TRENDS IN BIOMECHANICS AND BIOCHEMISTRY OF SPRINTS METHODOLOGY*

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The concepts of a sprints coach depends mainly on the point of view of the coach in his specific environment. Different coaches look upon training as they watch the same birthday cake, each from a different angle. Another difference in the mind of the coaches may be the way they cut up the cake in different shaped slices. My opinion is that the basic concepts of sprints training do not differ so much as may be expressed from looking at some training programs. One of the main problems in sprints training is that they rate of improvement in the long-term is only 8-12%, which is very little, compared with progress in other events.

This is the result of two aspects:

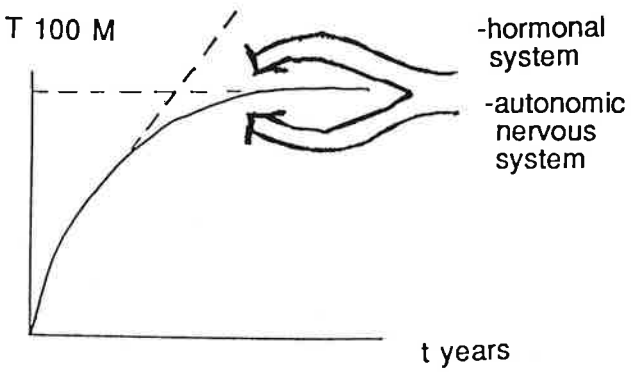
1. Improvement in sprints performance is based on changes in neuro-muscular features, which are very hard to change due to their basic role in human existence.

   - The central nervous system is the dominant "performance-organ" of the sprinter. As soon as our knowledge of the central nervous system and the brain increases, much more information may be gained about the functioning, changing and optimizing of (sprint) performance-limiting aspects.

2. According to one of the principles of the adaptation process, the principle of diminishing returns, the improvement becomes less and less as the performance level increases.

In the long turn, the rate of increase of performance is levelling off and one sees a phenomenon known as the "speed barrier". The mechanisms which are causing this specific curve of adaptation are:

- the adaptation-systems of the human body,
- the hormonal system, and
- the autonomic nervous system.



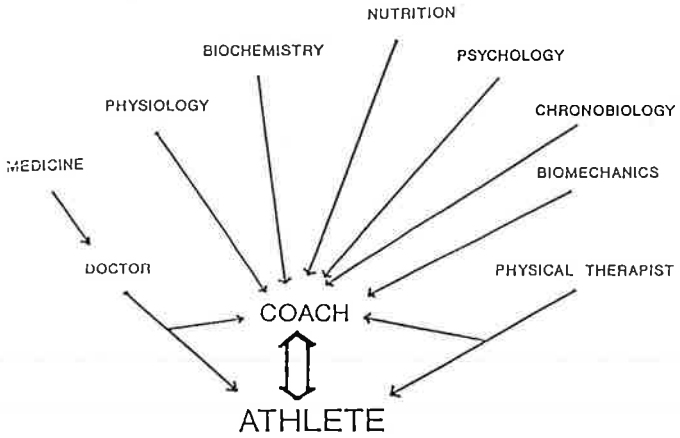
The use of anabolic steroids or amphetamines are expressions of intuitive knowledge of these mechanisms and how to manipulate them. The support of future research of the adaptation processes and the unlocking of the secrets of the nervous system for performance improvement in track and field may be a way to prevent the use of drugs in our sports. The role of a coach in the adaptation process is to optimize the adaptation in the widest meaning of the word.

The coach should have two heads:

1. To derive information from various scientific sources to apply his knowledge and experiences to his athletes.

2. Used to coach his athletes in a way:

   - they understand
   - to talk sense to them
   - to monitor their training
   - to correct their biomechanics.



The role of a coach is a central one in the training process. No scientist will be able to take over this position or to integrate the knowledge from a wide field of possibilities and apply them to the individual needs of the athlete. One possibility to analyze the general success in the sprints, is to count the amount of finalists or medalists in major championships such as in the World Championships and the Olympic Games.

A brief analysis showed:

1. More than 60% of the finalists came from only 5 countries of the 160 countries participating.

2. For the medals the picture is even clearer: 4 countries got 80% of the medals.

ANALYSIS OF RESULTS
WC 87 ROME - OS 88 SEOUL

96 FINALISTS		36 MEDALS	
USA	21	USA	13
JAM	11	DDR	7
CAN	10	JAM	5
USSR	9	USSR	4
DDR	8		
TOTAL	59 ▪ 61%	TOTAL	29 ▪ 80%

100M, 200M, 4 X 100M; MEN AND WOMEN

The features on which the results of the analysis are based I called the T-Factors.

4 T-FACTORS

- T1 - TALENT
  - ANTROPOMETRIC ADVANTAGE
  - NUMBER OF INHABITANTS
  - NUMBER OF PARTICIPANTS IN T&F
  - TALENT-SCOUTING SYSTEM
- T2 - TOP-ATHLETE SUPPORT
  - GOVERNMENT
  - UNIVERSITY
  - MILITARY SERVICE
  - SPONSORS
  - FEDERATION
- T3 - TEMPERATURE
  - SUBTROPICAL TEMPERATURE AND/OR
  - INDOOR FACILITIES
- T4 - TRAINING AND TECHNOLOGY
  - TRAINING SYSTEM
  - EDUCATION OF COACHES
  - APPLICATION OF HIGH TECHNOLOGY
  - APPLICATION OF SCIENTIFIC KNOWLEDGE

Four Factors - More or Less Independent From Each Other:

A lower score in one factor may be overcompensated by a higher score in another. A coach is now able to discover which factors for himself or for others are contributing to his success or lack of success. The way I decided to cut up my "sprint-cake" is according to the classical idea of splitting-up the 100 meters race into four parts:

1. **Starting Action.** The starting action is always connected to the acceleration as the starting action creates the condition for a proper acceleration. One of the parameters that is used to qualify the starting action is the reaction time. My personal view is that those two are relatively independent and that a short reaction time does not always imply a good starting action nor a good acceleration.

To improve the starting action we can use General Training Methods (for beginners or for elite athletes during the general preparation).

- Weight training may also be beneficial because a higher level of maximal strength can be applied during the starting action (500 ms) and the first strides of the race (300-150 ms).

STARTING ACTION
REACTION TIME

- TRAINING - GENERAL
  - REACTION EXERCISES
  - STARTING JUMPS
  - LEG PRESS
- TRAINING - SPECIFIC
  - 6 X 40 M BLOCKS / GUN
    PAUSE 3-4 MIN. INT. 100%
  - HIGH AROUSAL / AGAINST OTHERS
    TIMING
- CONTROL
  - BLOCK DYNAMOMETER
    - REACTION TIME
    - BLOCK FORCES

That is the reason shot-putters, weight-lifters and power-lifters are fast in the first part of the sprint race. They simply have the time to apply their higher level of strength, but this advantage decreases as soon as the race increases and the contact-time decreases (up to 85 ms).

The more specific training is to imitate the competition-circumstances:

- Starts from the blocks, with gun, with others
- Timing increasing the level of arousal, as in competition.

To control the improvement we use the block dynamometer to analyze the reaction times and block forces, together with a velocimeter (which measures speed continuously) and electronic timing. So changes in the position of the blocks and/or angles of the blocks can be evaluated for reaction time and speed over 20, 30 or 40 meters.

2. **The Acceleration** part of the race, which is generally considered as being the most important for the 100 meters result, can be trained generally through:

- Various jumps,
- Starts from different positions,
- Uphill accelerations, or
- The use of rope resistance which applies a pulling force to the athlete.

ACCELERATION

- TRAINING - GENERAL
  - START FROM DIFFERENT POSITIONS
  - "SHORT" JUMPS
  - UPHILL SPRINTING
  - STARTING WITH ROPE RESISTANCE
- TRAINING - SPECIFIC
  - STARTS 6 X 40 M BLOCK OR STANDING
    PAUSE 3-4 MIN. INT. 100%
- CONTROL
  - ELECTRONIC TIMING 10 - 70 M
  - VELOCIMETER

More specific is again the start from the blocks as used to improve the starting action. The control of the acceleration can also be done by using the velocimeter or electronic timing every 10 meters form 10 to 60 meters.

3. **Maximum Speed** is one of the most difficult parts to improve, because of the high demands for neuro-muscular and biomechanical facts. Which part of the 100 meter race in accepted as maximum speed is a matter of consensus. Actually we have to accept minor deviations for the 100% speed, as there will always be small deviations even during the fastest 10 meter split, yes even during the fastest stride within the fastest 10 meter split!

MAXIMUM SPEED

- TRAINING - GENERAL
  - FREQUENCY EXERCISES 2-10 SEC.
  - BUILD-UP RUNS (INCREASING SPEED)
- TRAINING - SPECIFIC
  - FLYING 20-40 M, 4-6 X, PAUSE 3-4 MIN. INT. 100%
  - SUPRA-MAXIMAL SPEED PULLEY SYSTEM (SPEED + 10%)
- CONTROL
  - ELECTRONIC TIMING 40-80 M
  - VELOCIMETER

The best way to increase maximum speed is to train specifically close to the 100% speed. This can be done by running flying or running at supra-maximal speed which is accomplished by:

- Running downhill,
- Running with a tail wind, or
- Using a pulley system

The maximum speed can be evaluated again by electronic timing or velocimeter. The much practiced hand timing is too inaccurate to evaluate the slight improvements in maximum speed.

4. **The Speed Endurance** part of the race starts when the speed begins to decrease significantly:

SPEED ENDURANCE

- TRAINING - GENERAL
  - GENERAL ANAEROBIC WORK
    - CIRCUIT
    - WEIGHT LIFTING
    - "LONG" JUMPS
- TRAINING - SPECIFIC
  - ENDURANCE RUNS
    - 4 X 120 M, PAUSE 8-10 MIN. INT. 100%
- CONTROL
  - TIME
  - LACTIC ACID IN BLOOD
  - AMMONIA IN BLOOD

- During the last 20 meters of the 100 meter the speed of men decreases only 2%, whereas
- The speed of women decreases as much as 7-8%.

The reason of the decrease in speed is unknown. It Might be caused by the following factors:

- Decrease of ATP and CP in muscle
- Increase of breakdown products such as lactic acid or ammonia in muscle
- Central fatigue in brain or decrease in neuromuscular transmission.

As long as we do not know the exact factor we can hardly optimize the training for speed endurance. At present we have to work with an eclectic system which covers most of the factors mentioned. Specific for speed endurance is the training with high intensity, in this way triggering the same speed decreasing factors as in competition.

BIOCHEMICAL ANALYSIS

- MUSCLE TISSUE BREAKDOWN
  - CPK
  - 3-METHYL-HISTIDINE
- TENDON TISSUE BREAKDOWN
  - HYDROXY-PROLINE
- NITROGEN BALANCE
  - UREA
- HORMONES
  - FREE TESTOSTERONE
  - CORTISOL
- NEUROTRANSMITTERS
  - (NOR)ADRENALINE
  - DOPAMINE
- VITAMIN DEFICIENCIES
- MINERAL DEFICIENCIES
- (FOOD) ALLERGIES
- METABOLIC DERANGEMENTS

- To monitor the adaptation process for the long term we use the muscle biopsy.
- To monitor the adaption process of the middle and short term we use the analysis of blood and urine. This way we are even able to find the individual super compensation curves. It is possible to check the amount of muscle tissue and tendon tissue broken down by high intensity and/or high volume training.
- To investigate the anabolic state which is an absolute necessity in the adaption process in order to increase the levels of contractile proteins and enzyme systems, we can measure the nitrogen balance.
- The same can be done by measuring the levels of free testosterone and cortisol; these ratios also tell us whether the body is in anabolic or catabolic state.

- The level of arousal before and after training and competition can be measured by the output of neurotransmitter in the blood. These measurements enable us to discover the optimal level of arousal.
- Another item that seems to be of increasing importance is the case of deficiency supplementation may be indicated.

RELATION STRENGTH AND 100 M

100-M	STRENGTH	BOSCO-TEST
• STARTING-ACTION	-EXPLOSIVE STRENGTH -MAXIMAL STRENTGH	-SJ -SJ-BW
• ACCELERATION	-EXPLOSIVE STRENGTH -START STRENGTH	-SJ
• MAXIMUM SPEED	-REACTIVE STRENGTH -START-STRENGTH	-DJ -CMJ
• SPEED ENDURANCE	-ANAEROBIC POWER	-15 SECONDS JUMPS

In the control process the Bosco system takes an important place as there is a relationship between the expressions of explosive strength and the 100 meter performance:

1. The starting action is related to the squat jump with body weight.
2. The acceleration is related to the squat jump with body weight.
3. The drop jump tells us how the muscles work during the maximum speed.
4. The 15 second jumping informs us about the endurance part of the race.

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The Relationship Between Muscle Strength, Sprinting Kinematics and Sprinting Speed in Elite Sprinters*

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Abstract

Twenty-three elite sprinters, 9 females and 14 males, were filmed while performing a maximal sprint. Age, height, weight, and personal best 100m time were also determined for each sprinter. Several kinematic variables were calculated for each athlete from the filmed sprint, including stride length, stride frequency, horizontal and vertical velocity of the CG, and the angular positions, displacements, and velocities of the arm and leg segments, and the trunk. A Kin-Com isokinetic dynamoter was used to determine peak and joints, at both a slow (S) and fast (F) speed, for both the eccentric (E) and concentric (C) contraction types. Correlation coefficients were calculated between each of the strength variables, and athlete. Stepwise multiple regression analysis was also carried out for each set of kinematic and strength variables, to determine the best predictors of sprinting times for the 100m and peak torque scores for all subjects (N.m/dg) for knee extension at both slow (30 deg/s) and fast (230 deg/s), knee flexion for both slow and fast (180 deg/s), and dorsiflexion at the slow speeds. There were some differences in these relationships between male and female subjects. The stepwise multiple regression procedure was used to determine the most important predictors of sprinting speed among the strength variables as follows: knee extension (F,C), hip flexion (F,C), knee flexion (F,C), hip flexion (S,E) and dorsiflexion (F,C). The most important predictors of sprinting time for the 100m among the kinematic variables were found to be: stride length, support time, angular velocity of the thigh, upper arm position behind the body, and angular velocity of the shank during support.

Recommendations

If possible, more highly skilled sprinters should be recruited for this study if it is repeated. However, it is often not possible to obtain permission from coaches to conduct maximum strength testing on elite sprinters, as they fear an injury will occur.

Strength testing should be conducted at faster speeds, which more closely mimic the speed on the limb motions during sprinting. These speeds would range between 500-800 degrees per second. However, at higher speeds, the risk of injury is even higher on the isokinetic strength testing machines, so this is likely not possible. A different technique of strength testing is desirable for elite sprinters, possibly something fashioned from surgical tubing, into which strain gauges have been imbedded to measure the strain on the pull on the tubing. A technique of this type may be required to give safe and accurate strength readings on elite sprinters.

Acknowledgments

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