Tom Tellez – The Start and Championship Sprinting
2014 West Coast SuperClinic

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SPRINTING: A BIOMECHANICAL APPROACH

In recent years, sports have become more scientific s coaches and athletes try to get the edge on the competition. It is important to both the coaches and athletes that they understand and apply these scientific principles correctly in order to maximize performance. These principles are based on the sports sciences: namely physiology, psychology, and kinesiology. This paper will discuss the latter and its contribution as applied to the short springs.

Kinesiology, the study of movement, is the plan (blue print) on which performance is based. This plan is derived from the engineering of the system and the physical laws that govern the system's movement, hence the term 'biomechanics' was derived.

The human body is engineered to utilize a series of lever systems (third class) where the force acts between the axis and the resistance. For any movement to occur, the lever must rotate around it axis. Based on this premise, it is safe to say that the origin of movement is rotary.

Movement becomes even more complex when there are intersegmental movements, i.e., the lever having joints (links) with varying ranges of motion and the ability to change the distance of the lever from the main axis.

Now that the means of movement have been briefly described, the laws that govern movement can then be applied. For an object to rotate, it must have two forces acting on it at right angles, i.e. a centripetal or centrifugal force causing the object to move toward the point of rotations (axis) and an axial or tangential force causing it to move perpendicular to the radius. In the human machine, the force is closer to the axis than the resistance and makes the lever very inefficient for movement because the closer the force being applied is to the axis and the further away from the resistance, the more torque it takes. For the sprinter, it is essential that the lever move through the full range of movement fast which requires a torque (turning force) both forward and backward. The torque (force X moment arm) contributes to the angular velocity of the lever. Had the length of the lever been constant, the lever would oscillate like a pendulum. However, as the length of the lever changes, so does angular velocity for any given force. Thus the angular velocity times the length of the lever produces the linear velocity at the point farther away from the axis. By the lengthening and shortening of the lever, the athlete can change the moment of inertia (resistance to movement). The farther the moment to inertia (mass X radius) is away from the point of rotation, the harder it is to change motion. Like in linear acceleration, angular acceleration is the product of the change in angular velocity divided by the change in time. With a given amount of force, a shorter lever with the same mass as a longer lever would rotate faster than the longer but would have a mechanical disadvantage. It will therefore take more torque (moment of inertia X angular acceleration) to turn the longer level than it would to turn the shorter. If no additional turning force is applied to the lever, angular momentum (moment of inertia X angular velocity) is conserved. An increase or decline in the moment of inertia will cause a decline or increase respectively. This inverse relationship between the moment of inertia and angular velocity in the conservation of angular momentum is one of the keys to great sprinting.

The above section described the internal mechanics (rotary motion) that aid in sprinting. Now it is time to look at the external. The internal motion is translated as to project the mass in the desired direction by applying force (mass x acceleration) in the opposite direction. The running motion is a combination of rotary (cycling) motion and translatory motion ((projectile motion (leaping motion)). Rotary motion describes what the body levers are doing relative to the body, while translatory motion describes what the body mass is doing relative to the ground (linear velocity). Stride length is the distance the center of gravity travels between each foot contact. Stride length is the resultant of the momentum plus the net impulse (force X time) which is given to the mass. Stride length is best increased by applying force downward and backward but not reaching. The objective of sprinting is to build momentum until it peaks then try to maintain and deccelerate as little as possible.

Impulse (force X time) is the only means of changing momentum. Any increase in stride length is a gain in speed because stride length is a reaction to impulse. Stride length can be broken down into the takeoff distance, the flight distance, and the landing distance.

The takeoff distance is the distance that the center of gravity travels between landing and the point where ground contact is broken. The velocity at which the center of gravity is projected forward is also critical to the flight phase of the stride and is determined by the velocity at touchdown and the vertical and horizontal impulses. Thus the speed through the takeoff distance along with good body position and angle of projection determines the takeoff velocity. It will therefore be advantageous to have a big takeoff distance coupled with a great amount of angular speed as the time element of impulse diminishes. Here, it should be noted that the negative velocity of the foot sets up the body position for takeoff but contributes very little to the actual takeoff which is the result of pushing the ground away from the body (or body away from the ground).

The flight distance is the distance that the center of gravity travels in the nonsupport phase of the stride. These factors determine the flight distance: velocity at takeoff, relative height of the center of gravity at takeoff, air resistance, and acceleration due to gravity.

The landing distance is the distance the center of gravity is away from the landing foot. This distance is relatively short so as to reduce the breaking forces which decelerate the body.

Stride frequency is the number of strides taken per unit of time. Many coaches confuse stride time with stride frequency, but stride time is the time it takes to complete one stride (time of support and time of nonsupport) while the former holds true. Stride speed, the angular velocity through the full range of motion (front and back oscillation), determines the stride time. Stride speed is more of a physiological function (muscle type, muscle flexibility, strength, neuro-muscular coordination, etc.) than biomechanical because it depends on the state of body (fitness). Yet the path which the legs take that create the speed and mechanical advantage is biomechanical as mentioned above.

Running velocity is a product of stride length X frequency. Each athlete has a unique combination of the two at different running speeds. Many authors and coaches tend to conclude that there is an inverse relationship between the two. However, I think that there is an interdependence between them and the relationship is based on the amount of resistance that must be overcome. There are some factors that they both have in common, particularly those mentioned in the flight phase as stated above. At the beginning of the race, both stride length and frequency are at their lowest, but increase as the mass is accelerated down the track. Also at the start of the race the mass is at rest and to get it moving at high velocity requires great force. The greater the mass, the more force ti will take to accelerate it. The forces are the first applied backward and downward are where the shin slopes steeply behind the knee. This motion is piston-like as it pushes the mass forward from its resting state. At the start, the horizontal impulse (force X time) is at its greatest but diminishes over time as the mass picks up speed. It is the net force that causes the mass to accelerate: i.e. the difference in mass forward force and the pushing force. At the start of a run when resistance is at its highest, it is easier to increase stride length because force needs something to work against. However, because the resistance is high and the mass is in a rest state, it takes longer to go through the cycle so the frequency is therefore is low. This is the reason why the first stride is the slowest and the shortest. As momentum is built and the resistance diminishes, stride length tends to stabilize as the net force approaches zero. On the other hand the frequency increases because there is a constant decrease of the resistance. Both stride length and frequency are improved by the amount of power (force X velocity) generated by the muscles. The velocity component of power allows more work to be done (stride length) and increases stride speed (stride frequency). It is important to increase stride speed (angular velocity) with each stride. It should be noted that the stride speed is only voluntarily increased on the force application phase which is downward and backward.

Many coaches also stress stride frequency instead of stride length but frequency does not cause motion. The problem could be in their perception of motion and their misuse or understanding of the word "frequency". There is a distinction between stride speed and stride frequency. Stride speed is the angular velocity of the stride while frequency is the number of impulses (strides) per second. Frequency is useless in the absence of force. Note that the movement should not be hurried as it may result in the sacrifice or misdirection of the forces or both. The faster the levers move does NOT necessarily mean that the mass is being transported rapidly down the track. The process of applying force (sequence of movements) should be emphasized over trying to be too quick. The forces must be applied to the ground along with correct body position in order to project the center of mass (as far as possible without overreaching) down the track. It should be noted again that the length of the stride comes from the reactive forces of the ground and not from reaching. It is therefore evident that an increase in force production would result in an increase in both stride length and frequency.

The horizontal impulse from each stride is the difference in momentum between each stride. Newton's second law states that force is the rate of change in momentum; therefore force can affect momentum positively or negatively. The forces applied at track level have both a horizontal and vertical component, thus body position plays a very important role in sprinting. The horizontal force comes from pushing the hips away from the feet while the mass is supported by the ground. Some coaches stress pre-activation of the leg to strike in a pawing-like action. The illusion of foot pawing is the result of the rapid hip extension. Too much voluntary action at the knees and ankles would cause a reduction in the angular velocity of the hip which is the prime generator of force. I must stress that force causes motion but speed is a measurement of motion. Note that the cyclic force is applied from the hip (radial force) which results in tangential motion of the foot. At foot placement, the shin should be approximately 90 degrees to the ground. As the center of mass passes over the point of support, the heel briefly touches the ground and the ankle angle closes. This motion puts the Achilles tendon and calf in a stretch position while the knee is bent. This loading action yields a great push-off force from the ball of the foot than just staying on the ball of the foot. It should be noted that the hips extend in one continuous motion from the knee-lift position through the end of the push-off. In other words, there are no pauses in hip extension at foot contact. The vertical forces are greater than the horizontal forces even at the beginning of the race. The reason is that there is a force (mass X gravity) working against the athlete. The vertical force comes at takeoff when the mass is elevated by pushing downward (pushing off the heel back on to the ball of the foot). The recovery foot steps up and over the drive knee, as the foot takes the shortest path to the front of the body while the center of mass rises above the surface. The knee then raises and extends as the foot moves forward and the shin becomes plumb. The thigh is dropped to the ground as the knee extends causing the foot to have a negative velocity at foot placement. As the athlete builds momentum (mass X velocity), the ratio between both forces (vertical and horizontal) increases as the net horizontal force decreases. It should be noted that the stride gets progressively quicker and longer as stride frequency and length are optimized to produce maximum speed. The two basic components of sprinting are force, which yields stride length, and leg speed (angular velocity) which yields stride frequency with the end result being power. It should be noted again that the ability to move through the full range of motion fast is a physiological function and is based on the amount of fast twitch fiber in muscles.

After the athlete has been successful in setting the body in motion and the center of mass begins to gain momentum, a toppling would occur if the feet continued to go backward and downward. The acceleration process then goes through a mechanical transition where the legs go through the form of a cycling motion. The lever lengthens to give a mechanical advantage and shortens on the recovery phase to give a speed advantage. The position of the body dictates how the reactive forces affect the center of mass. The center of mass accelerates at a decreasing rate until maximum velocity (top speed) is attained where the net horizontal force being applied is zero. As mentioned before, the ground tends to recede faster when the body picks up speed resulting in a reduction of contact time as well as effective force because of a reduction in resistance. At this point in the race, the athlete tries to keep the effective force at zero until the net horizontal force becomes negative. When the momentum of the body becomes greater than that of the legs, the body starts toppling over causing a braking action each time the foot hits the ground. At this point, the athlete tries to relax and let the momentum of the mass take the body down the track. In the short sprints it is important to accelerate over the longest possible distance in the shortest amount of time and try to maintain and decelerate gracefully.

The acceleration process requires STRONG, QUICK, and BACKWARD SWINGS OF THE ARMS. The arm swing comes from the shoulders as the forearms and lower arms are relaxed. The arm swing is likened to that of a pendulum moving back and forth on its axis. This action is coordinated with the leg in range and force.

Elbows and upper arms must come (go) all the way back and up when swinging the arms. By driving the elbows up on the back swing, it allows a greater take off-distance thus enhancing stride length. NOTE: The elbows do not stay in a flexed (locked) position throughout the arm swing; instead they open on the back swing and close on the forward swing to match the legs. By closing the angle at the elbows, thus reducing the moment of inertia of the arm, angular velocity is increased, resulting in quicker turnover. The hand is flung downward as the shoulder and elbow extend. As the hand passes the hip, the angle of the elbow starts to close but the shoulder keeps extending through the full range of motion.

Do not concentrate on the arms opposing each other on the swing (back and forth) but rather, concentrate on the arms with the corresponding legs. Hand should come no higher than the chin on the forward swing, preferably shoulder height in preparation for the downward thrust.

The hands first initiate the downward stroke as the arms and legs are then synchronized in range of motion and force.

There has been much debate of the best way of improving sprint speed whether increasing stride length or frequency. We are limited physiologically to the amount of strides that can be performed in a second. It is true that most good spring athletes have just about the same frequency so the deciding factor is the athlete who takes the longest strides usually wins the race if he has the conditioning to do so.

Stride speed is involuntarily increased through the conservation of angular momentum. By shortening the radius, thus reducing the moment of inertia, would result in an increase in angular velocity. The shortening of the lever occurs after the foot breaks contact the the ground. This movement is the response of the forces being applied correctly to the ground and is non-volitional.

Remember that both legs as well as arms oscillate in opposite directions in the same time frame therefore it is only necessary to apply force in the downward and backward direction as the recovery of the opposite leg would be automatic. Trying to make the recovery quicker would cause a reduction in impulse and hence a reduction in stride length. It is best to go through the full range of motion which also allows the athlete to utilize the elastic component (stretch reflex) of the muscles. After the stretch, there is nothing that the athlete can do that would make the movement faster. A good example would be a person, after loading a "Y:" (fork) sling shot, trying to make the projectile move faster by moving the hand with the projectile forward. This action would cause a reduction of the elastic force resulting in slower movement. There is an illusion of speed when the lever does not go through the full range of motion but the objective is not to move the lever fast but rather transport the mass down the track in the least time possible.

Some coaches stress high knee-lift but I think that it interferes with the timing of the stroke. The main focus should be applying force downward and backward. Knee-lifts and butt-kicks are the reaction of the force bring applied to the ground correctly.

To summarize, the coach and athlete should use these biomechanical principles as a model to plan their strategy. The job of the coach then would be to change the athlete's physiological state (getting the athlete physically ready) to accomplish such.

TOM TELLEZ

BASIC SPRINTING

1. The human body is engineered to use third class levers where the force acts between the axis of rotation and the resistance.

2. For any movement to occur the lever must rotate around its axis

3. The origin of motion is rotary.

4. Movement becomes more complex when you have intersegmental joints.

5. For the object to rotate it must have two forces acting on it at right angles.
   A. Centrifical / Centripedal Forces
   B. Translatory Force (projectile)

6. The running motion is a combination of rotary (cycling) motion and translatory motion (projectile)

7. Rotary motion is what the levers are doing relative to the body.

8. Translatory motion describes what the body mass is doing relative to the ground (linear velocity)

9. Sprinting is the product of three factors.

   A. Stride Frequency - Phisiology
   B. Stride Length - Push the Body
   C. Anaerobic Conditioning
      1. Phosphogen System - Lasts for 5 - 8 seconds (start)
      2. Glycogen System - Lasts for 40 - 50 seconds (maintenance)

10. The Best way to improve sprinting is by lengthening the stride by pushing. <u>Not by reaching.</u>

11. Stride Length - the distance the center of mass travels between foot contact. Stride length is the result of momentum and impulse (Force x Time) Given to the mass.

12. Stride length is best increased by applying force downward and backward but not by reaching.

13. Reaching to increase stride length will cause negative acceleration. It does not utilize the stretch reflex mechanism in the body. It will slow down hip rotation and place to much stress on the hamstrings. It will affect angular acceleration of the leg.

14. A pawing - striking action of the leg is actually an illusion resulting from rapid hip extension. Too much voluntary action at the knees and ankles causes a reduction in angular velocity of the hip, which is the prime generator of force.

15. Consciously lifting the knees high while sprinting inhibits the legs natural timing during the recovery phase.

BASIC SPRINTING
(continued)

16. Impulse is the only way (Force x Time) to change momentum.

17. Any increase in stride length is a gain in speed because stride length is a reaction to impulse.

18. The negative velocity of the foot sets up the body position for the take-off but contributes very little to the result of pushing the ground away from the body (or the body away from the ground).

19. The heel of the foot must touch the ground briefly to set up the body position for the take - off. It will also stimulate the stretch reflex in the calf.

20. The main objective in sprinting is to propel the body down the track as fast as possible (translatory motion).

21. The athlete who can best project his/her body forward and maintain top speed will be more successful.

22. It is not the athlete with the 'quickest' turnover or the 'longest' reach who wins but the one who can get his/her body to travel the fastest over the longest distance.

23. The athlete who can best utilize the hip joints will be more successful in sprinting.

24. The hip acts as a crank to deliver the force to the ground. This force is then returned to the center of mass lifting it up off of the ground.

25. The athlete whose body moves away from the ground the fastest will end up in front. Given the correct angle of projection, the athlete will cover more distance.

26. A gain in distance is a gain in speed.

27. The 'push-off' is the most important phase in the stride. The body is stretched upward from the ground. The origin of the motion is at the hip joint.

28. The athlete should try to apply the biggest force in the longest time possible. This will result in a stronger impulse, which yields a bigger change in momentum. (The athlete would have a higher change in velocity with a bigger impulse).

29. The athlete should follow through with the arm stroke, allowing more time for the forces to work. As a result, the body will move away from the ground faster.

30. It is important that the levers go through the full range of motion at the hip and at the shoulder.

31. The athlete should think that movement feels slow because of the time allowed pushing (driving) the hips up.

32. Recovery speed is in the stretch. This requires the athlete to move the lever through the full range of motion.

BASIC SPRINTING

(continued)

33. At foot placement, the hip continues to extend. The foot (ankle) is placed directly under the knee joint. The shin is perpendicular (right angle) to the ground.

34. Contact is first made at the (outside) ball of the foot, and then the weight is distributed to the ball of the foot. As the boy passes over the foot, the heel slightly touches the ground. The ankle extends naturally as the hip joint is stretched upwards (mid-foot contact with ground).

35. On the leg recovery, the foot is brought off the ground by stretch reflex at the hip. The knee leads the foot during the forward swing. This increases the angular velocity of the leg. The heel should not kick up behind but move towards the glutes when ground contact is broken (wall running).

36. After the knee comes forward, the foot begins to drop for the next stride. The cycle repeats itself throughout the run.

37. Head is held in natural alignment with the spine.

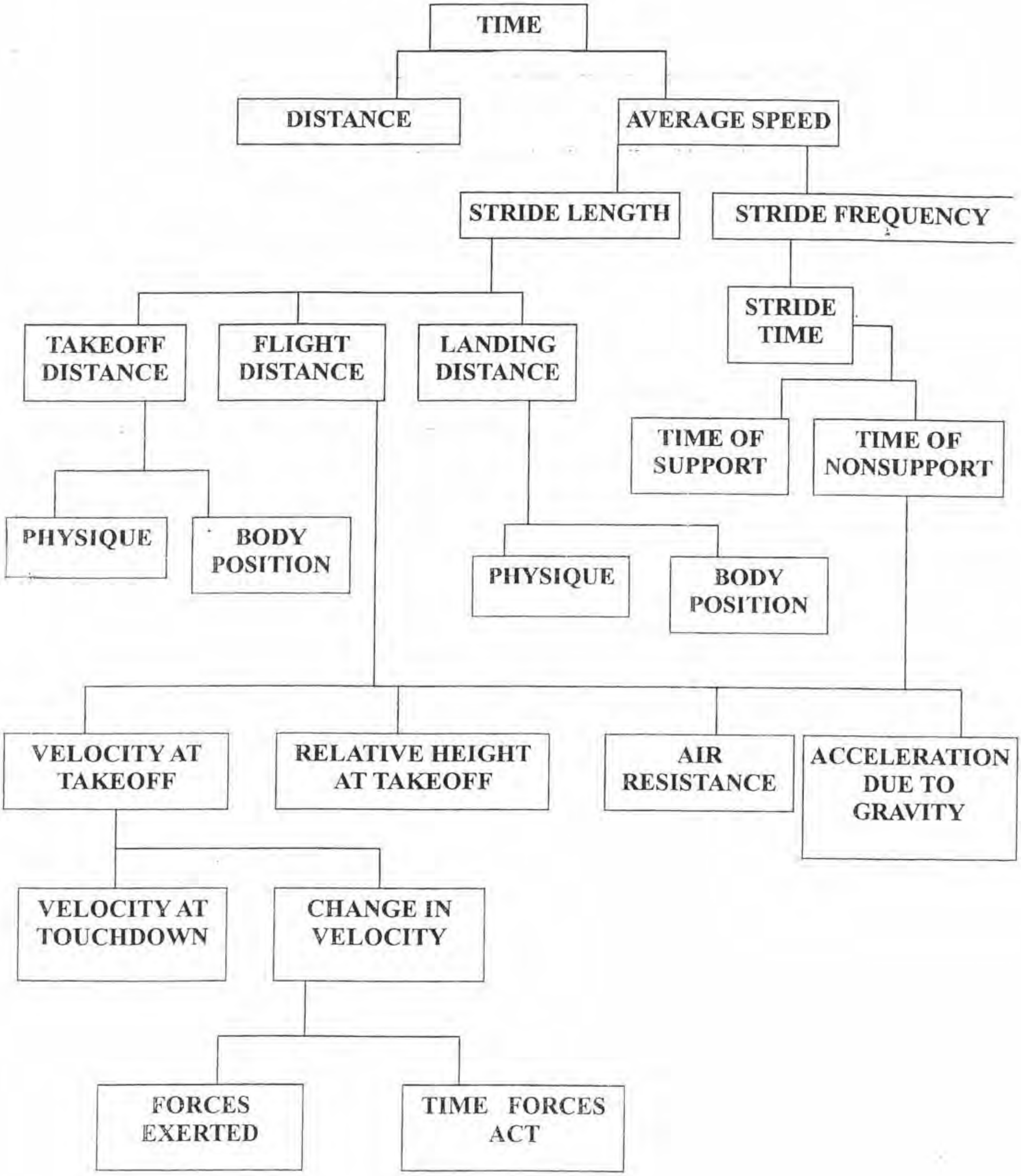
38. Relaxation is the key for successful sprinting.

39. Keep ankle joint neutral. There is no dorsi-flexion or plantar flexion of the ankle joint.

40. The foot only acts as support.

41. There is a negative velocity of the foot which sets the body position for take-off.

SPRINTING
OUTLINE 2



Sprinting Outline

Sprinting is the ability to run at maximal or near maximal speed for short periods. Sprinting is the product of three factors:

I. Stride Frequency

A. Limited to the physiology of the athlete
   1. Leg length
   2. Muscle type
   3. Stretch reflex

B. Time spent on the ground
   1. Foot placement

C. Time spent in the air
   1. Gravity
   2. Relative height at takeoff
   3. Air resistance
   4. Take off velocity
      a. Velocity at touchdown plus change in velocity
         1. Force X Time (Impulse)

II. Stride Length

A. Takeoff Velocity
   1. Velocity at touchdown plus change in velocity
      a. Force X Time
         Note: Force X Time equals impulse. Impulse equals the change in Momentum (Mass X Velocity). Because mass does not change, it is the velocity which changes. Velocity is the speed at which the body is traveling. The body travels slightly farther each push as it gets faster until maximum velocity is attained. A gain in distance is a gain in speed. The athlete should try to apply the biggest force for the longest possible time.

III. Sprint Mechanics

A. Overview
   1. Basic Concepts
      a. Forward Lean
      b. Head alignment
      c. Driving
   2. Phase by Phase
      a. In the first phase (out of the blocks) of the race, the strides are downward and backward. These powerful pushes off the ground propel the body forward.
      b. In the acceleration phase, the body moves into its sprinting position. There is still some backward push but there begins a little bit of bouncing.
      c. In the maximum speed and maintenance phase, there is lots of spring off the ground. Each step becomes quicker through the full range of motion

until full speed is attained.

B. Drive Phase (push off)

1. Foot strikes under body's center of mass
2. The athlete should land on the ball of the foot or flat
3. The shin should be 90 degrees to the ground at landing
4. ? The athlete should experience a heel strike to start the push off or rebound process
5. The drive leg stretches as the body is pushed upward
6. The foot leaves the ground with the leg extended slightly behind the athlete's center of mass
7. The origin of motion is at the hip joint (hip extension)
8. The conversion of rotary motion to linear motion (Translatory Motion)
9. The body is meant to push not pull

C. Swing Phase (leg recovery)

1. After the foot leaves the ground, the knee flexes to bring the lower leg in a tucked position under the center of mass
2. The leg swings forward in the tucked position to increase angular velocity
3. The speed of the swing is the result of the stretch at push off
4. The athlete should lead with the knee as the leg swings forward
5. After the knee comes forward, the knee joint unfolds and the foot starts to drop
6. Contact is made (becomes the drive leg)

D. Arm Action

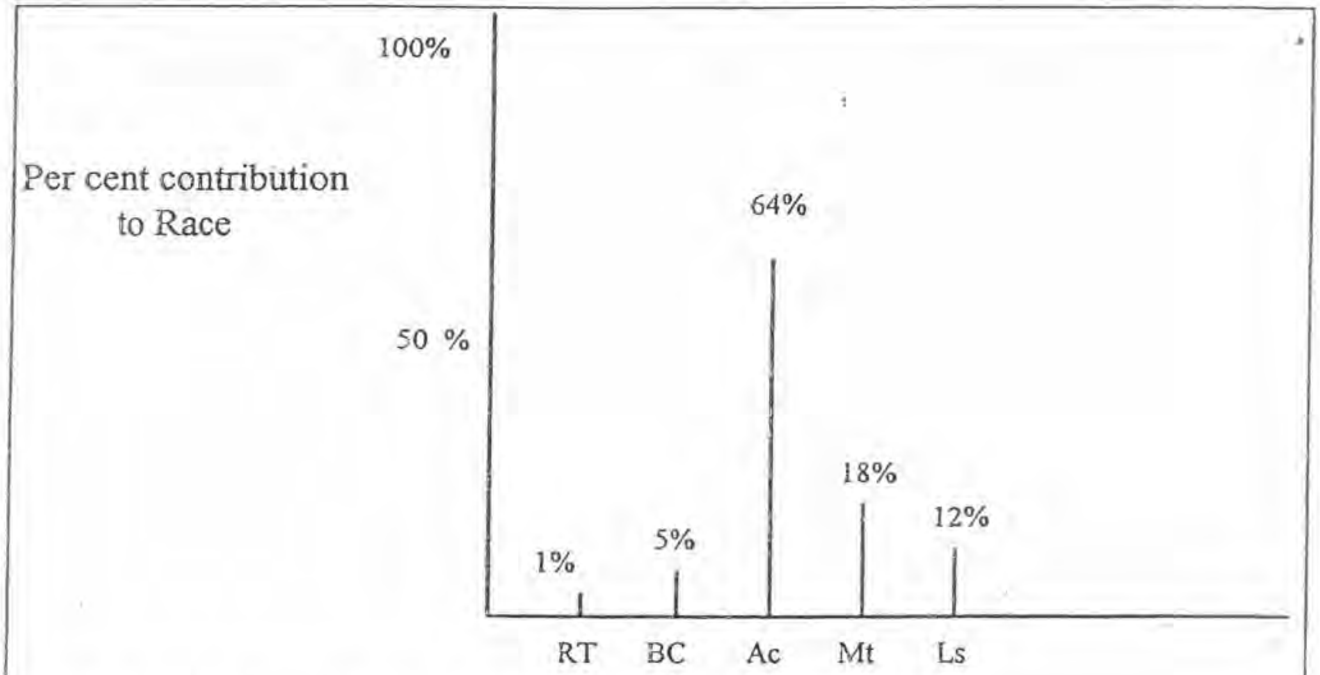
1. Downward and backward through the full range of motion
2. Stretch reflex
3. Relaxation
4. Swing from the shoulders
5. The arms lead the legs in tempo and in range
6. After full speed is reached, the athlete tries to maintain stroke speed
7. Run through the finish line

SPRINTING - FROM START TO FINISH

by
Tom Tellez - University of Houston

Regardless of ability, in order for an athlete to reach his maximum potential as a sprinter, his training should center around these factors: Reaction Time, Block Clearance, Speed of Efficient Acceleration, Maintenance of Maximum Velocity and Lessened Degree of Deceleration.

Based on a 10.0 second 100 meter dash, a breakdown of the race allows an estimated distribution of each of the factors in the following graph. (It should be noted that efficient acceleration over the longest possible distance is influenced by the position of the body as the athlete leaves the blocks. Therefore, block clearance may be thought of as contributing much more to the total race than 5%. The block clearance "sets up" the acceleration pattern of the race.)



RT - Reaction Time; BC - Block Clearance, Ac - Acceleration,
Mt - Maintenance of Maximum Velocity, Ls - Lessened Degree of Deceleration

100 meters

Stride	1 2 3 4 5 6 7 8 11 12 13.............................30.....45
Distance in meters	0....10..60-70....100

Total forces are the combination of vertical and horizontal forces.

Force (vertical): At the beginning, the vertical force is equal to the horizontal because of the 45-degree angle of projection. The force shifts quickly to predominately vertical as the body becomes more upright. First, the vertical has to be greater than gravity in order for contact to be broken with the ground. Vertical forces continue throughout the race.

Force (horizontal): The horizontal forces are established at take off and determine the changes in Horizontal velocity. Horizontal forces start out big but get smaller as the body picks up speed and approach top speed. At top speed the net horizontal forces are zero. After top speed is attained, the horizontal forces increase negatively which causes the body to slow down.

Time: At the beginning of the race, the first stride is the slowest. The stride gets progressively faster as momentum is built. Time diminishes with speed as contact time decreases. Stride time should be fastest as the athlete approaches top speed then levels off and increases as fatigue sets in during the deceleration phase.

Changes in p: Changes in momentum is directly related to the impulse imparted to the system.

Changes in v: Changes in velocity is the result of a mass being accelerated for some given time. In sprinting, the mass is acceleration updated. How long (the time) the mass spends acceleration is directly proportional to the changes in velocity (speed). As force is applied the mass, it picks up speed until the net horizontal forces become zero. At this point, there is no change in velocity (top speed). As the net horizontal forces become negative, the mass slows down. The changes in velocity are cumulative which results in an ending velocity.

Momentum: Momentum increases with each positive change in velocity until full speed is attained. It levels off at top speed and then slightly decreases towards the end of the 100 meters. The changes start out big because the body has to overcome inertia or its rest state but decreases as they approach zero toward 60-70 meters depending on the race plan. After top speed is held for a brief period, the changes begin to grow negatively at an increasing rate.

Acceleration grows at a decreasing rate until approaches zero. The biggest gains are at the start of the race then get smaller as top speed is approached at which time acceleration becomes zero then shifts to negative at the onset to fatigue.

The human body acts under the influence of projectile motion once launched from the ground during sprinting.

The path that a projectile (body) follows is called its trajectory. There are two components of projectile motion so it is useful to consider the vertical (y) and horizontal (x) of the velocity and displacement separately. With each launch, projectile travels as a constant horizontal velocity. This horizontal motion depends on the horizontal component of the initial velocity at take off. Hence, the distance traveled will be the initial velocity times time. The vertical motion of a projectile depends on the vertical component of the initial velocity and on the acceleration due to gravity. A projectile will follow a parabolic trajectory unless it projected completely vertical 90 degrees.

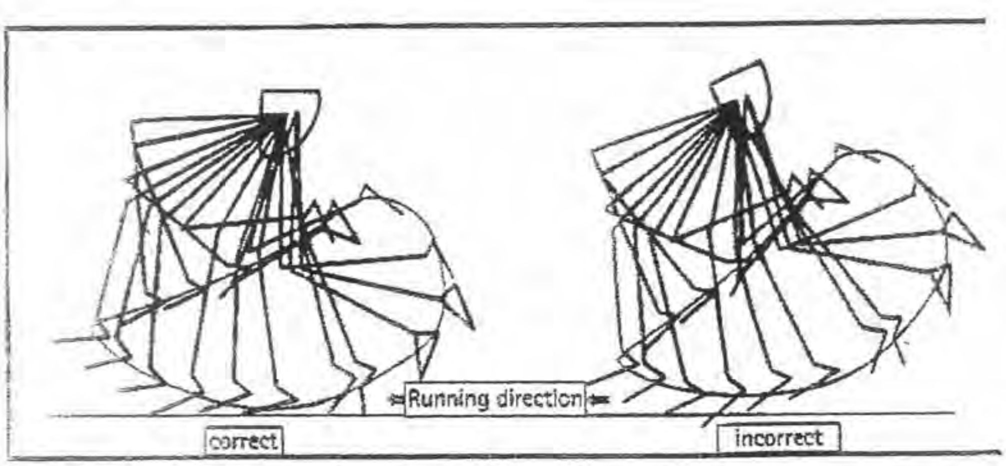
Above there is a description of the motion. Now let's take a look at what causes the motion. To get the body (center of gravity) to travel along a trajectory requires that an impulse (force times time) be applied to the objects (c of m). This impulse directly changes the velocity of the center of mass. To get the largest possible impulse requires the athlete to either apply the largest possible force, apply the force for the longest possible time, or both.

Good (proper) running mechanics (technique):-

Position of the hips (pelvis) determines the path and position of the legs. Body position (posture) is also responsible for the timing of when the foot makes contact and when it leaves the ground.

When the pelvis is tilted backwards, the athlete must catch himself and leave the ground prematurely. Some coaches consider this as back side mechanics.

When the pelvis is upright, it becomes easier to run fast. The forces can be better applied to the ground thus giving a longer faster stride. See figures below.



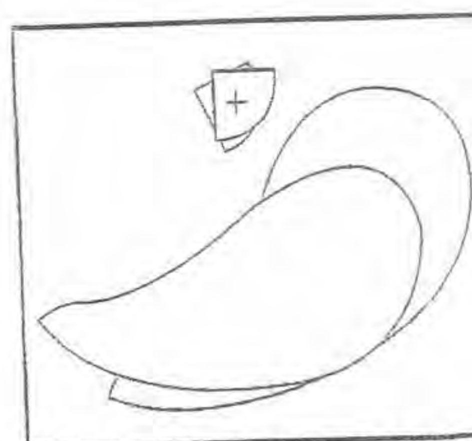
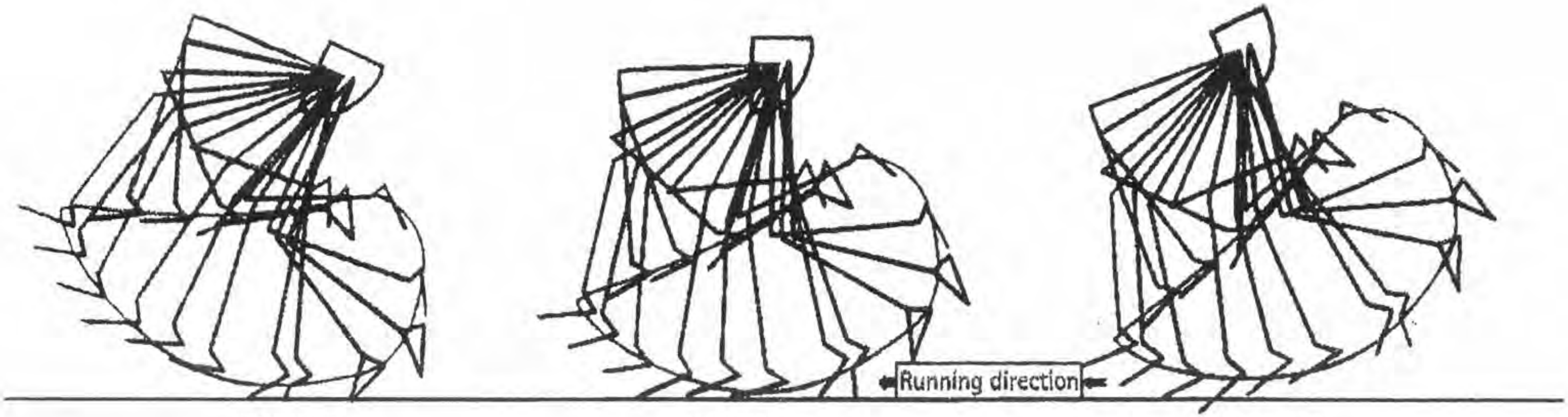


Figure 3: Effect of the position of the pelv

Note that both movements are identical to each other and a mirror image of each other. The only difference is the position of the pelvis.



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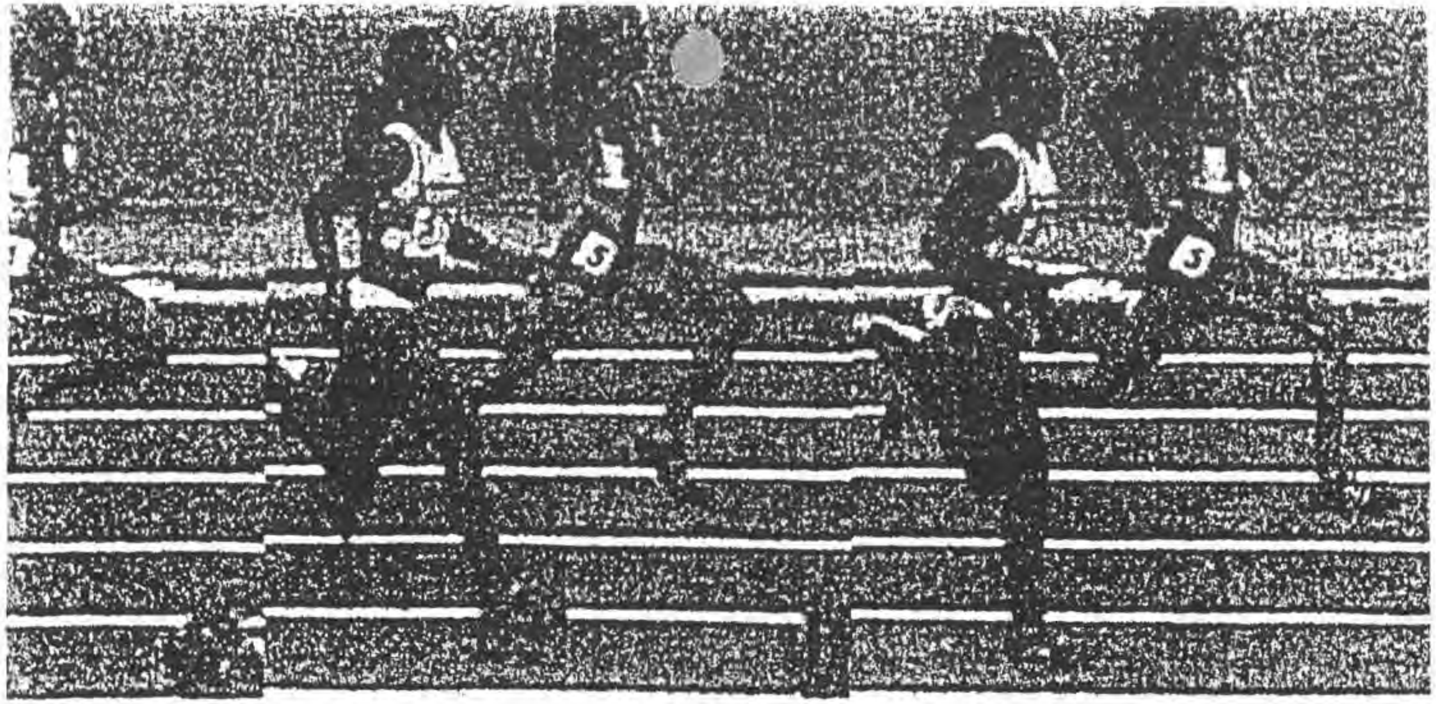

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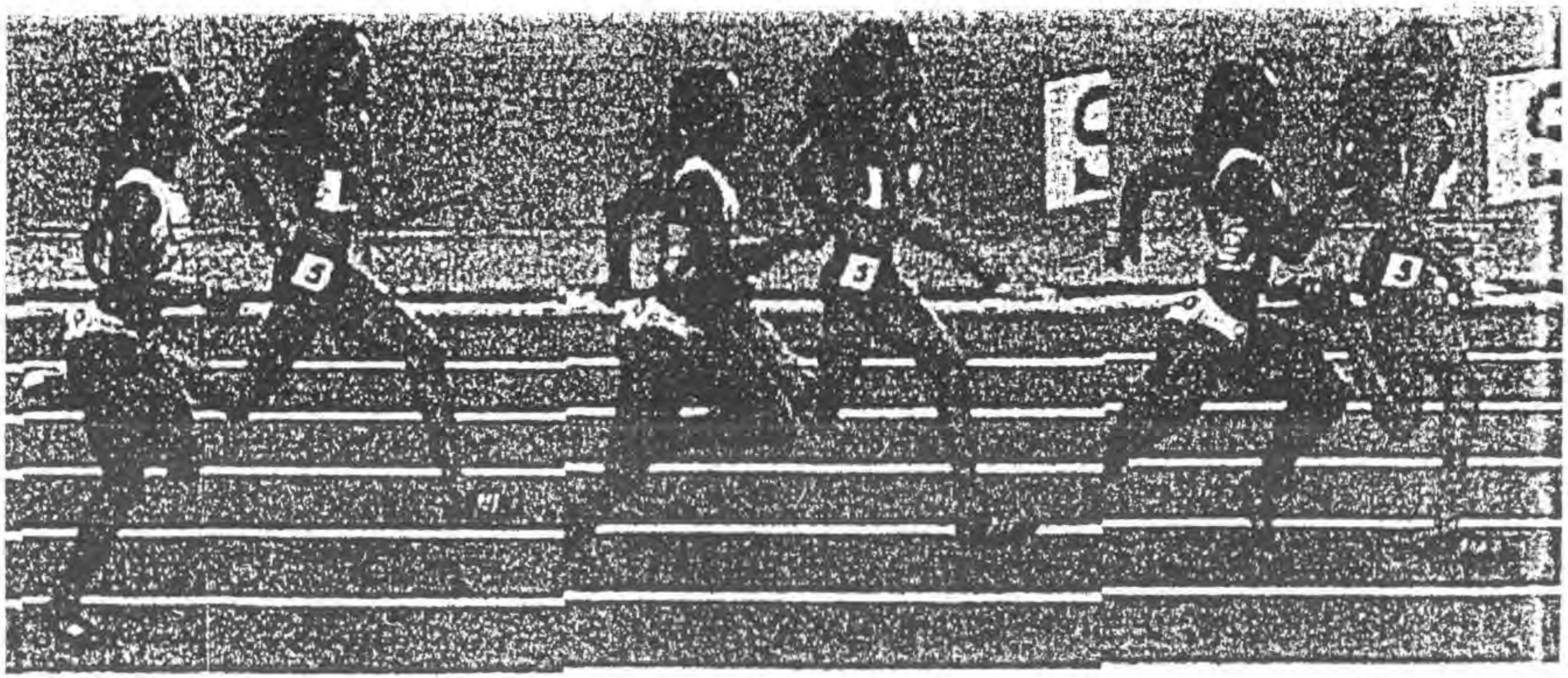

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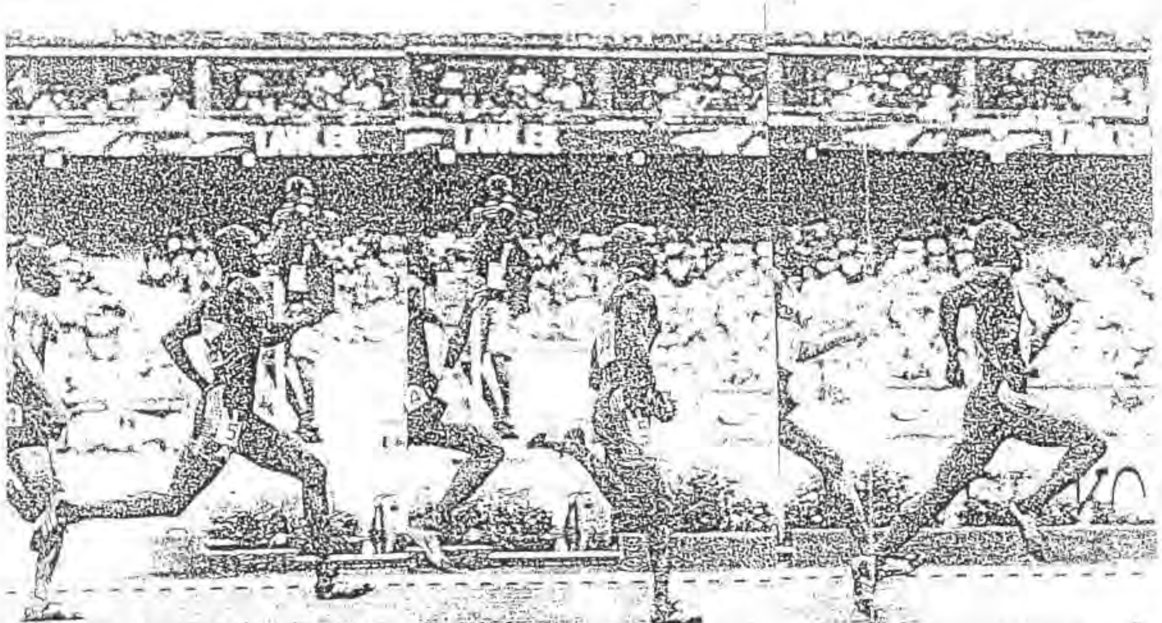
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Figure 8

Figure 7

Figure 6

Figure 5

1. 2. 3. 4.

STRIDE LENGTH

1. Distance the center of gravity travels between each foot contact.
2. Best increased by applying force down and backward, not reaching.

LANDING DISTANCE

Distance the center of gravity is from landing foot.

1. Distance should be short
2. Reduce braking forces which decelerate the body.
3. Pawing and clawing the ground with the leg is an illusion. This is a result of rapid hip extension.

FLIGHT DISTANCE

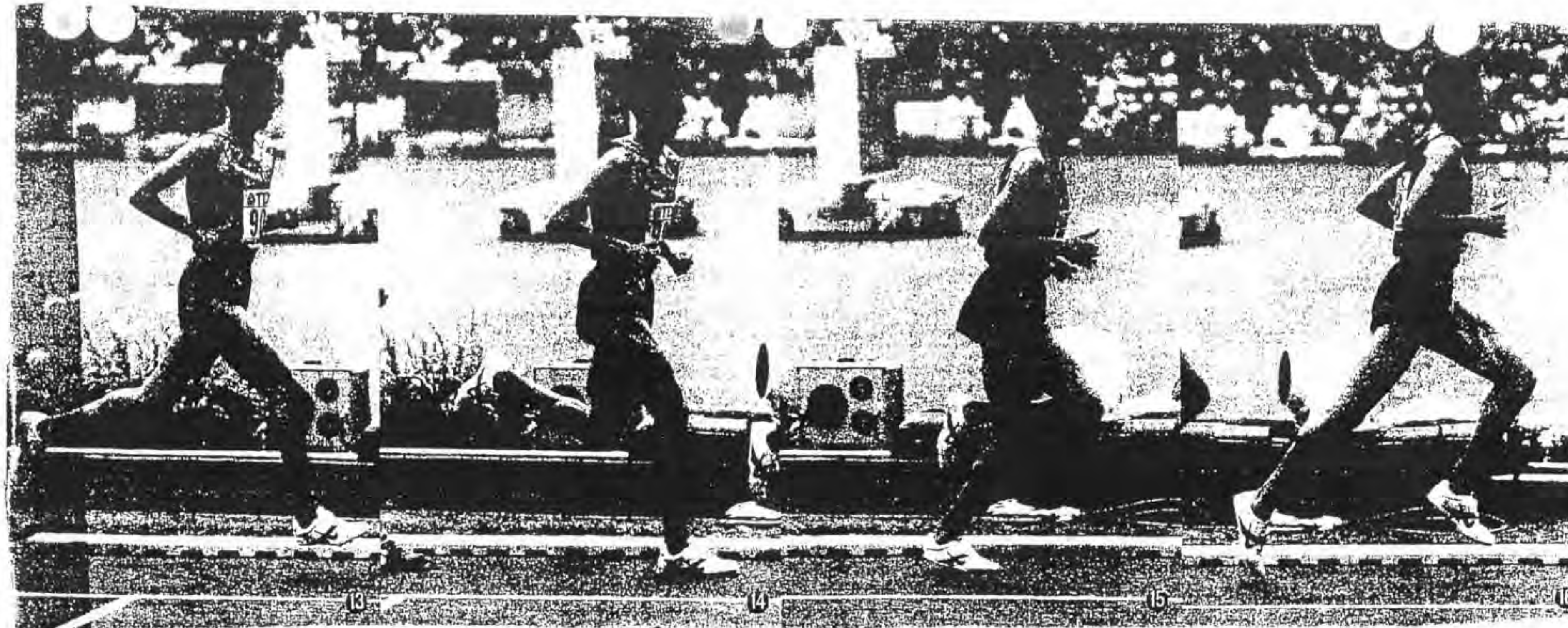
Distance the center of gravity travels in a non-support phase of a stride.

1. Velocity at take-off.
2. Height of center of gravity.
3. Air resistance.
4. Acceleration due to gravity.
5. Vertical and horizontal.
6. Good body position.

TAKE-OFF DISTANCE

Distance that the center of gravity travels between landing and point at which ground contact is broken

1. Good body position
2. Vertical and horizontal impulses.
3. Angle of projection.
4. Big take-off distance.
5. Negative velocity of foot sets up body for take-off, but contributes little to take-off.



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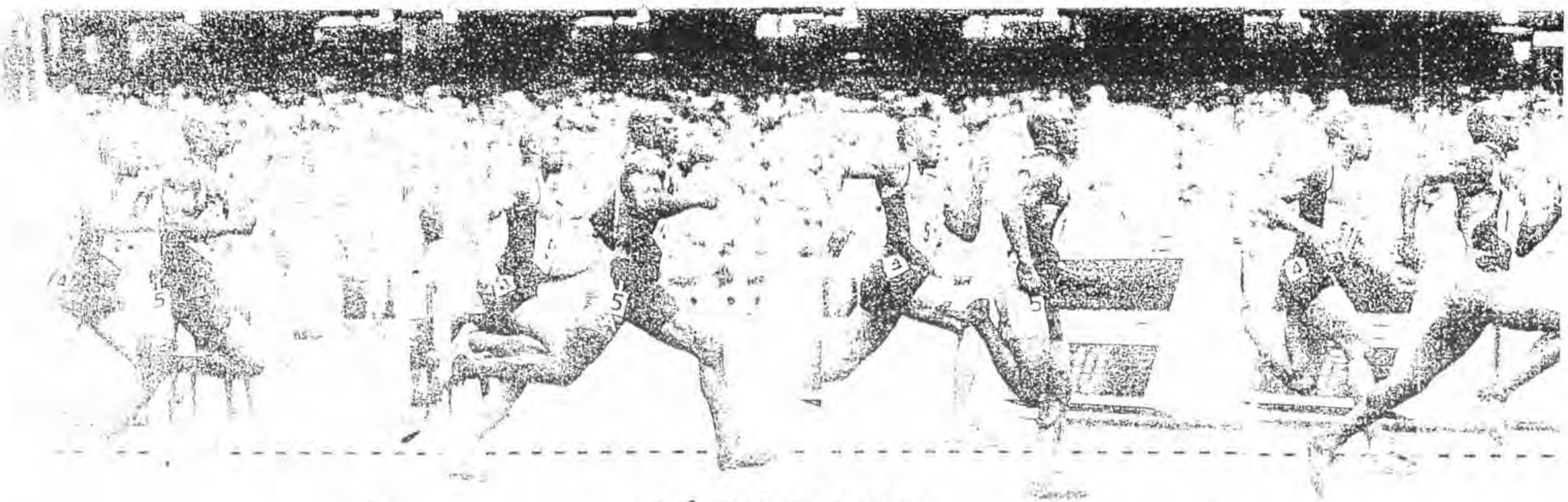
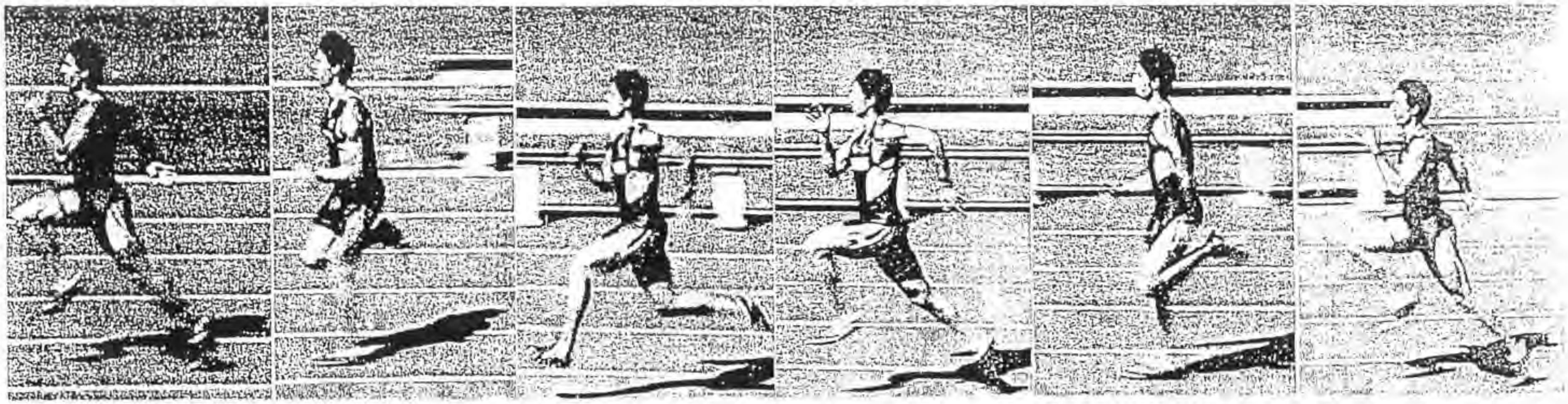


CRAWFORD



STRIDE FREQUENCY

1. Number of strides taken per unit of time.

STRIDE TIME

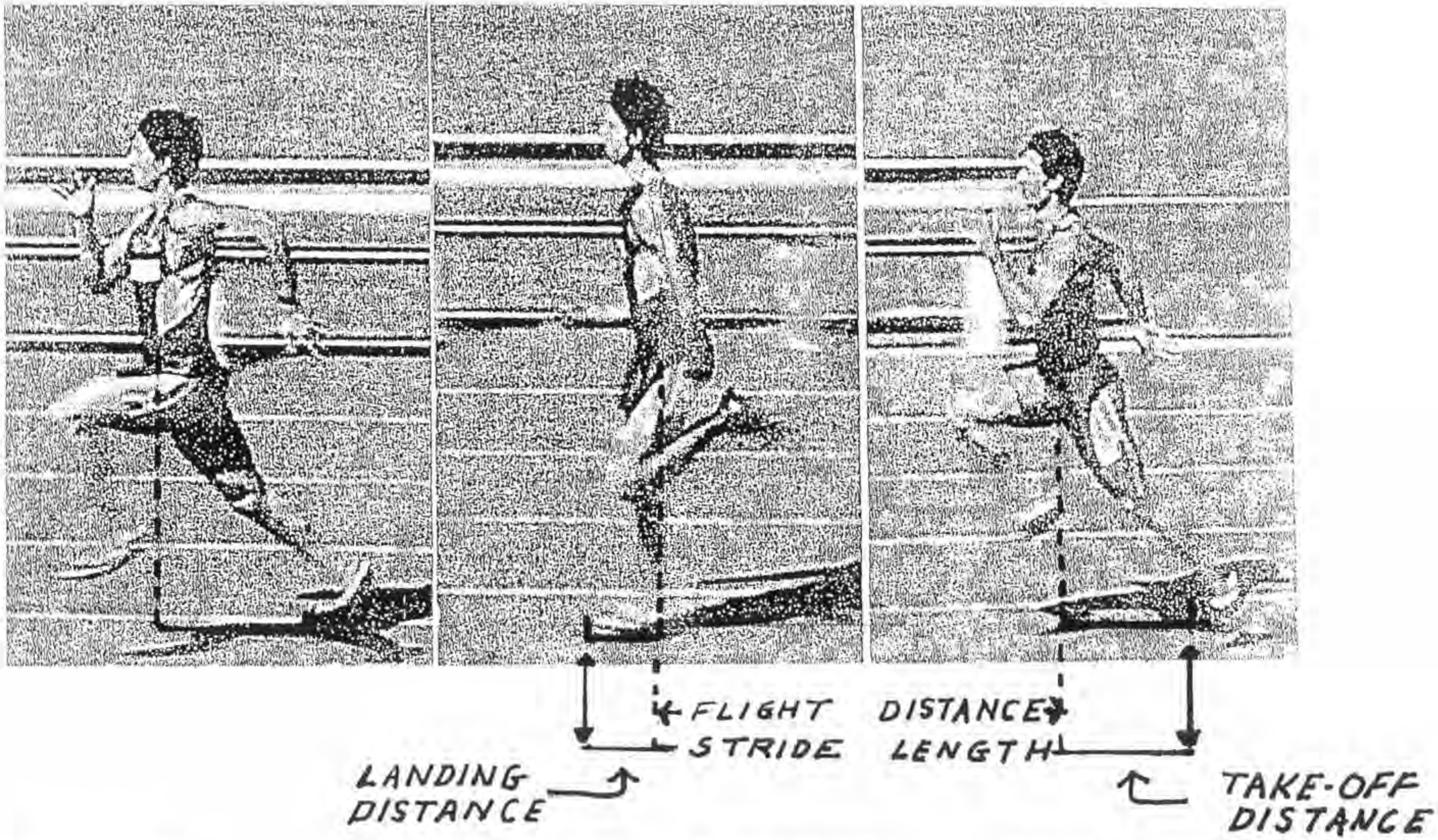
1. Time that is takes to complete one stride.
2. Time of support and time of non-support.

STRIDE SPEED

1. The angular velocity through the full range of motion.
2. Front and back oscillation.

STRIDE SPEED (DEPENDENT ON)

1. Physiological functions
   - A. Muscle type.
   - B. Muscle flexibility.
   - C. Neuromuscular coordination
   - D. Body fitness.



STRIDE LENGTH

1. Distance the center of gravity travels between each foot contact.
2. Best increased by applying force down and backward, not reaching.

LANDING DISTANCE

Distance the center of gravity is from landing foot.

1. Distance should be short.
2. Reduce braking forces which decelerate the body.
3. Pawing and clawing the ground with the leg is an illusion. This is a result of rapid hip extension.

FLIGHT DISTANCE

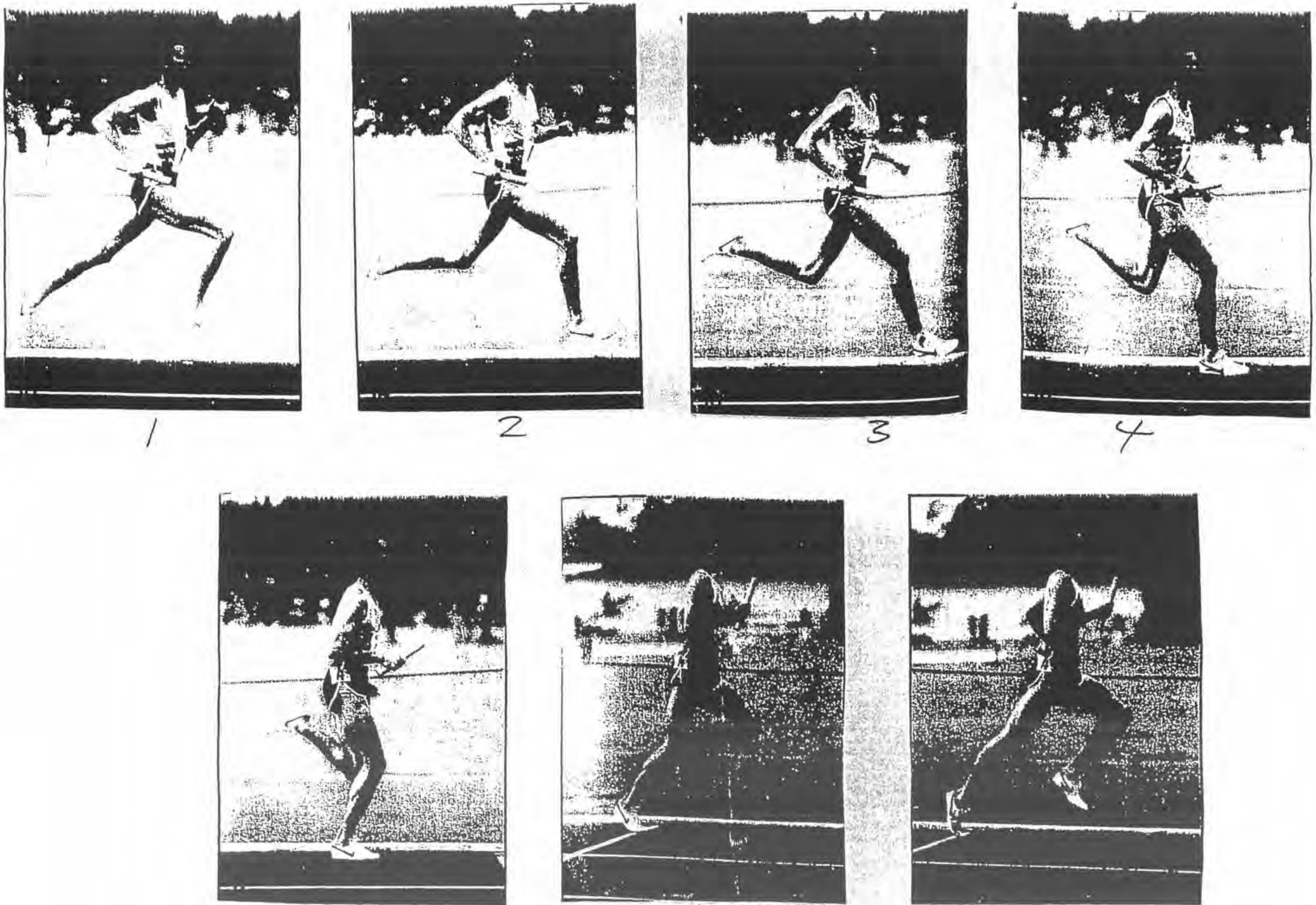
Distance the center of gravity travels in the non-support phase of a stride.

1. Velocity at take-off.
2. Height of center of gravity.
3. Air resistance.
4. Acceleration due to gravity.
5. Vertical and horizontal
6. Good body position.

TAKE-OFF DISTANCE

Distance that the center of gravity travels between landing and point at which ground contact is broken.

1. Good body position.
2. Vertical and horizontal impulses.
3. Angle of projection.
4. Big take-off distance.
5. Negative velocity of foot sets up body for take-off, but contributes little to take-off.



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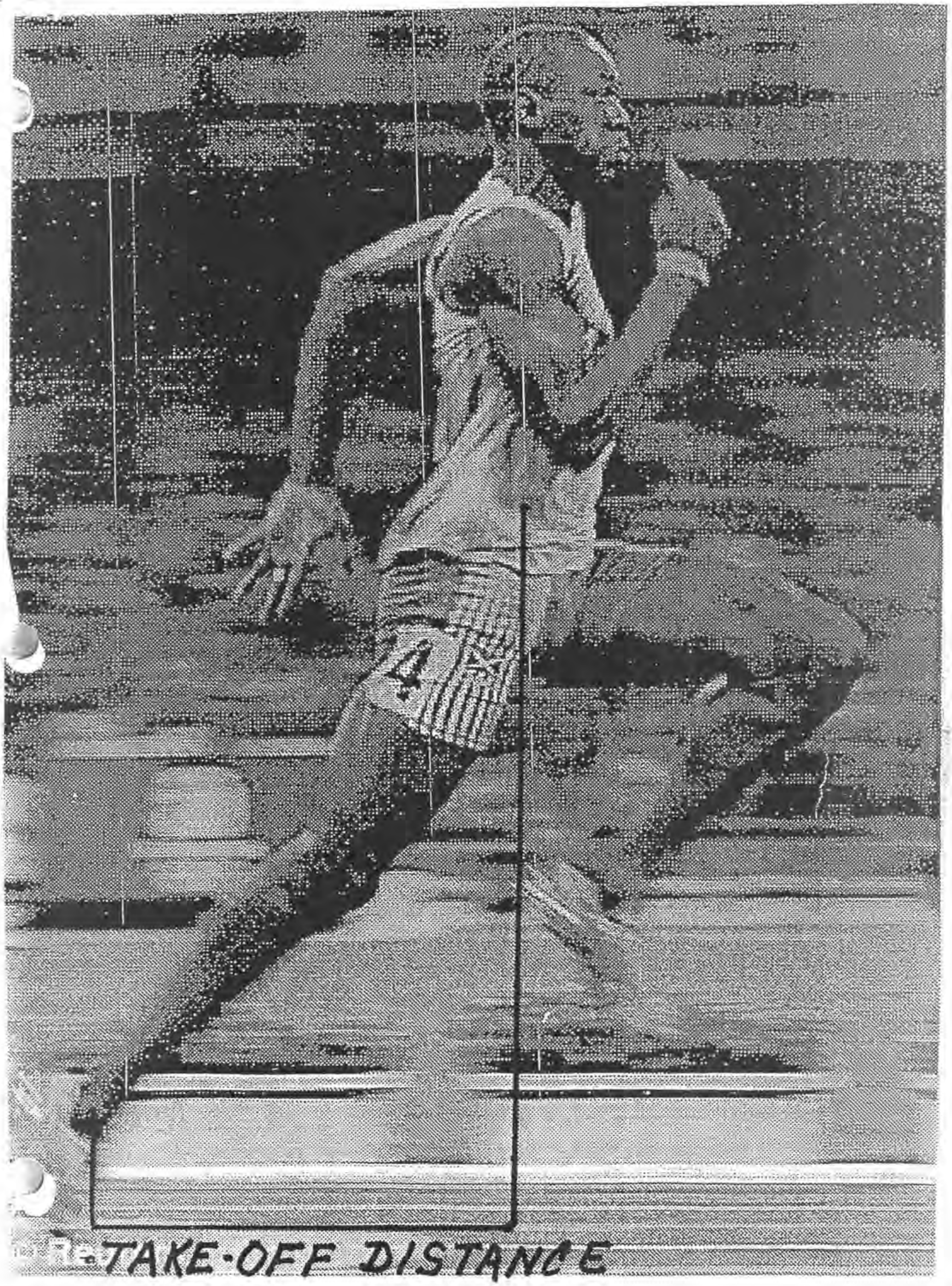
5 6 7

Olympic record: Time beat his run in Beijing.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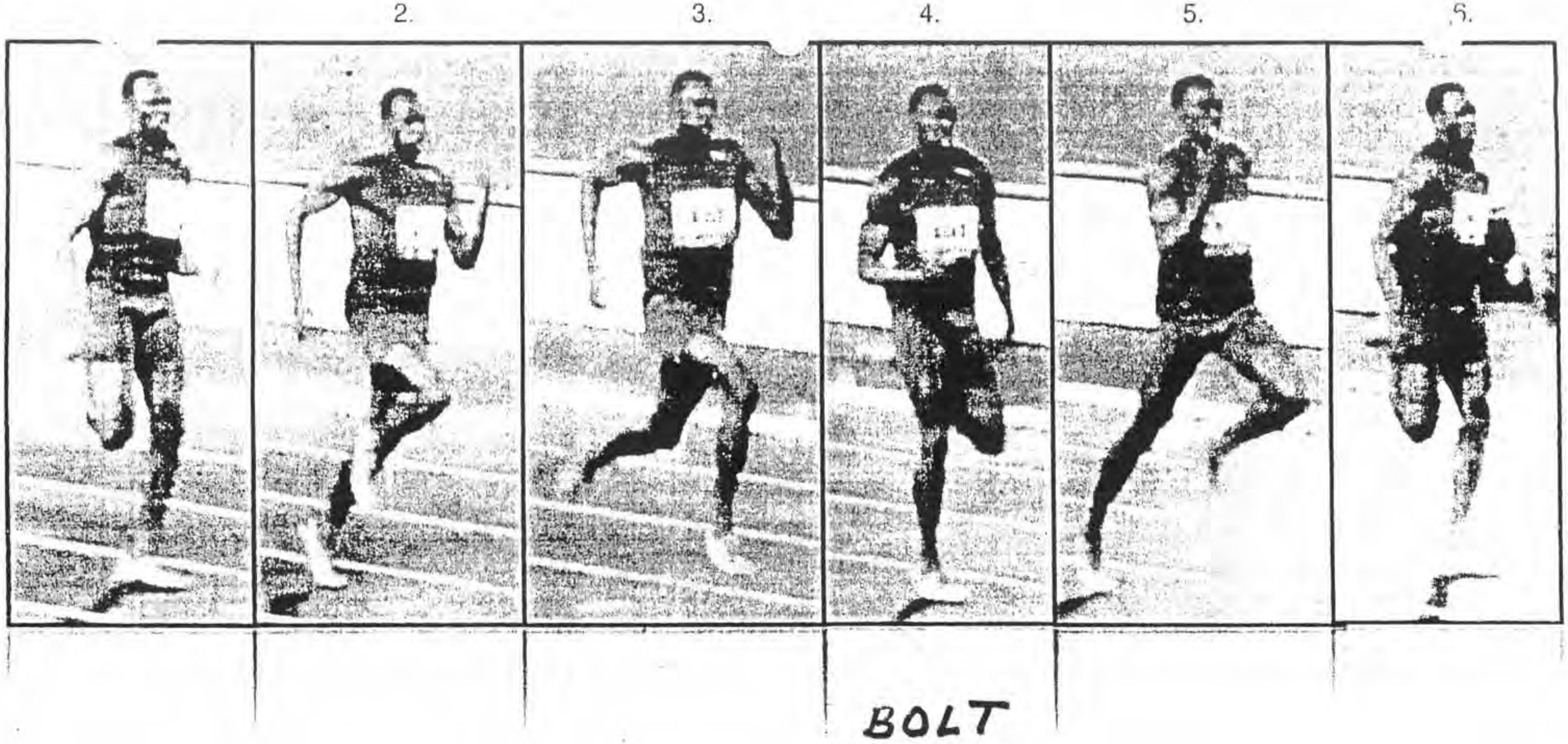
TAKE-OFF DISTANCE



STRIDE LENGTH
1. Distance the center of gravity travels between each foot contact.
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LANDING DISTANCE
Distance the center of gravity is from landing foot.
1. Distance should be short
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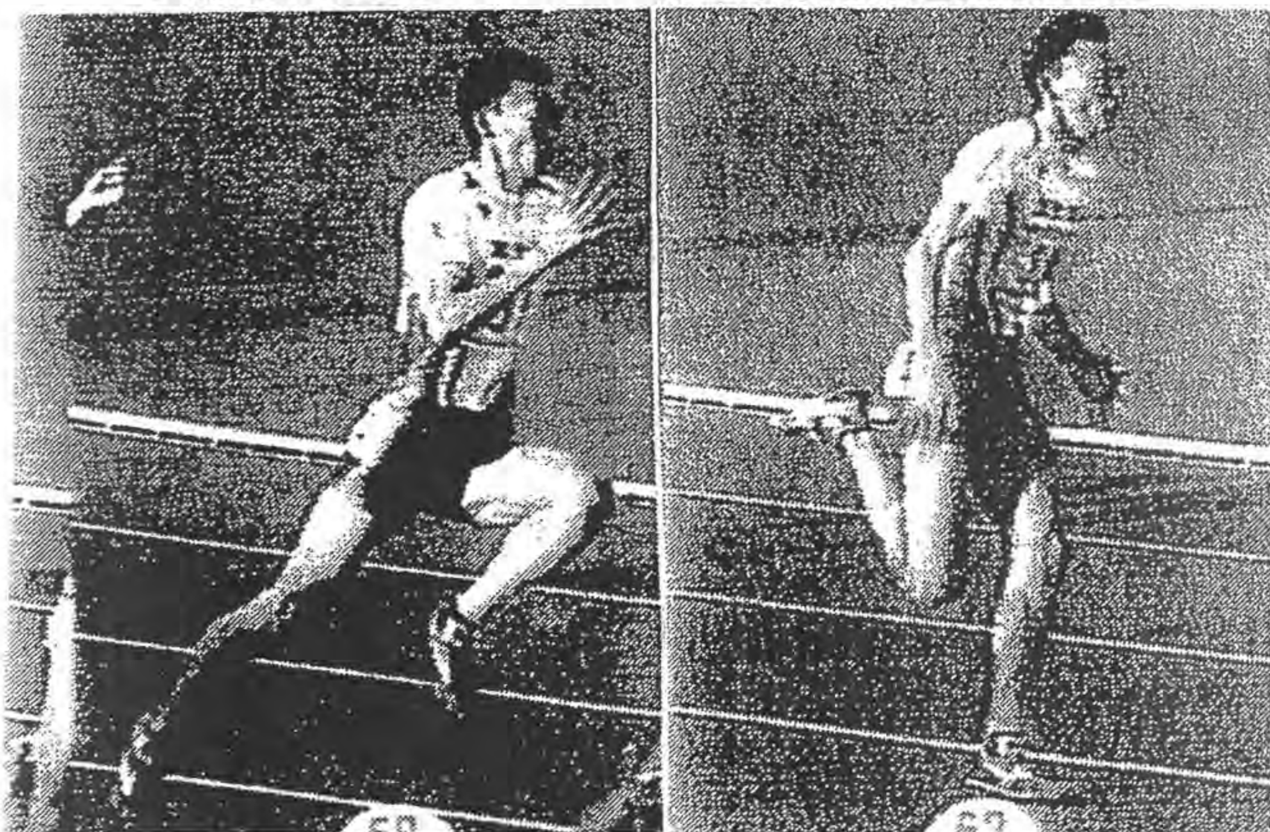
6. Good body position.

TAKE-OFF DISTANCE
Distance that the center of gravity travels between landing and point at which ground contact is broken
1. Good body position
2. Vertical and horizontal impulses
3. Angle of projection.
4. Big take-off distance.
5. Negative velocity of foot sets up body for take-off, but contributes little to take-off.

By: Tom Tellez

FINISHING KICK
800 M
SNELL
1500 - 3:37
800 - 1:44 3

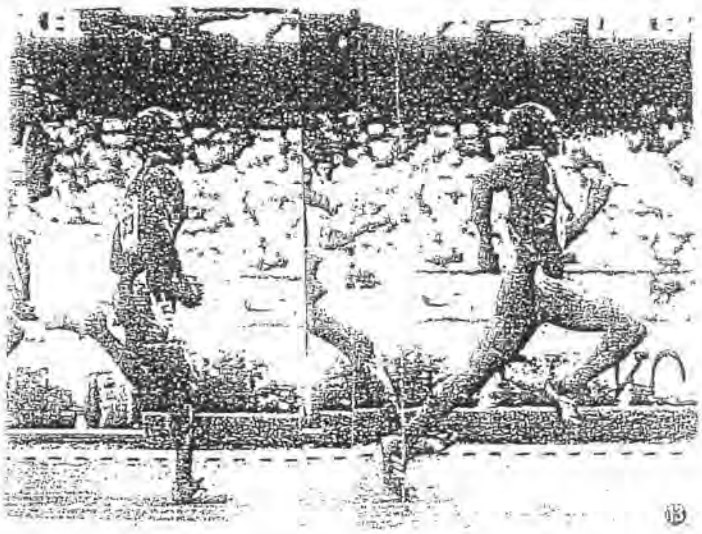


TAKAHIRA
200 M
20:22

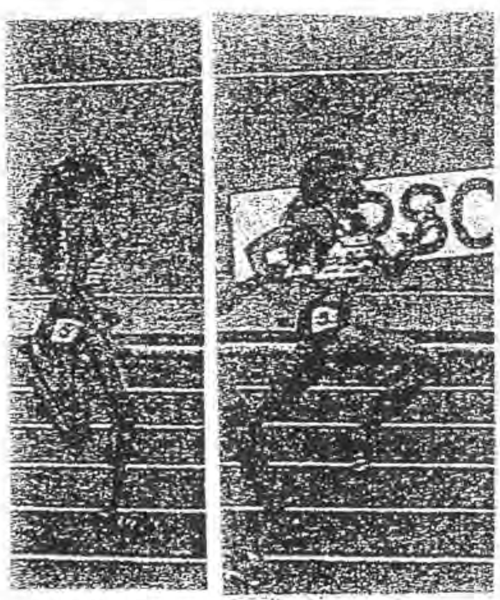
OLIVER
H H
13.4

DIVERS H H

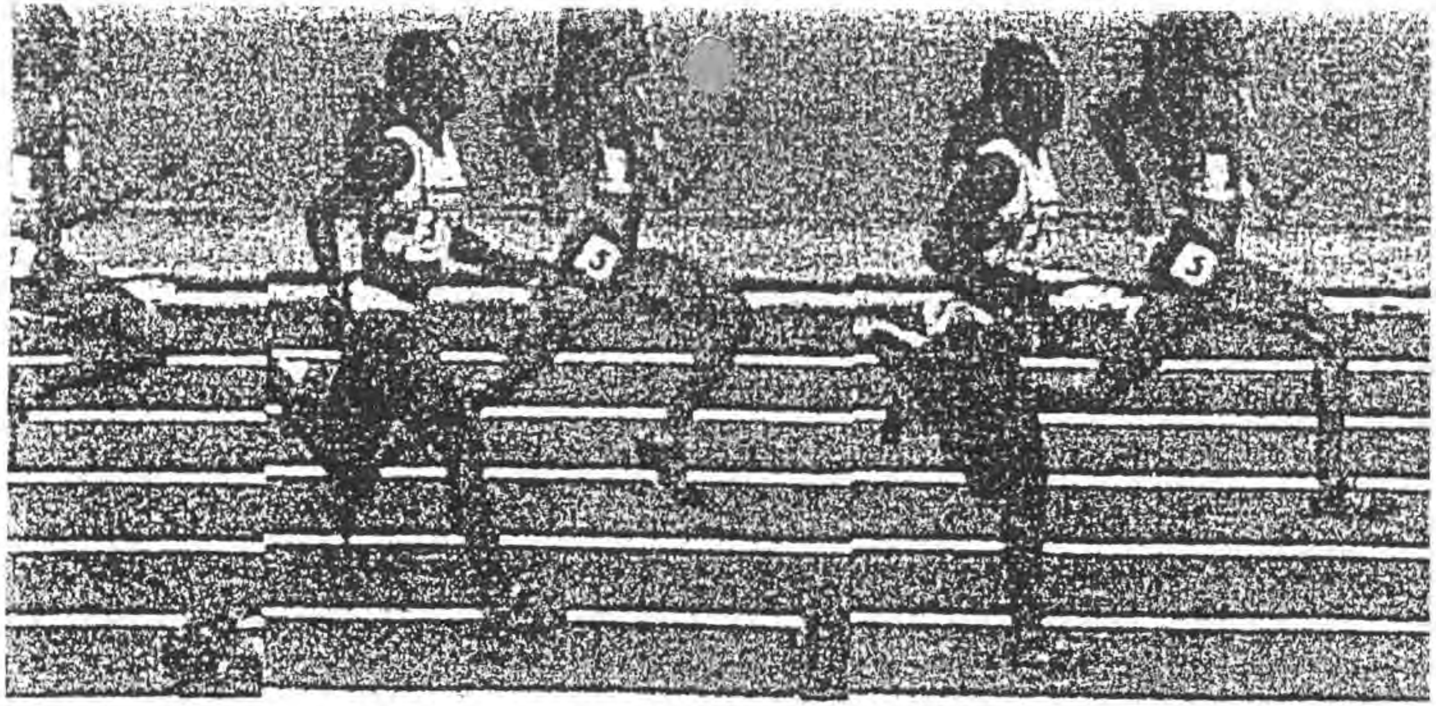
OLIVER H.H.



CRAWFORD - 200



FELIX 200



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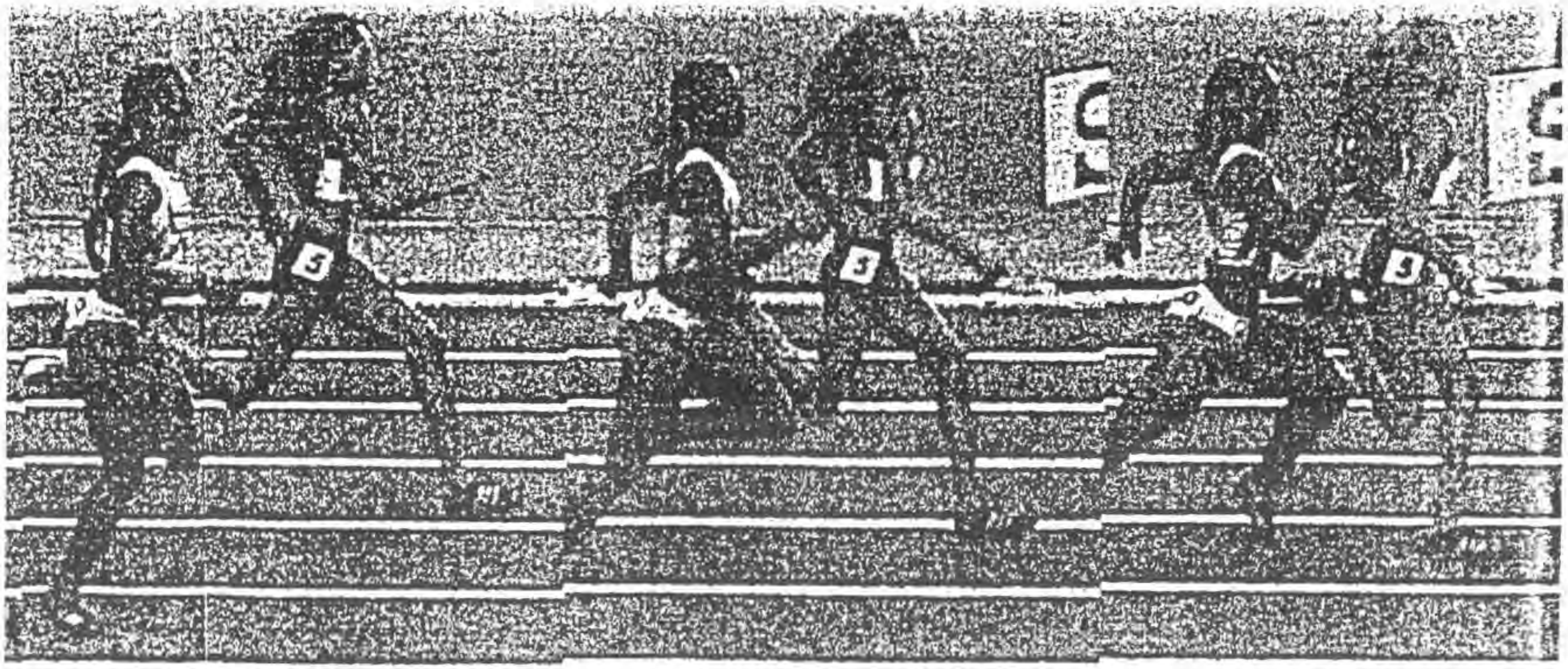

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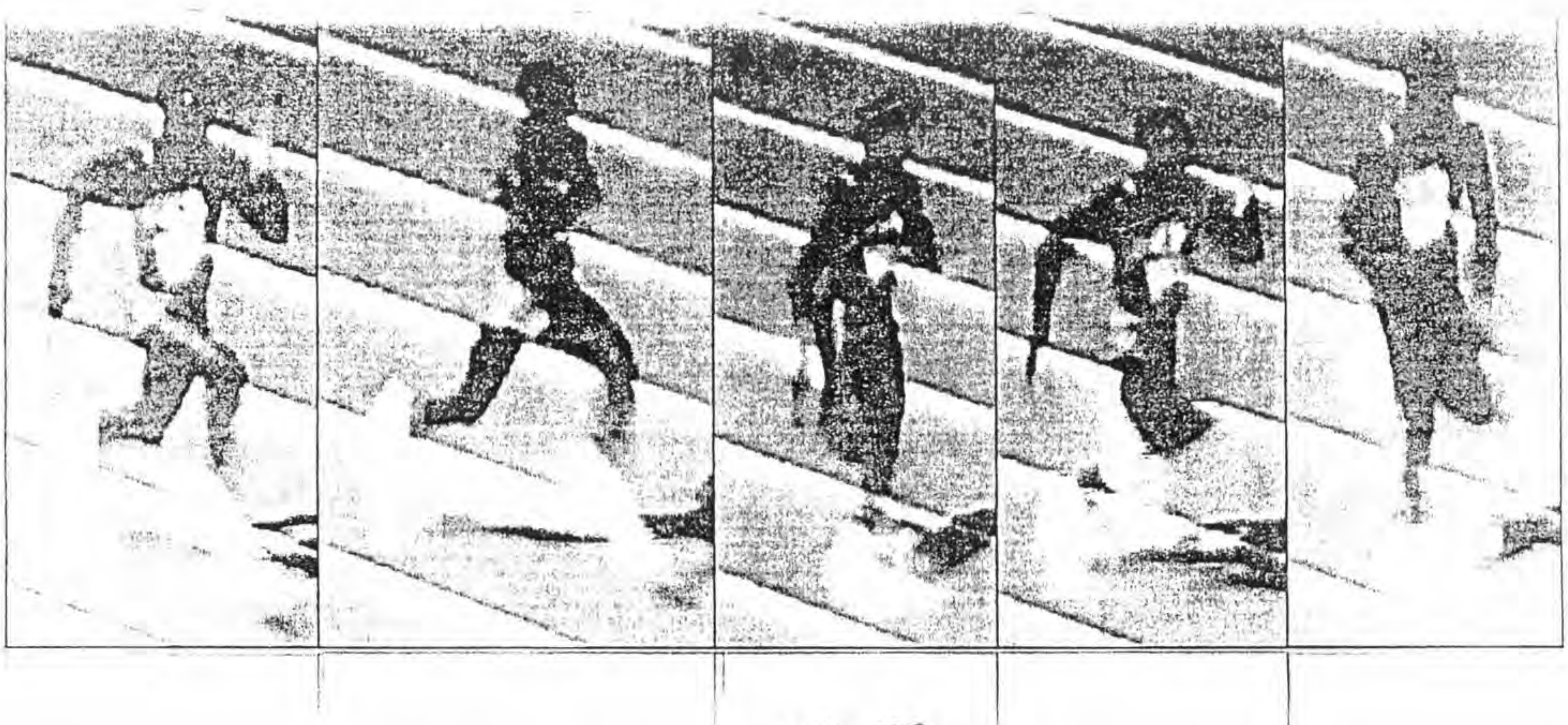
2. 4. 5.



LEWIS

STRIDE LENGTH

Distance the center of gravity travels between each foot contact.

Best increased by applying force down and backward, not reaching.

LANDING DISTANCE

Distance the center of gravity is from landing foot.

1. Distance should be short
2. Reduce braking forces which decelerate the body.
3. Pawing and clawing the ground with the leg is an illusion. This is a result of rapid hip extension.

FLIGHT DISTANCE

Distance the center of gravity travels in a non-support phase of a stride.

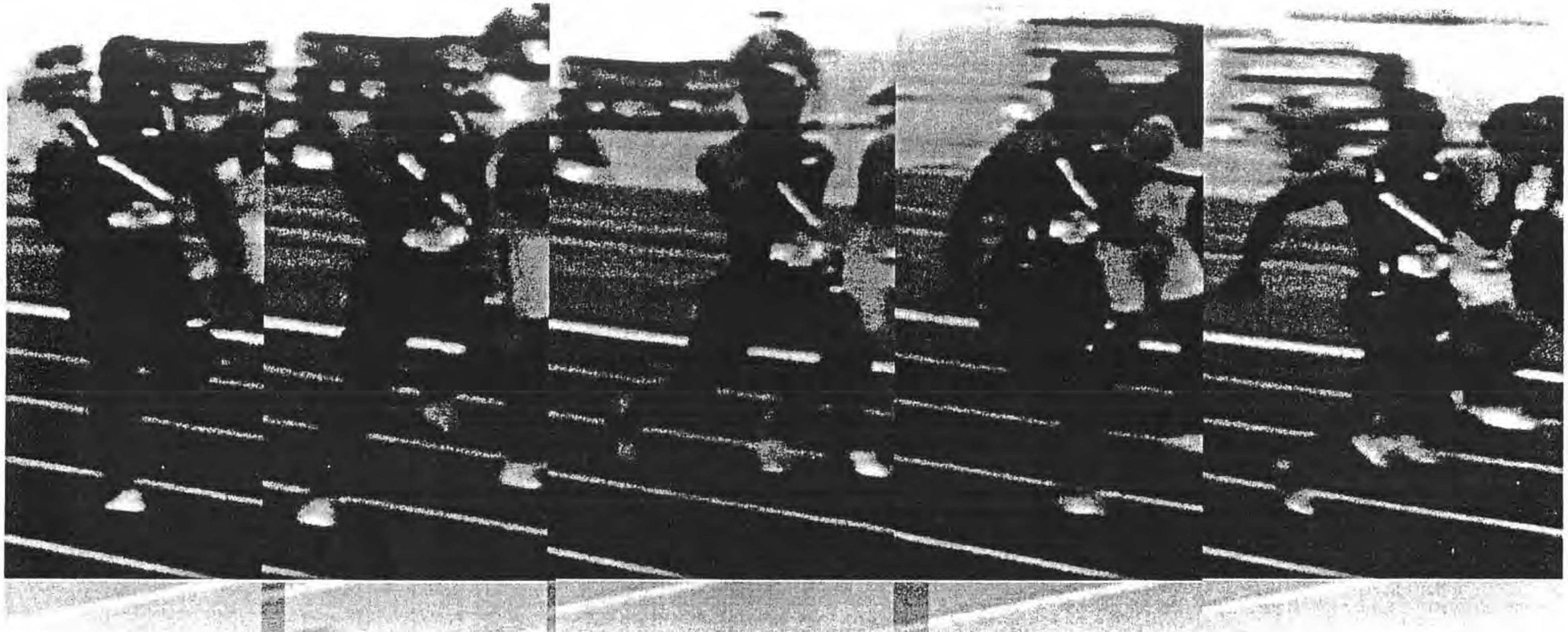
1. Velocity at take-off.
2. Height of center of gravity.
3. Air resistance.
4. Acceleration due to gravity.
5. Vertical and horizontal.
6. Good body position.

TAKE-OFF DISTANCE

Distance that the center of gravity travels between landing and point at which ground contact is broken.

1. Good body position.
2. Vertical and horizontal impulses.
3. Angle of projection.
4. Big take-off distance.
5. Negative velocity of foot sets up body for take-off, but contributes little to take-off.

1. 2. 3. 4.



GAY

STRIDE LENGTH

1. Distance the center of gravity travels between each foot contact.
2. Best increased by applying force down and backward, not reaching.

LANDING DISTANCE

Distance the center of gravity is from landing foot.

1. Distance should be short
2. Reduce braking forces which decelerate the body.
3. Pawing and clawing the ground with the leg is an illusion. This is a result of rapid hip extension.

FLIGHT DISTANCE

Distance the center of gravity travels in a non-support phase of a stride.

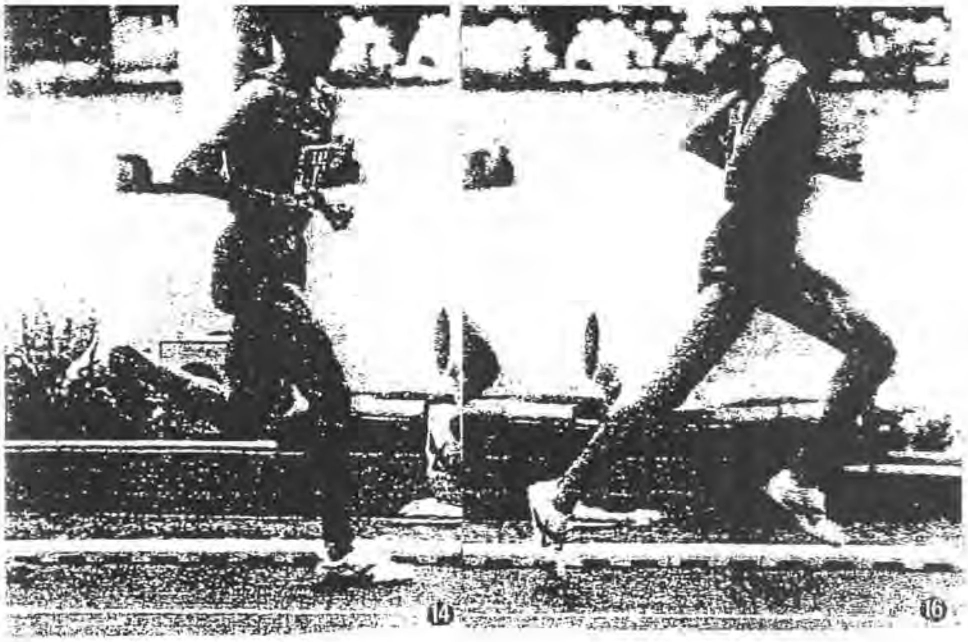
1. Velocity at take-off.
2. Height of center of gravity.
3. Air resistance.
4. Acceleration due to gravity.
5. Vertical and horizontal.
6. Good body position.

TAKE-OFF DISTANCE

Distance that the center of gravity travels between landing and point at which ground contact is broken

1. Good body position
2. Vertical and horizontal impulses.
3. Angle of projection.
4. Big take-off distance.
5. Negative velocity of foot sets up body for take-off, but contributes little to take-off.

By: Tom Tellez



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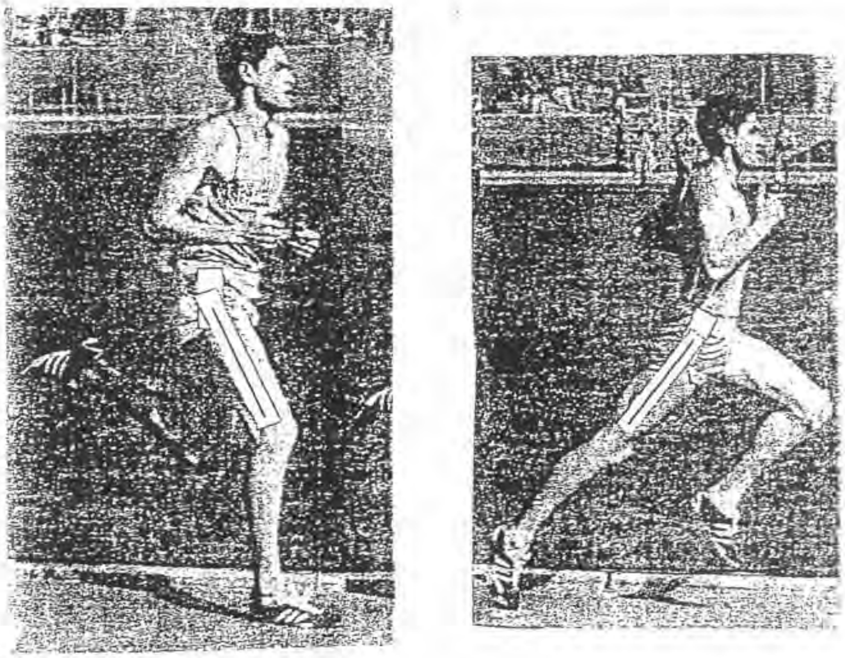
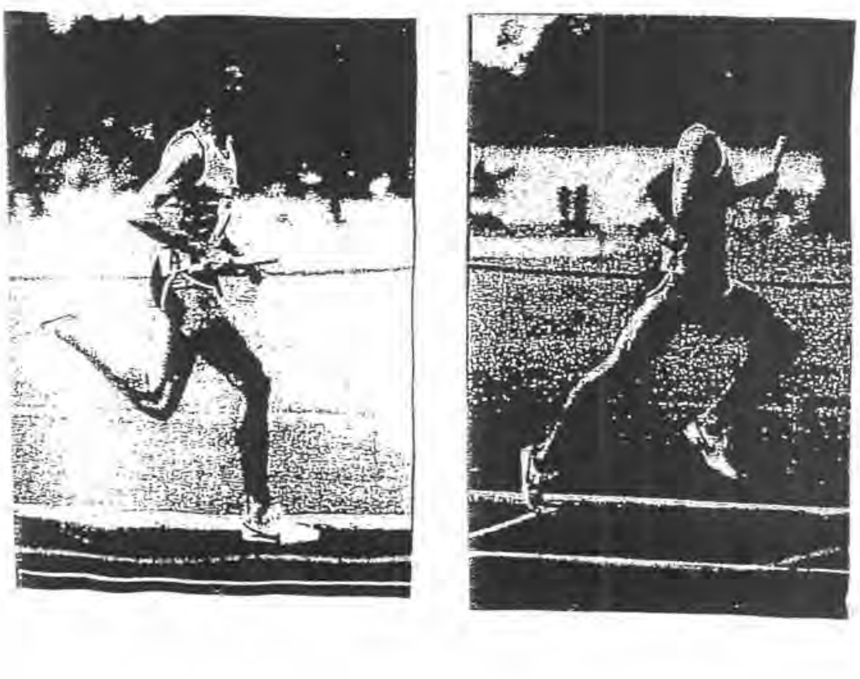
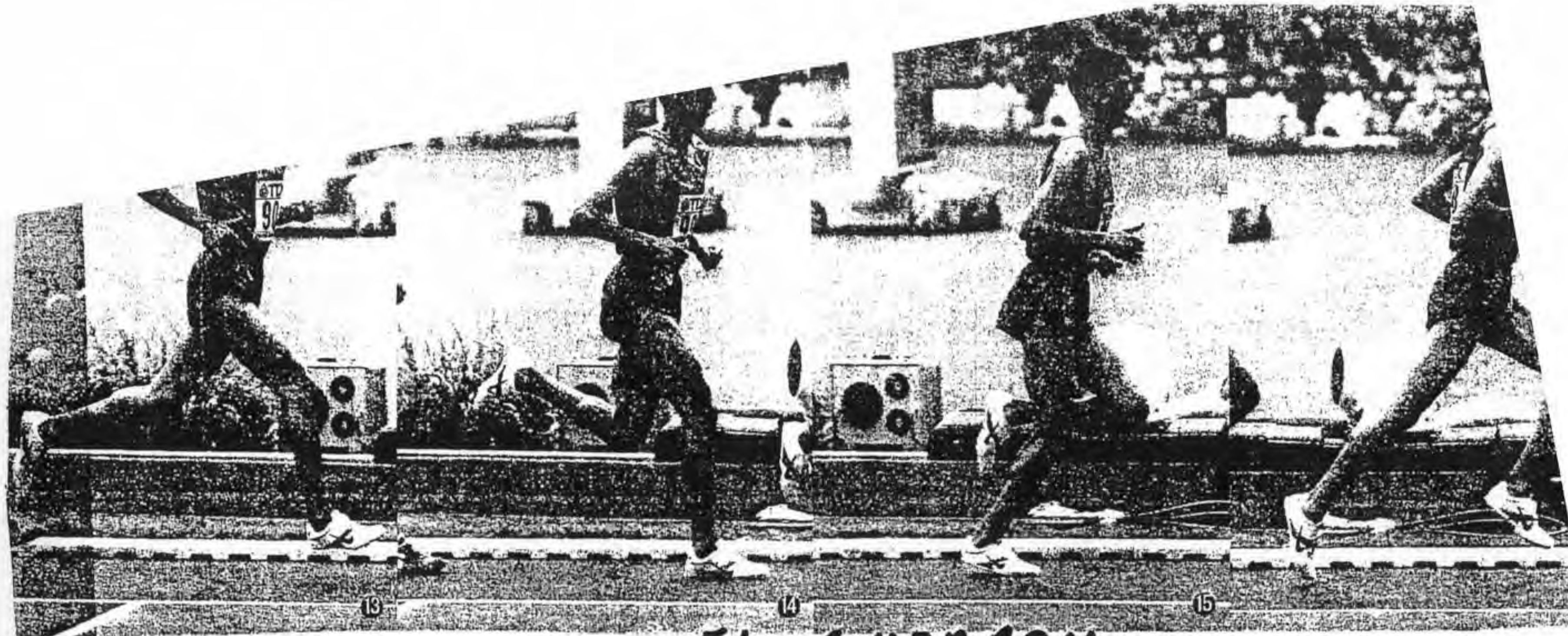
1500-3:26.0



RYAN
MILE-351.1



COE
800M-1:41.+



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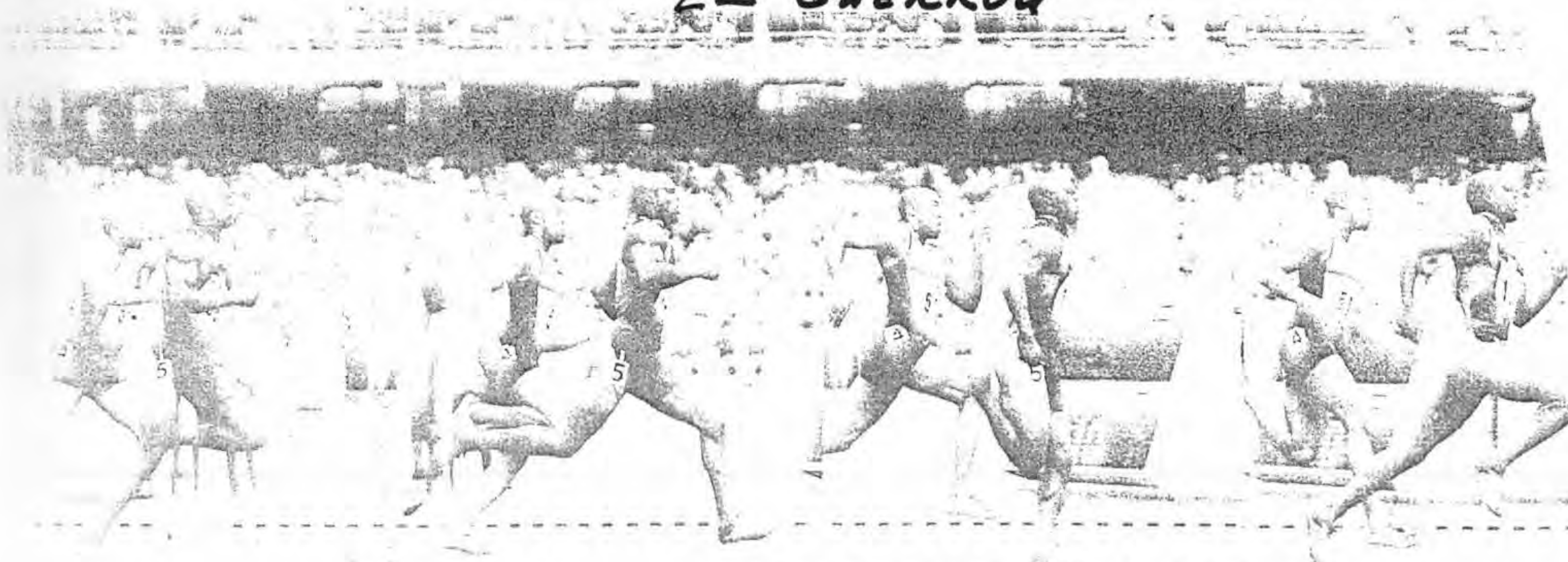
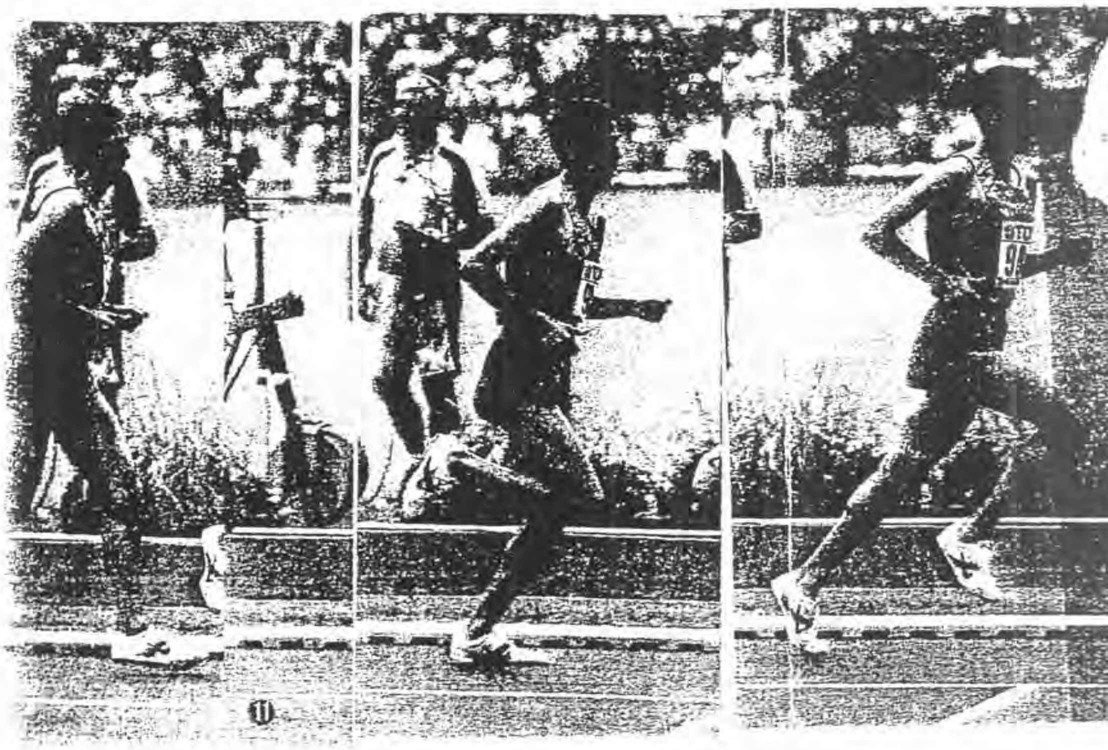


CRAWFORD - 200M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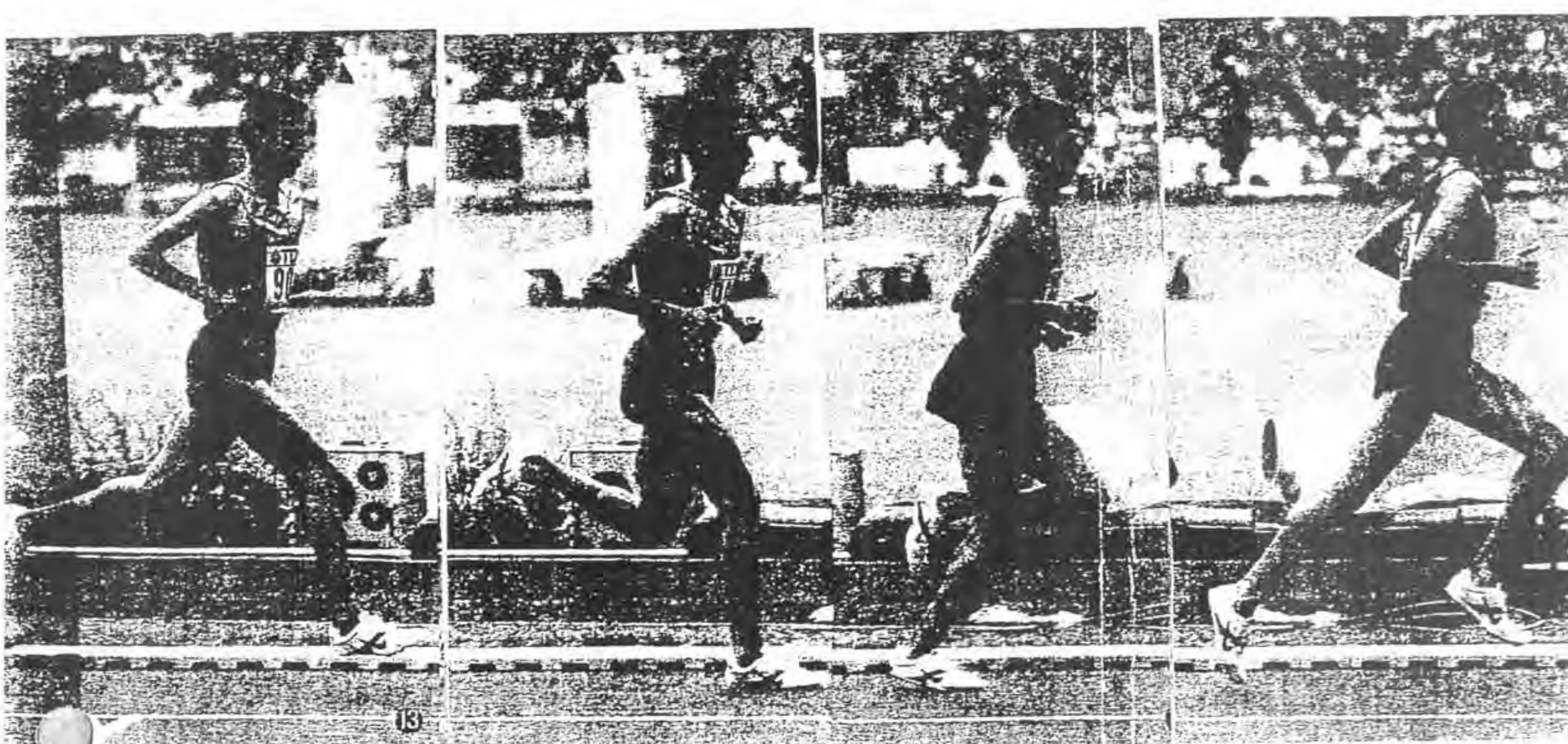
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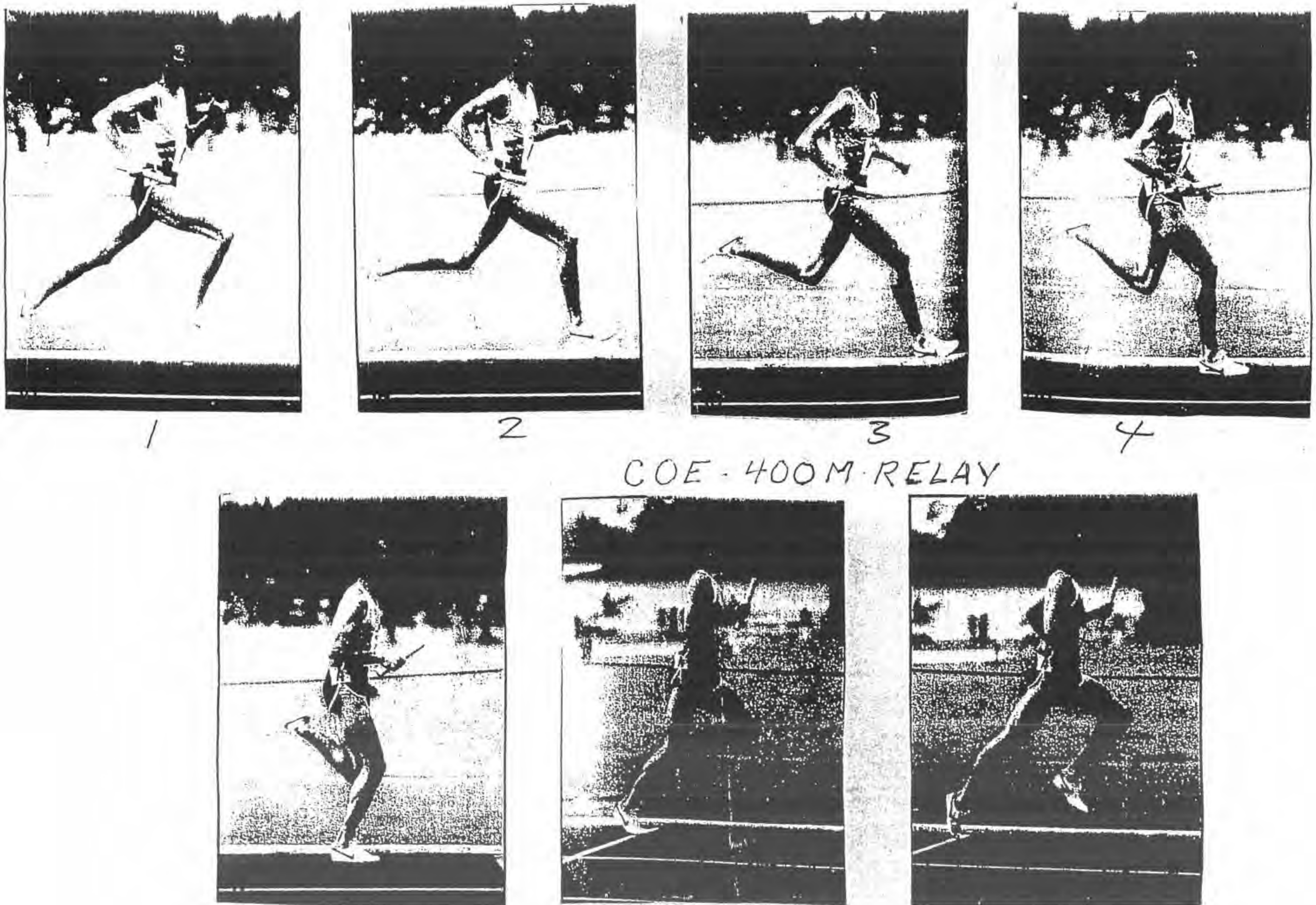

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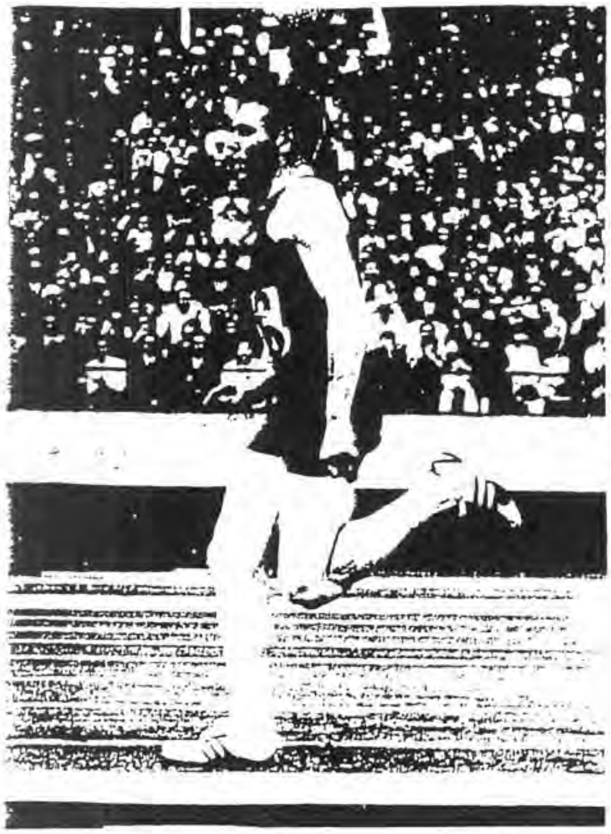
COE · 400M · RELAY

5 6 7



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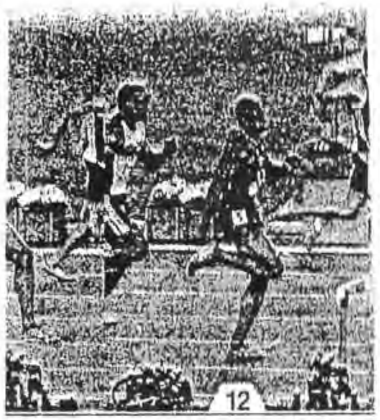
SNELL - FINISH 800 M

6 Led from the start: The women's marathon was dominated by Rosa Mota (POR). Silver went to Lisa Martin (AUS), and bronze to Katrin Dörre (GDR).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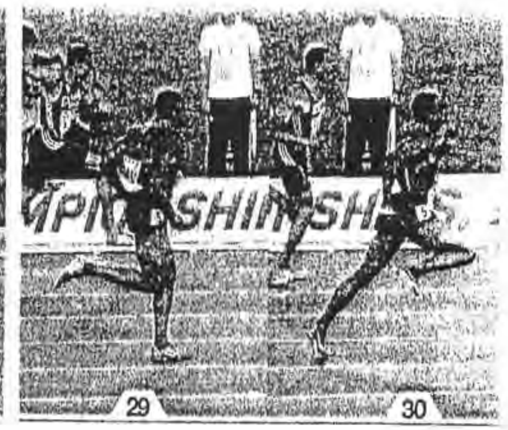
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VOCABULARY

Newton's First Law:

"An object continues in a state of rest, or in a state of motion at a constant velocity along a straight line, unless compelled to change that state by a net force.

Newton's Second Law:

Relating force, Mass and Acceleration, force equals mass times acceleration.

Newton's Third Law:

Whenever one body exerts a force on a second body the second body exerts an oppositely directed force of equal magnitude on the first body.

---

acceleration: The rate of change of *velocity*, expressed as a vector

angular acceleration: The rate of change of *angular velocity*

angular displacement: The angle between the initial and final angular positions

angular momentum: The product of an object's *moment of inertia* and its *angular velocity*

angular velocity: The rate of change of *angular displacement*

centripetal acceleration: The *acceleration* needed to keep an object in circular motion; centripetal acceleration is directed toward the center of the circle

centripetal force: The *force*; directed toward the center of the circle, that keeps an object going in circular motion

conservation of energy: The law of physics that says that the total energy of a closed system doesn't change

displacement: The change in an object's position in terms of distance and direction

energy: The ability of a system to do *work*

frequency: The number of cycles of a periodic occurrence per unit of time

friction: The force between two surfaces that always acts to oppose any relative movement between them

impulse: the product of the amount of force on an object and the time during which the force is applied

inertia: The tendency of masses to resist changes in their motion

kilogram: The *MKS* unit of *mass*

kinematics: The branch of *mechanics* concerned with motion without reference to *force* or *mass*

kinetic energy: The *energy* of an object due to its motion

kinetic friction: *Friction* that resists the motion of an object that's already moving

law of conservation of momentum: A law stating that the *momentum* of a system doesn't change unless influenced by an external force

linear momentum: The product of an object's *mass* times its *velocity*; momentum is a *vector*

magnitude: The size, amount, or length associated with a *vector* (vectors are made up of a direction and a magnitude)

mass: The quantitative measure of the property that makes matter resist being accelerated

mechanics: The area of physics that deals with the motions of bodies and the forces imposed upon them

MKS system: The measurement system that uses meters, kilograms, and seconds

moment of inertia: The property of matter that makes it resist rotational acceleration

oscillate: Move or swing side to side regularly

period: The time it takes for one complete cycle of a repeating event

potential energy: The *energy* an object has because of its internal configuration or its position when a *force* is acting on it

power: The rate at which work is done by a system

scalar: A quantity that has magnitude but not direction (in contrast to a *vector*, which has both)

specific gravity: The *density* of a substance relative to a reference substance

static friction: *Friction* on a stationary object

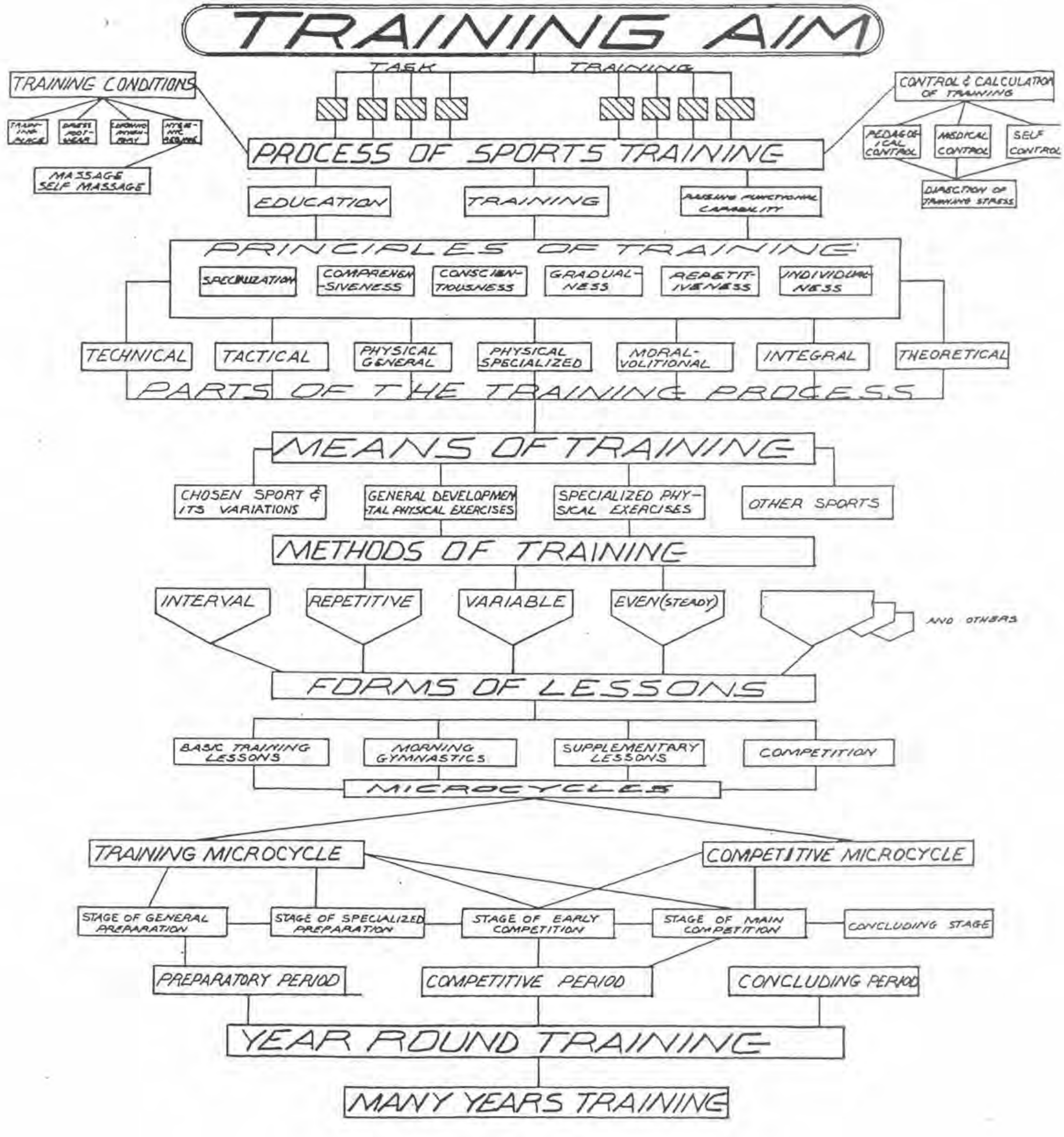
torque: The product of a *force* around a turning point and the force's perpendicular distance to that turning point

vector: A mathematical construct that has both a *magnitude* and a direction

velocity: The time rate of change of an object's position, expressed as a *vector* whose *magnitude* is speed

weight: The *force* exerted on a *mass* by a gravitational field

work: *Force* multiplied by the *displacement* over which that force acts and the cosine of the angle between them; force is equal to the amount of *energy* transferred by a force



TRAINING AIM
TASK
TRAINING
TRAINING CONDITIONS
MASSAGE
SELF MASSAGE
CONTROL & CALCULATION OF TRAINING
PEDAGOGICAL CONTROL
MEDICAL CONTROL
SELF CONTROL
DIRECTION OF TRAINING STRESS
PROCESS OF SPORTS TRAINING
EDUCATION
TRAINING
RAISING FUNCTIONAL CAPABILITY
PRINCIPLES OF TRAINING
SPECIALIZATION
COMPREHENSIVENESS
CONSCIENTIOUSNESS
GRADUALNESS
REPETITIVENESS
INDIVIDUALNESS
TECHNICAL
TACTICAL
PHYSICAL GENERAL
PHYSICAL SPECIALIZED
MORAL-VOLITIONAL
INTEGRAL
THEORETICAL
PARTS OF THE TRAINING PROCESS
MEANS OF TRAINING
CHOSEN SPORT & ITS VARIATIONS
GENERAL DEVELOPMENTAL PHYSICAL EXERCISES
SPECIALIZED PHYSICAL EXERCISES
OTHER SPORTS
METHODS OF TRAINING
INTERVAL
REPETITIVE
VARIABLE
EVEN (STEADY)
AND OTHERS
FORMS OF LESSONS
BASIC TRAINING LESSONS
MORNING GYMNASTICS
SUPPLEMENTARY LESSONS
COMPETITION
MICROCYCLES
TRAINING MICROCYCLE
COMPETITIVE MICROCYCLE
STAGE OF GENERAL PREPARATION
STAGE OF SPECIALIZED PREPARATION
STAGE OF EARLY COMPETITION
STAGE OF MAIN COMPETITION
CONCLUDING STAGE
PREPARATORY PERIOD
COMPETITIVE PERIOD
CONCLUDING PERIOD
YEAR ROUND TRAINING
MANY YEARS TRAINING

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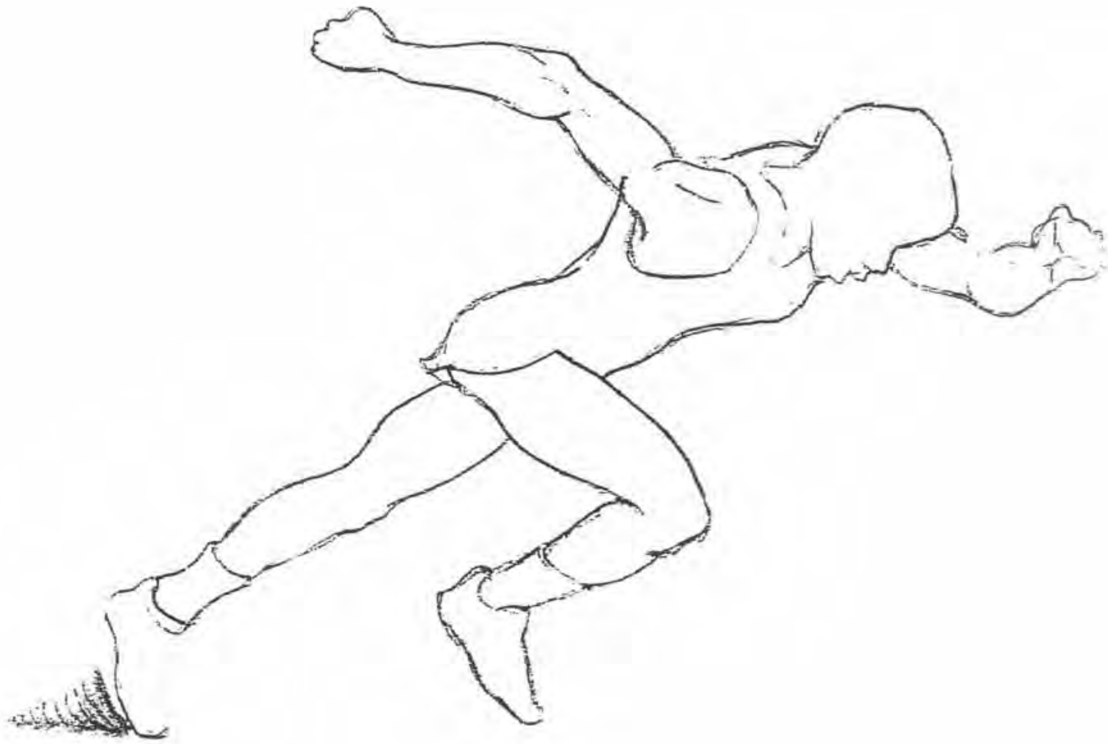
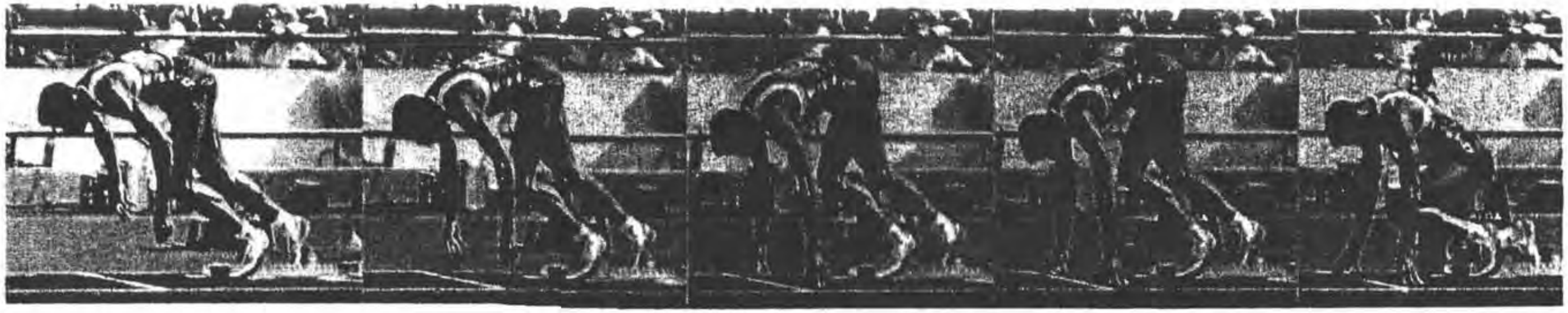


TOM TELLEZ
CARL LEWIS
(START)



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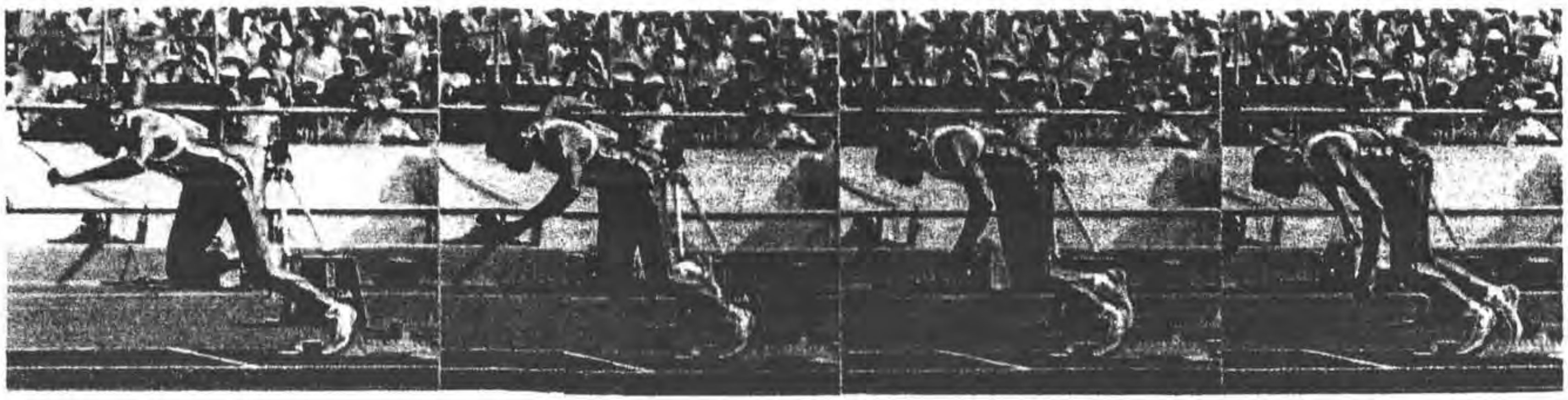

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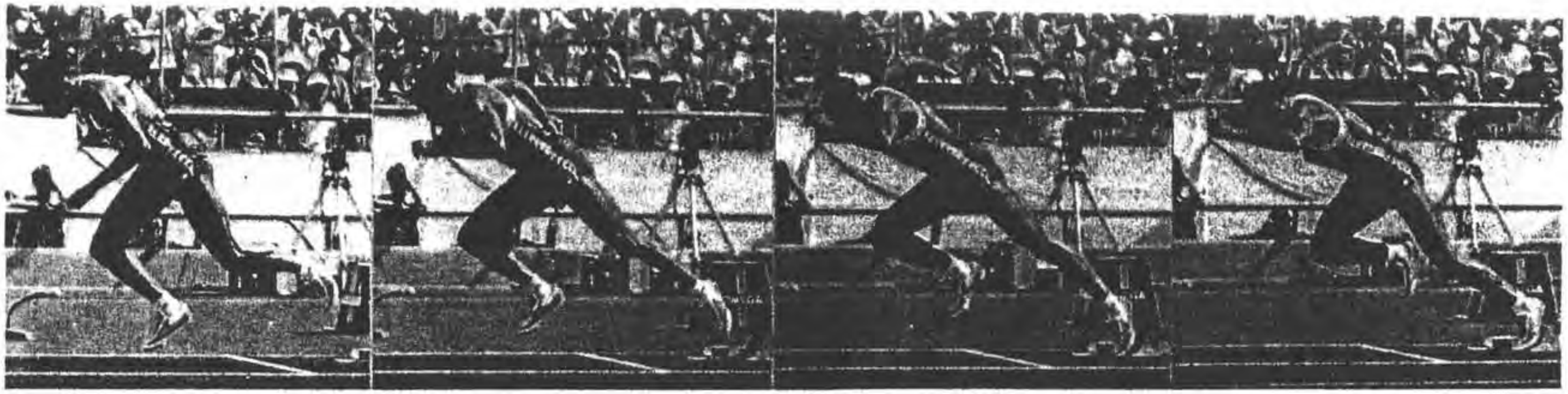

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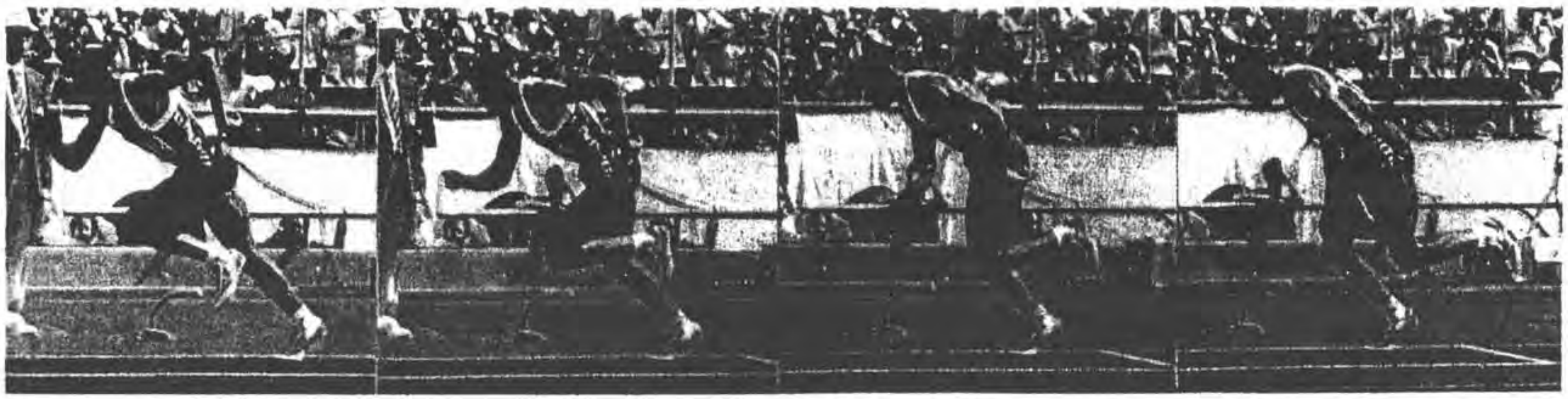

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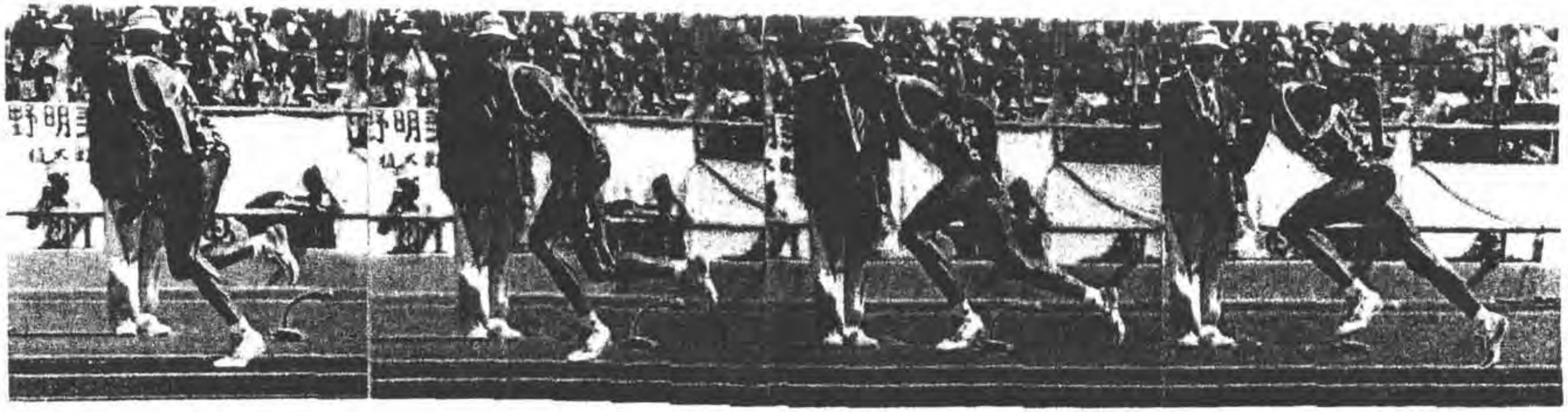

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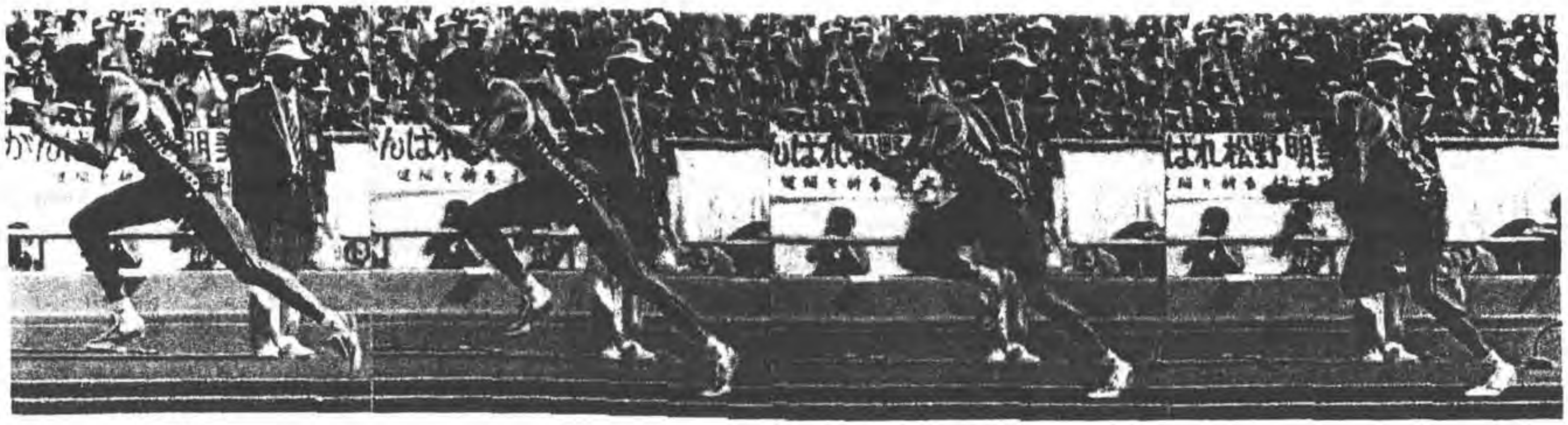

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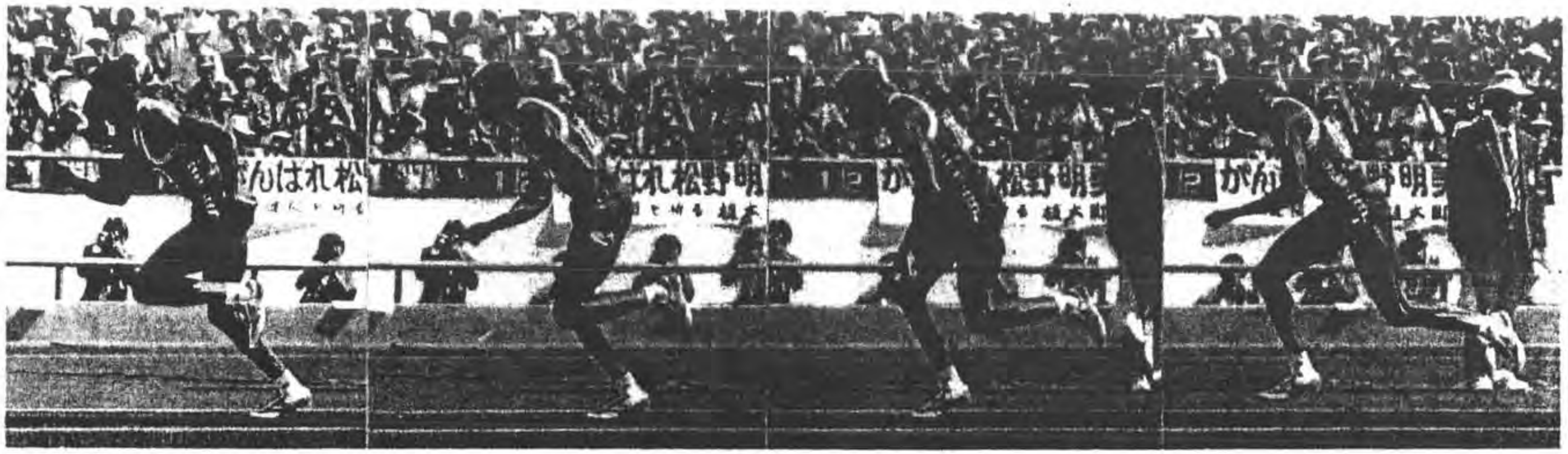

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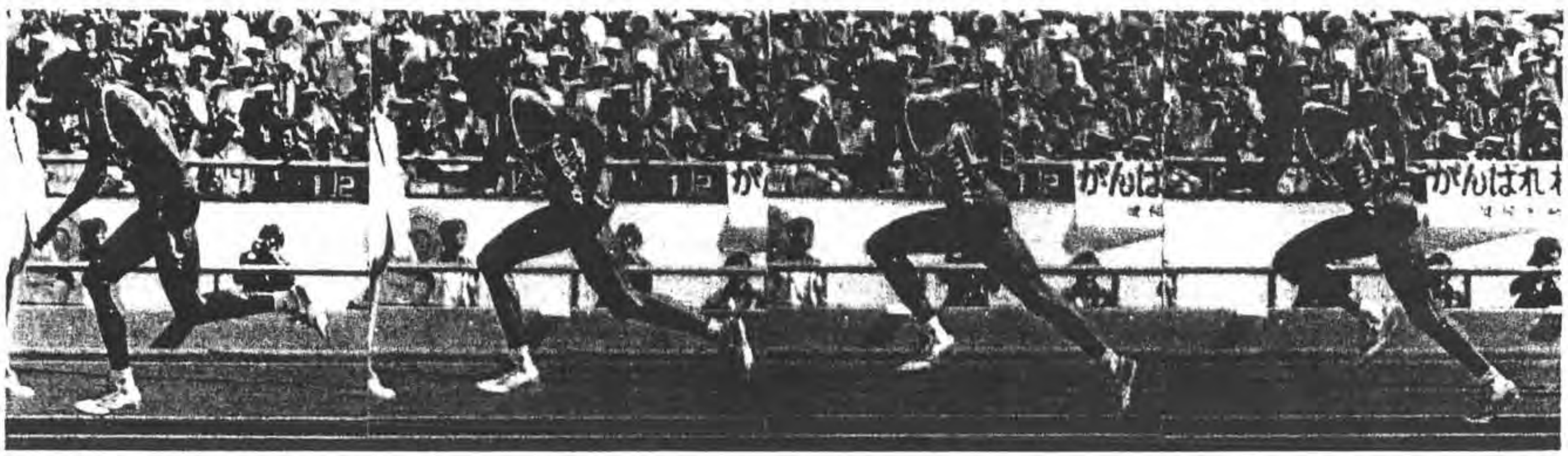

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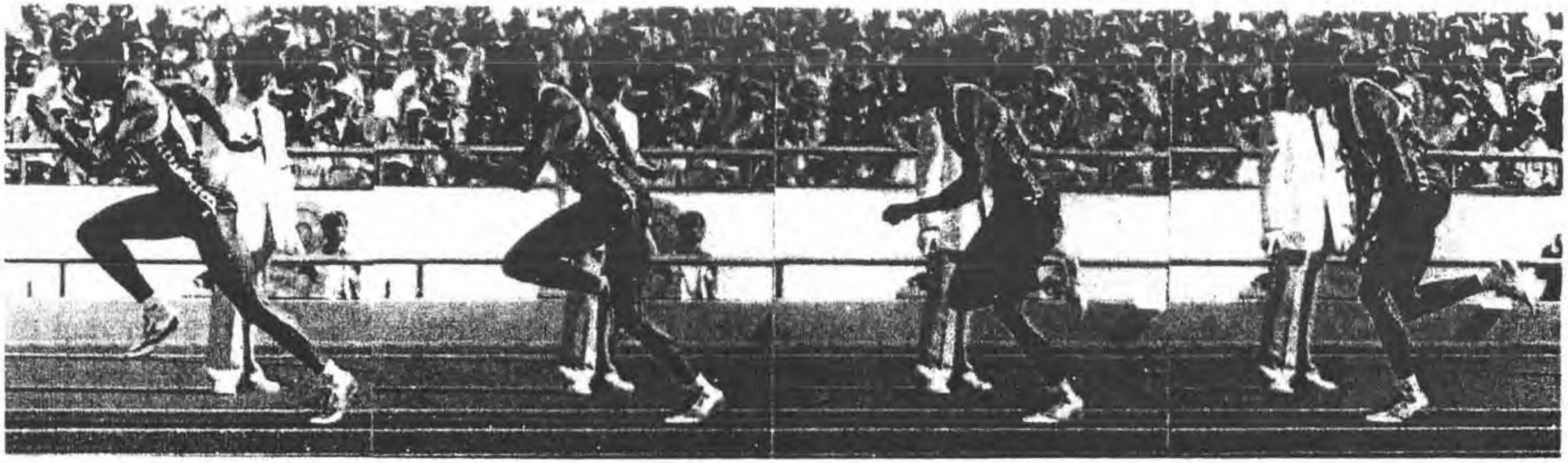

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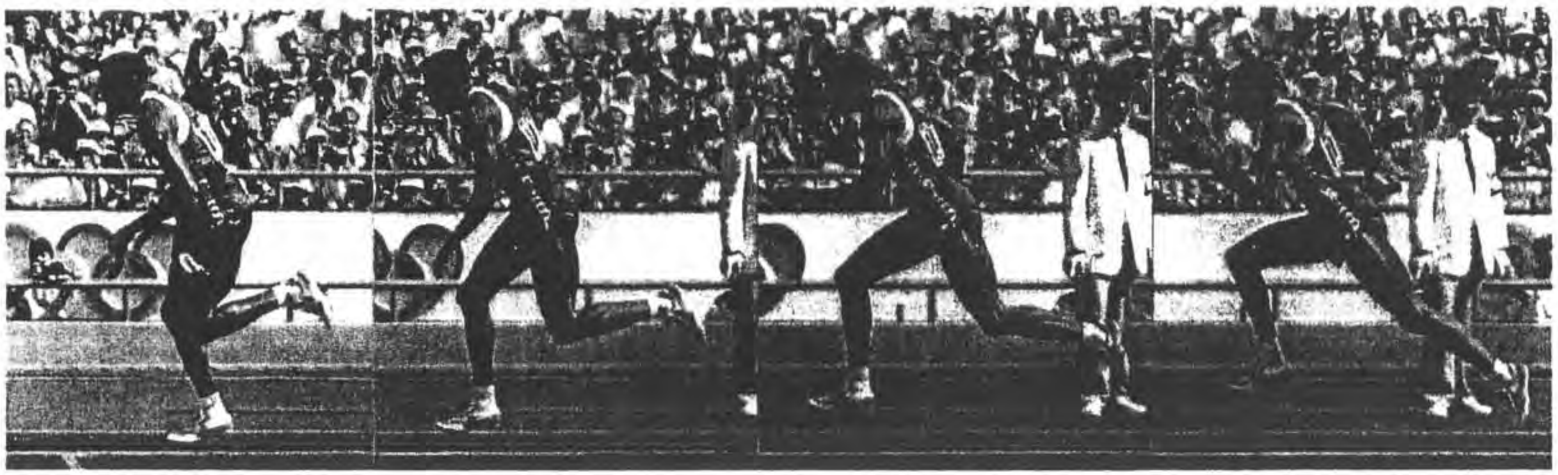

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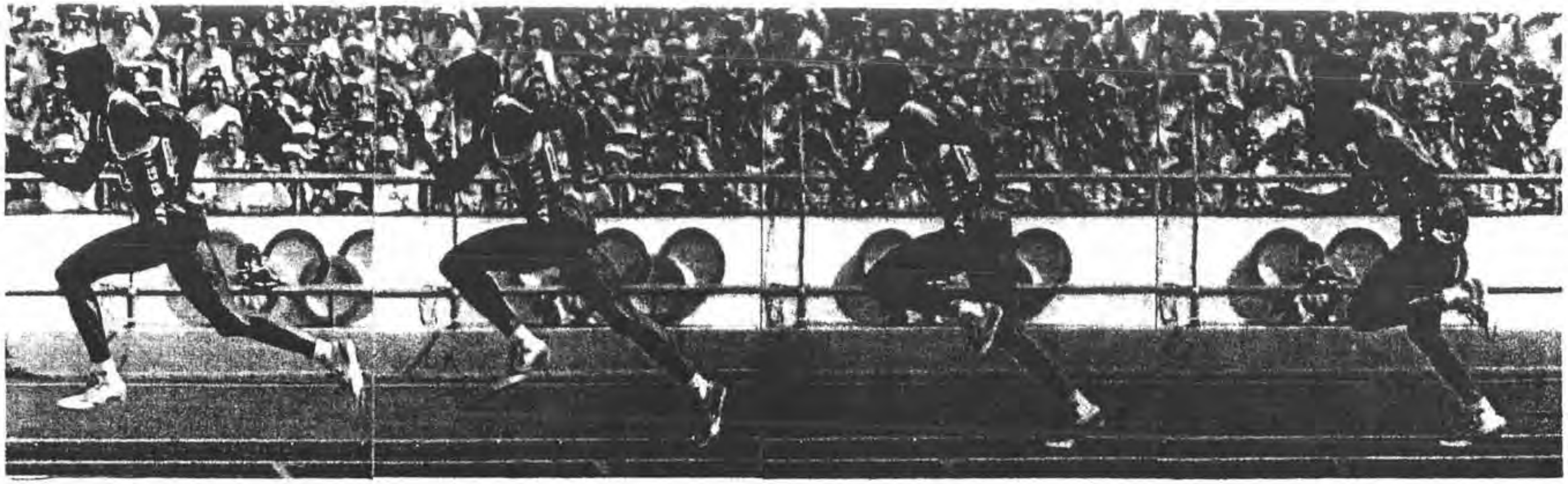

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