموت ديج

ترجم من المقال الألمانية

ملخص

من وجهة النظر التشريمية، حقق تطور ألعاب القوى قصة نجاح عالمي. فقد لعبت أوروبا دوراً مهمانياً، سواء من حيث الضرورة، ونتائج المفاهيمية، ولكن نهاية الاستماع، ومع ذلك الخلاصية التطورية، تظهر أن توزيع على الأداءات. فقد لم الهدف وهو عرض مجال إبة بالاندماج الدولي، وليس سابق للاتحاد الدولي. من حيث أن الكب كبير من الجانبين مازالت الرفعية خليط من الفصول الإنجليزية والنسائية. ومع ذلك، هناك عدد من اللفة المشرفة، وسترى أن استمرار الاتحاد، بعد توضيح الحاجات المختلفة للدولة بالتفصيل، أُخذ الملف المشاركًا موسعاً على استمرار الاتحاد في مساره ونور من تنظيم دورات الألعاب الأولمبية لعام 2016 في ريو دي جانيرو.
صناعة أبطال ألعاب القوى الكوبئين
بعلم أريل موزيس ساندرا

ملخص

على الرغم من أن كوبا لديها قاعدة مكانيقة صغيرة نسبيًا، فهي تتمكّن باستمرار قوة ألعاب القوى لأكثر من نصف قرن، إذ أنهم لا يبحثون بأولمبيادو– ألعاب العالم في 26 مسابقة، فقد حقق نجاح هذه الدولة من خلال عملية تطور اللاعبين التي تم تخطيطها جيداً ودقيقة على أسس علمية، مما جعل اللاعبين الكوبئيين الفائزين بالألعاب المختلفة يتنافون على سر صناعة أبطال ألعاب القوى. تزودنا دراسة هذه الحالة بوصفها عالياً بيئتها موضوعية والمتميزة التي تكمن في صناعة نخبة اللاعبين، كما تغطي هذه الدراسة ثلاثة عناصر رئيسية هي: (1) التدريب النموذجي لتطور ألعاب القوى، (2) التدريب النموذجي ل照明 ألعاب القوى، و (3) رياضيات تحقق النجاح في ألعاب القوى ذات الأداء العالي. ويتبع الموضوع إلى القول بأن مجابات التدريب المناسب في كل خطوة من خطوات تطور اللاعب أولاً ضروريًا للوصول إلى النجاح في عملية التدريب والإعداد.

تطور المسابقات المركبة: هل من الممكن إقامة مسابقة عالمية في يوم واحد؟

putation

ملخص

من أصعب المشاكل التي تتعرّض لها المسابقات المركبة هي وضوح ديناميكية المنافسة للمخصصين وتحديد وصحة نتائج الترتيبات الذين نحن قادرون على أيهما بمثابةها حتى النهاية. لا يستطيع ذلك إلى الدقيقة حيث يستغرق كل لاعب في مسابقة الدراجات التي تقام وفقًا لطفل الحالية من 8 إلى 9 نقاط لداء الدراجات الذي يستمر إلى ما يصل إلى 10 سعات. وما إذا كانت هذه المقالة تظهر نتائج بين المخصصين وغير المخصصين حول مستقبل المسابقة. بعد طرح مسألة عن الأطراف المتقدمة التي تم تشربها في السنوات الأخيرة، استعرض المقال نموذجية تعلم على نطاق الأزرار لمسابقات الدراجات ويمكن أن يستخدم في 10 ساعات. وبعد الأخد في الاعتبار تحسينات التخسيس الخاصة بإمكانية الاستماع بهذا الشكل توصل المقال إلى إمكانية إقامة عالمية عالمية في يوم واحد.

الدور الحاسم لقوة الجذع والتوانز في الوقاية من إصابات العضود القبلي

بعلم بوب أند وفردريك ديبز وجاك رسمون

ملخص

إن ثبات منطقة الجذع أمر ضروري للاعبين مزايا الجسم والعضلات وذالك للاسترتو في نقص الوقت الحد من حدوث الإصابات. إذ أظهرت الدراسات الحديثة في الجذع على لاعبي المخاطر أن ما يقرب من ربع الإصابات تشمل الجذع أو منطقة الفخذ، مما يؤدي إلى مشاكل تأثيرية على الأعصاب. (مثل العضلة المخاطة الخارجية والعضلة العضلية المستقطبة وناسبة العضود القبلي (لاجح/-الخليقية))، والدرا تتاريخي مثال على العضلة المستقطبة العلمي، والعضلات الداخلية الخاطئة والعضلات العضلية المحاذية. إذا فالعلم على تحقيق التوانز والتوانز يجب أن يكون عناصر لأي برنامج من برامج التدريب أو إعادة التأهيل. ويفضل تجهيز الملاعب الأساسية والصالة العامة للمتفرجين، والخصائيين المختصين الذين يعملون مع فريق اللاعبين، ناك هذا المقال أي عينة توالزت وتبين شكل أسباب إصابات العضود القبلي وطرق تقييمها وعلاجها. ويختم المقال بتوضيح طرق إدارة ومنع تكرار وقوع إصابات الظهر عند اللاعبين الذين يذعرون بالفعل، كما يفعلونه ويسري الإصابة. فالتدرب الأساسي للوقاية هي القبلي لتجنب الاصابة، والإعالة، لفترات طويلة والتعاون الوقائي، المحافظة على المدى المركزي وسرعة الحضارات والقوة والقدرة.
Special Topic

Horizontal Jumps

including:

- Biomechanical Analysis of the Horizontal Jumps Events at the 2009 IAAF World Championships in Athletics by Eberhard Nixdorf and Luis Mendoza