The Use of BIOMECHANICS IN THE JUDGING OF RACE WALKING

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Presented at the
International Race Walk Forum
Shenzhen, China---March 23rd, 2007
(Re-edited April 13, 2007)

A. INTRODUCTION.

Race walk judges should base their calls on their knowledge of the biomechanics of race walking, not on how they interpret a definition. The definition of race walking is not clearly written, and should be rewritten or replaced.

1. The Race Walk Definition. Race walk judging requires the observation of walkers competing at fast speeds for adherence to a definition of race walking most recently codified in 1995 as Rule 230.1 of the International Association of Athletics Federations (the IAAF).

"***Race Walking is a progression of steps so taken that the walker makes contact with the ground so that no visible (to the human eye) loss of contact occurs. The advancing leg shall be straightened (i.e., not bent at the knee) from the moment of first contact with the ground until the leg is in the vertical upright position.***

Race walk judges are expected to base their calls solely on this definition, as written. However, because the definition does not use standard biomechanical terms the judge must interpret the definition for its meaning. Ambiguous language within the definition results in misinterpretation. When translated from English, the non-standardized words have been altered so that the definition loses meaning. It is my feeling that interpretation has resulted in the disqualification of many race walkers who were technically correct and the missed disqualification of many who were not. The definition should be re-written.

Good coaches are trained in biomechanics. Race Walk judges should be as well; however, most are not. Many have never coached race walkers, and only see the event at competitions. They should know the event better. They should be students of its technique.

Without an understanding of race walk mechanics judges as a group lack the knowledge upon which they can consistently interpret the definition. This lack of consistency manifests itself in the officiating of race walks at all levels. Performance evaluations of judges, based on summary sheets of the calls made at these competitions give false pretense to their validity. The lack of consistency among judges has been an ongoing problem within the discipline as well as within the IAAF community at large.

The most recent IAAF judges' video exam given in Paris was created to measure the ability of the best judges in the world to interpret the definition of race walking. It did not. Ten percent of the test questions were mistakenly answered by 43 of 45 of the best judges in the world. Is that really what happened? Or, did 95% of the best judges in the world get it right, and the test was wrong? Many, including this author were forced to guess at answers. Judges should not guess! They should know!

I have heard arguments from judges that walking biomechanics should not be considered in the application of the definition. They say that the judge should only look for visible loss of contact and for straightened legs without asking or knowing why.

Judges tolerate excessive loss of contact because they can not see it until it is very obvious. Perhaps they can not "see" loss of contact until it is very obvious, because they do not know what causes it. Because they do not know what causes loss of contact, they do not know when it occurs. If they knew, calls would be made when the athletes have "visibly" lost contact, not when they think they

have. Can you give biomechanical reasons why the two walkers in the center of Figure 1 have contact faults?

Fig. 1. Walkers losing contact , why?

Fig. 2. Is this knee straightened? It is knobby.

"Bent Knees" are easy to call if the judge knows the biomechanics of how the leg straightens at the knee, yet there are many strange calls made for bent knees; even more than before 1995 when the definition was re-written.

Many judges say they look for "straight" legs. They should not! Many judges do not know why?. Too often, judges struggle with the physical structure of legs, i.e. if they are bowed, or if knees are knobby, and they give cautions or red cards because they do not see "straight" legs. Most judges do not know the difference between "straight" and "straightened" as it applies to human legs! They agree that legs do not resemble sticks, yet that is what they say they are looking for when they use the word "straight. When I say that legs can never be straight, only straightened, many do not know the difference. The difference is very important. Judges may let bent-legged walkers who have not straightened pass by because they think their legs are straight, when in fact they have not straightened. Has the walker in Figure 2 straightened his leg? He has, and it is easy to see why.

Because of how the definition is written many judges may only guess about a competitor's legality---just as they might about the legality of the walkers in figures 1 and 2. That is wrong. (If they knew the mechanics of race walking they might not.) If the definition was written using standard biomechanical terms and if judges received training in biomechanics, everyone within the discipline could look at walkers the same way, with the same "set of eyes." Someday, perhaps!

2. This Paper's Goals. This paper discusses the biomechanical parameters critical to the officiating of race walking. In doing so, the biomechanics of legal race walking are presented for the use of walkers, coaches and judges alike. At a minimum, it is hoped, that by presenting "the Use of Biomechanics in the Judging of Race Walking," judges will be better able to apply the current definition and there will be increased consistency within judging panels, thus assuring fair competition for all.

It is hoped that coaches and athletes will find this paper useful from their perspectives. Perhaps they may gain from

knowing what judges should look for, and they will prepare accordingly.

It is also hoped that this paper will initiate discussion at the international level that will change the definition to one that makes use of standard biomechanical terms. Towards this goal, this paper will suggest a new definition.

Perhaps, in my wildest dream, the definition will be scrapped in favor or a set of rules for race walking that do not rely on a definition. To that end I have included such a proposal.

B. INTERPRETATION OF THE RACE WALK DEFINITION--Dynamics and Confusion.

1. A Dynamic Definition. From the outset, it is important to state that the definition of race walking describes dynamic activity. The definition uses words descriptive of action and motion occurring over time; i.e. “a "progression of steps," "the advancing leg," "straightened at the knee," “from the moment of…until in the vertical upright position;" these are words that describe body parts in motion. They describe movement, not static images. That is important, and should be kept in the definition if we are to use one. However, the definition is confusing.

2. Ambiguities in the Definition Creates Confusion. Many words in the definition are ambiguous and cause confusion. First, just what does “no visible (by the human eye) loss of contact” mean? (Spanish speaking judges parenthetically use the expression “simple view,” meaning without visual aids.) Judges must be told it is ok to wear glasses, but that pictures, even high speed video cameras may not be used.

How do judges look for loss of contact? Basically they do what they say they do not. They have to look for continuous contact before they can judge its loss. In reality, they are not looking for loss of contact.

Judges are supposed to know that the “advancing leg” is not really the “advancing leg.” Think about this--at the point from which the judge is supposed to judge straightening of the leg--from contact, the leg which was advancing has stopped advancing--the leg in the back takes on that function. Are you confused?

The parenthetic inclusion “(not bent at the knee.)” uses the word “bent” which means “not straight.” So, no wonder judges think the word “straightened” means “straight!” At least the inclusion spells out which part of the leg should not be bent, without it, the whole leg, which includes the foot would have to be straightened! Picture athletes walking on the tips of their toes! A closer look at the second clause of the definition adds more insight to the ambiguity.

3. Straight or Straightened? The phrase "the advancing leg shall be straightened", should require that judges have knowledge of how legs straighten at the knee, how the joint works, and how muscles of the thigh work to move the bones that comprise the knee joint.

When the word “straight” is incorrectly substituted for “straightened” (as it is in the Spanish translation of the definition where “estar rectar” is used), the judge no longer needs to know how the leg straightens, only that the leg is “straight,” or that it is not; that it is “bent,” or not bent.” Race walk judges must not use the word "straight" when explaining their “bent knee” calls. “Bent” should be removed as well, because it’s opposite is straight!

When the word straight is used there is no implication of motion; of a process over time. Asking “when should it be straight?” is a lot different from, asking “when it should be straightened.” While the words “from the moment of first contact until…” seem clear enough, many judges seem to think that the word “at” can be substituted for “from.” They should not! The use of from implies a time period over which the leg must be straightened. The definition says the advancing leg shall be straightened "from the moment of first contact." It does not say “straightened at” and it also does not say “fully straightened.” It

also does not say, "straightened before," The point here is that the straightening of the leg is a biomechanical process which takes time. The leg can not be straightened in an instant.

Does this mean it is acceptable to land with the leg straightening but not yet fully straightened? A further understanding of how the leg is straightened by race walkers will allow the judge to think so. Why?

Most bowlegged and knobby-kneed walkers are fully capable of straightening their legs, as you can see in Figure 3, but their knees never look straight. In the vertical "upright" position, extremely tight individuals may never be able to straighten but because of their muscularity their legs may look straight. Judges must know why.

Fig. 3. World Champion Robert Korsenwski straightened his "Bent" leg very well.

You can see that the cause of much of this confusion comes about because the definition employs words that are not standard biomechanical terms. To interpret this definition without confusion, the judge must know what causes loss of contact and they must know how the knee functions. To do so, they must be able to describe what they see in standardized biomechanical terms.

C. A GLOSSARY OF BIOMECHANICAL TERMS FOR RACE WALKING

The following biomechanical terms will be used to describe race walking biomechanics in this paper.

1. **Toe Off**-When the rear foot loses contact.
2. **Heel Strike**-When the foot makes contact on the heel.
3. **Step**-From toe off to heel strike of the same foot.
4. **Stride**-Two steps
5. **Gait Cycle**- the interval of time from heel strike of one foot to heel strike by the same foot. It has two phases, **stance** and **swing**.
6. **Stance Phase**-When body weight is supported by the legs, divided into three parts, from **contact** (heel strike to **flatfoot)**, to **mid-stance (**flatfoot to **heel lift),** and to **propulsion** (heel lift to **toe-off**).
7. **Single Support**-When one leg is supporting the body's weight; when one foot is in contact with the ground.
8. **Double Support**-When two legs are supporting the body; when two feet are in contact with the ground. (A principal difference between running and walking.)
9. **Heel Lift**-When the heel of the rear foot is pulled off the ground, at the end of stance
10. **Swing Phase**-When the leg is moving forward during a step.
11. **Flight Phase**-When neither foot is in contact with the ground.
12. **Extension**-The opening up of a joint; where two or more bones comprising a joint move away from each other; Full Extension is 180° (**Extended**)
13. **Hyperextension**-Extension greater than 180°

14. **Flexion**-The closing of a joint; where two or more bones comprising a joint move closer to each other (**Flexed**)
15. **Center of Mass/Gravity (COM)**-A point above the navel representing the summation of all body points.
16. **Vertical Position**-When the leg is directly under the **center of mass.**
17. **Momentum**-From Newton's Law, that a body put in motion stays in motion until acted upon by an outside force.
18. **Rotation**-Movement about an axis.

D. HOW MUSCLES WORK AND HOW THE BODY MOVES FORWARD.

1. Three Types of Muscle Contraction. One of the primary functions of skeletal muscle is to do the work of flexing or contracting limbs and bones at joints such as the hips, knees ankles and toes. Neurological impulses innervate, or turn the muscles on to do work. When muscles are not innervated neurologically, they do no work. Muscles either turn on neurologically or are left off. They may not be on and off at the same time. When they work there is tension and when they are off they are relaxed. EMG (electromyographic) studies record when muscles are innervated. Muscle contractions occur in three ways: **Statically, concentrically,** and **eccentrically.**

During static contraction, muscle fiber length is unchanged and therefore the joint does not flex or extend. Therefore, we need not concern ourselves with it in this discussion. Suffice it to say that static contractions help stabilize joints once they have been flexed or extended into position to the degrees required for specific movements.

When muscles contract concentrically they shorten and become thicker; they bulge. Concentric contractions are employed to move limbs and weight away from or against the pull of gravity

When muscles contract eccentrically they lengthen and become narrower. Eccentric contractions are employed to resist the pull of a weight towards gravity.

To illustrate the difference, picture yourself grabbing a heavy object and flex your elbow to lift it. As your forearm moves towards your shoulder, your biceps will bulge as it contracts to move your forearm and the object away from the pull of gravity. Then release the contraction and slowly allow your forearm and the object to return to the starting position. To prevent your arm and the object from falling too quickly contract your biceps. Visualize the contraction. It is narrower over the length of the muscle, and your biceps lengthened to resist the pull of gravity.

2. Three Sources of Forward Motion. There are three primary sources of forward motion in race walking. The body can be propelled or pushed forward. The body can fall forward, as if pulled by gravity. And the swing leg can be driven forward through synchronized hip rotation and flexion causing the body to be repositioned with each step.

In race walking all three are used. The question is to what degree is each emphasized and how do they affect the appearance of double contact, and conversely to its loss? It is important to remember that legal race walkers should demonstrate a technique which conserves energy through motion that is both smooth and fast.

To judge loss of contact judges must know how the body moves forward, and how it can move forward with the least amount of upward movement which contributes to loss of contact.

E. "VISIBLE LOSS OF CONTACT"

1. Heel and Toe is Walking. The so-called "heel and toe" requirement has generated much controversy in the race walk community. Having one heel and one toe on the ground (momentary double support) is what used to define the discipline. It is what separated

running from walking. Now it seems as if judges have to look for something else that is not walking, but is not running. What is it?

2. Loss of Contact, a history. Prior to 1995, the definition of race walking required contact so that steps were taken so that unbroken contact with the ground was maintained, and, that the advancing foot…made contact with the ground before the rear foot left.

Since photography and film, as well as studies recorded periods of flight *phasing* for almost all walkers at the elite level, loss of contact was not being detected, proponents of a liberalized definition advocated elimination of the contact provision altogether.

Concerned with the contradiction between the definition and what race walkers actually did, but wanting to maintain some adherence to the concept of walking, the definition was re-written to require that judges see "visible loss of contact." The 1995 changes to the definition offered a compromise by allowing loss of contact until the judge could see it with his own eyes. Video or still photo analysis by judges is not permitted; the onus being completely in the eyes of the judge. To the event's discredit, walkers may very well be off and allowed to get away with it when not seen by the judges.

Today's rules are bewildering to the non-race walking public. And, rightly so, because they have further separated race walking from normal walking and have removed one of the two technique requirements that distinguished walking from running. To the sporting world in general, this provision in the 1995 definition makes a mockery of the discipline. To many, the IAAF advocated cheating until caught by the judges.

Changes to the rules of race walking in 2001 have speeded of the transmission of red cards to the DQ posting board and the way notice is given to disqualified athletes. And the Chief Judge has been given the power to disqualify walkers in the last 100 meters of a race when the walker's mode of progress obviously fails to comply with the definition. (What does obviously mean?)

To aid in the selection of judges for the IAAF Panel, eye exams are now required, to see if candidates have normal vision. But not much is asked about their ability to judge contact. It is now doubly important that race walk judges know the biomechanics of race walking, so that they may see loss of contact as it happens.

E. FORWARD MOVEMENT WITHOUT LOSS OF CONTACT

1. Propulsion is Needed, but Not as Much as Intuitively Thought. The muscles of the lower leg, in the calf and foot propel the body forward. Fundamental to all forms of upright human locomotion, propulsion is highly developed in race walking technique. Without it, the initial step would not occur, and the steps that follow would not be very long. Also, with each push against the ground, the race walker helps to lift the body at double support. Propulsion and measured arm swings make race walkers more "point to point" on their heel and toe. When point to point the walker may feel less weighted, or up, as if "floating" over the ground. This smooth movement, if done correctly increases efficiency and allows for rapid turnover. Floating implies contact (just as boats float on the water). To what degree can the race walker use push before there is obvious visible loss of contact? What should the race walk judge look for to see if there is too much propulsion?

Plantar flexion (when the bottom of the foot gets smaller from the toes to the heel) causes the ankle and foot to extend relative to the leg. The muscles of the calf, the soleus and gastrocnemius, contract concentrically through the Achilles tendon to plantar flex the foot backwards, resulting in both vertical and horizontal movement as reaction to the push against the ground.

When there is too much push, the race walker presents a foot that points backward after toe-off. The ankle and knee extend as much as 180°. The gastrocnemius bulges

noticeably. Because the foot is extended acutely in relation to the ankle, almost straight back, it must be quickly flexed at the ankle (dorsiflexed) by concentrically contracting the anterior tibialis at the front of the shin to clear the ground in swing. If not, the knee must be lifted high to clear the ground. Because of rapid leg swing it is often impossible to dorsiflex enough before contact, and contact is made almost at flatfoot without noticeable heel strike.

Fig. 4-Jefferson Peres, World Champion Legality

In normal walking, flexion of the knee at the end of propulsion occurs prior to toe off as knee flexion initiates heel lift. Hip flexion assisted by a push of the toes then pulls the foot away from the ground beginning the swing phase. If push is not the primary emphasis in walking, the walker will demonstrate less loss of contact. Look at Figure 4 and note the degree of knee extension by Jefferson Peres after heel lift, and how he flexes the knee before toe off.

In stance, EMG studies show the calf muscles, primarily the soleus contract eccentrically to stabilize the ankle and to prevent the lower leg, and the rest of the body from collapsing against the force of gravity. When contracted concentrically late in stance, the gastrocnemius act to initiate swing and help to propel the body horizontally, not vertically. The ankle extends very little relative to the leg, because the toes do the work of pushing the body forward. Look at Peres' toes in Figure 4; they push him forward, not up.

When there is too much emphasis on propulsion, particularly when accompanied by no hip rotation, foot strike shifts from the heel to the forefoot, and in extreme cases the swing leg makes contact and extends at the knee behind the body's center of mass, or past the vertical position. The knee may even be bent.

2. The "Fall" Into Gravity. Forward fall implies a gravitational force that acts on the body. Obviously the race walker does not fall onto their face because the swing leg breaks the fall, and the postural muscles at the back of the stance leg contract eccentrically to prevent disaster after contact. From heel lift through toe off, the walker's position becomes less stable as the mass of the swing leg and body move forward over the rear stance leg. Gravitational pull accelerates the body forward, and as heel lift and heel strike become more accentuated the body becomes even less stable. Compare stance when both feet are flat on the ground with stance when you rise up on your toes; balance is affected. Standing still, a high "heel and toe" race walker will lose his or her balance as gravity pulls against the unstable body. With sufficient forward momentum this race walker flows forward using the assistance of gravity to his advantage.

Letting gravity do the work of walking means conservation of muscular energy. Studies of simple walking robots have shown walking requires very little muscular activity. These robots were able to walk down a slight slope without any internal power, simply by using the pull of gravity acting on the body and the swinging leg.

At heel strike an elevated forefoot reduces ground-braking forces, maintaining forward momentum. Landing on the heel allows the foot at contact to roll forward as it goes to mid-stance. The longer the forefoot is

kept up, the longer instability is maintained and the body continues to fall forward.

High arm action helps to raise the body's center of mass, however, it needs to be emphasized that rear arm swing is upward to the back, while forward swing must not go any further then mid chest height. Higher swing gives the appearance of too much lifting of body mass which may be a precursor to possible loss of contact.

Muscular activity to maintain and assist arm swing should be to the rear, with forward swing being a natural pendulum motion. When the forward arm swing is accentuated the hips are pushed backward and forward hip rotation is reduced, and the torso bends at the waist.

Too much reliance on gravity, such as when emphasizing forward lean, adversely affects technique. After the first few steps, it is not necessary to lean forward. Gravity pulls on the whole body mass. The rear toes act as a fulcrum allowing the body to be rotated forward. If lean is emphasized it will most likely occur at the waist, restricting forward hip rotation.

The torso should be kept upright throughout each stride. The dynamic instability of hip rotation is accentuated by legal race walkers with good technique. They demonstrate proper upright body alignment and maximize the pull of gravity.

3. Momentum, the "Progressive Force." The push of toe-off and the fall forward which occurs as the body rocks forward, combine with the moving mass of the swing leg as it is driven forward generating forward momentum. Hip and knee joint flexion lift the heel and literally pull the leg off the ground at the rear and rapidly accelerate the mass forward.

By not emphasizing rear propulsion through plantar flexion, the ankle stays at the same angle throughout toe off, swing and heel strike. No muscular activity is required to do this task. Just before heel strike the hamstring muscles contract to decelerate the foot. To prevent the appearance of increased upward motion of the leg, it is brought forward, close to the ground, as a high swing leg may contribute to loss of contact as the body moves forward horizontally.

F. THE BIOMECHANICS OF MAINTAINING CONTACT

1. Oscillation of Center of Mass. In normal walking, the center of mass (COM) oscillates. The center of mass is lowest at double support, and highest at mid-stance. To conserve energy, normal walkers at mid-stance usually bend their leg to decrease the up and down movement, and thus avoiding excess muscle work from raising and lowering body weight with each stride.

In race walking, pronounced arm swing and emphasis on strong toe off and heel lift replaces much of the oscillation and levels the path of COM as it moves forward Compared to the normal walking gait, heel lift in race walking is higher and toe off appears more exaggerated. At toe off (or slightly afterwards when flight phasing occurs) the heel is directed at the ground. The high heel and toe position raises the COM at double support. The swinging arms are flexed at the elbows and swung upward to the back and to mid-chest level in front. Point to point (or almost point to point) double contact and the swinging arms helps raise the COM to its maximum greater than the height required to pass the vertical with a leg extended at the knee, without knee flexion. To lower COM at mid-stance the arms may be lowered slightly as they pass the hips. The hip of the swing leg may be dropped slightly producing **pelvic list**. Some very legal race walkers avoid pelvic list altogether, because while hip drop does lessen the overall COM at mid-stance, it is not efficient. The constant lateral sway back and forth of pelvic list is energy consuming.

2. Walkers Do It With Their Hips. The hips are the center of walking activity in the

human. As a bipedal machine, locomotion is centered in the hips. Deep inside the hips, concentric contraction of the iliopsoas initiates hip flexion to accelerate the swing leg forward. The coordinated activities of hip flexion and hip rotation serve to move the swing leg together. Hip rotation is optimal when it appears as if the legs follow the hips. Leg extension to the rear is markedly greater than flexion to the front. (See figure 4.)

Forward hip rotation repositions the body's COM well in front of the stance leg without forward lean at the torso, and lengthens the step by as much as one tenth of a meter. A counter-balanced rearward arm swing aids forward hip rotation. To further reduce lateral pelvic sway, foot placement is in line with the arms, not crossing the mid-line in front of the torso, and the shoulders are squared to the torso with little horizontal rotation.

Without hip rotation, hip flexion alone appears to move the legs. Step length is shortened and walkers appear to bounce with each step. Figure 5 illustrates obvious loss of contact; look at his shoulders. They are rotating while his hips are not.

Fig. 5. Obvious loss of contact

G. THE "STRAIGHTENED" LEG RULE-Extension at the knee in single support.

To explain the 1995 IAAF race walk definition using standard biomechanical wording, it must be said that walkers must extend their stance leg in single support at the knee from heel strike to the vertical position, and that they may not flex the knee until past the vertical.

1. A Brief History. Prior to 1995, walkers could land with flexed knees. They complied with the definition if they achieved full extension at the knee, if only momentarily, when at the vertical position. Full extension of the support leg at the knee has historically set race walking apart from running. However, at high speeds, the pre-1995 definition allowed race walkers to contact the ground as flat-footed runners, only briefly fully extending at the knee as they momentarily snapped the knee back. The revised "straightened-leg-on-contact" part of the definition has mandated a longer period of extension, clearly separating race walking from running. So clearly, that race walkers should never look like runners.

The requirement that the leg must be extended from the moment of first contact until in the vertical also delineated race walking from normal walking, where there are natural flexions of the knee joint after heel contact, and at mid-stance to level out the path of the COM when in single support.

2. Contact on the Heel? The IAAF Race Walk Committee had considered adding a provision to the definition that required walkers to first contact the ground on the heel. However, it was felt that by not allowing flexion of the knee in single support before mid-stance would accomplish the same purpose. In fact, it is very difficult to land flat footed in front of the COM without flexing the knee; adding that provision would have guaranteed extension. The only way race

walkers may land flatfooted is by shortening the stance phase in front of the COM by making contact at or near mid-stance. Doing so would lessen the walkers' ability to visibly maintain contact.

It was also felt that adding a heel strike provision would make it more difficult to judge, in essence, creating something else for judges to look for.

With the revision to Rule 230 judges should have been required to know the difference between running and walking. The difference is quite simple to describe.

H. THE BIOMECHANICS OF KNEE EXTENSION; the Locking of the Knee Joint in Walking

An explanation of how the race walker extends the knee joint in front of COM, and how the extended knee is maintained without flexing, until the body passes the vertical position, requires a basic understanding how the knee works.

1.Muscle Contractions of the Quadriceps
To be able to look for extension or flexion of the knee joint judges need to concentrate on one group of muscles at the front of the thigh, the quadriceps. To understand how that muscle group functions, stand with both feet together, with your legs fully straightened (not bent at the knee). Lift one leg slightly and straighten it, while pointing the heel towards the ground. Notice the contraction in the front of the upper thigh? You should feel it bulging. As a concentric contraction, you have flexed the hip joint by moving your leg and torso from 180° to less than 180°. Now put the foot on the ground, keeping the leg straightened. Relax the contraction and shift your weight to that leg. If your knee buckles because of your body's weight you will flex at the knee and your quadriceps will contract to prevent you from falling. Does the quadriceps bulge at the top concentrically, or does it contract eccentrically over the length of the muscle? The muscle contracts to stabilize the leg, to prevent it from collapsing, it contracts eccentrically.

This is the primary difference between running and race walking. In running, at contact, the quadriceps contract eccentrically, to prevent falling to the ground. Look at the runners in Figure 6. The quadriceps group is working to prevent gravity from pulling the runners to the ground as they put weight on their stance legs.

Fig. 6. Runners in single support.

EMG studies of runners show that the quadriceps fire at the beginning of stance, and then shut off. EMG studies of race walkers show that the quadriceps group does not innervate at contact, remaining at rest. <u>At contact, when weight is put on the leg, the quadriceps of race walkers do not innervate eccentrically to help stabilize the leg.</u> Look at the race walkers in Figure 7 and note how relaxed the quadriceps group is in single support. There is no muscular activity. This is a second fundamental difference between walking and running and is easy to see.

Fig. 7. Race Walkers in Single Support

2. Extension and Locking of the Knee. While standing, shift your weight to one leg, and at this time make the decision to fully extend the leg at the knee before putting weight on it. Allow the knee to fully extend from the moment you do put weight on it. Your quadriceps will stop working. You will feel some tension in the knee joint and in the smaller diamond-shaped muscle at the inside of your thigh, just above the knee--the vastis medialis. The tension you feel is the knee locking. The unique design of the knee allows the bones of the leg to take up the weight of the body by screwing in to a locked and extended position without using the quadriceps group. Walk forward for a few steps, flexing at the hip and relaxing the thigh muscles at heel strike while extending at the knee as you put weight on your leg. Feel the knee drop backward to a locked position. If you are walking with a straightened leg, you should feel no muscle contraction in the quadriceps except for a brief concentric contraction while extending the leg and pointing your heel towards the ground, before heel strike. After that, the quadriceps relaxes.

3. What Happens When the Knee Unlocks? When the knee is unlocked, the knee will flex. Simultaneously, to avoid falling, eccentric contractions in the leg muscles will resist further flexion in the joint, like the two runners in Figure 6. It is very obvious! The eccentric contraction causes the muscle group to noticeably lengthen, and muscular tension is seen throughout the front of the thigh. Likewise, when a step is taken without fully extending at the knee once weight is put on it, the quadriceps must work eccentrically. Look at the Figure 8. Notice the difference between the two walkers. One is in violation, and the other is not.

The key to making correct "bent knee" calls is to keep in mind that quadriceps activity ceases then when the leg is properly extended at the knee. The quadriceps is relaxed, or “off".

4. How to Judge the Leg. The key to judging the straightening of the leg is to look at how

Figure 8. Incorrect and Correct Quadriceps Use by Race Walkers. This is easy to see!

the quadriceps muscle group works at heel strike. If there is little visible tension over the

length of the muscle group, the muscle group is off and the walker is legal. If there is obvious tension in the quadriceps after heel strike, the race walker will not be able to extend the leg at the knee, and the walker will demonstrate visible flexion before mid-stance. The athlete who lands with a flexed knee, and who does not turn off the quadriceps to allow momentum and his body weight to lock the knee will not be able to extend at the knee either. They may also visibly flex the knee as they go from heel strike to mid-stance because they can not hold the contraction without some lengthening of the quadriceps. The race walker who extends the knee joint to a locked position will visibly demonstrate an increase in the angle moving towards 180° or greater (hyper extension) as the knee moves backward into full extension rather then less than 180°.

6. Hyperextension and the Time it Takes For Full Extension. In no case, should a walker be cautioned or be given red cards if he hyperextends at the knee. Hyperextension more than satisfies the requirement of a "straightened" leg.

For walkers who look as if their leg is not straight as they come into heel strike, the judge should reserve judgment until the process of extension is finished. Some walkers, because of their style may take longer to get to full extension of the knee. The key to remember is that the walker must neurologically relax the quadriceps before heel strike in order to let the knee move to a locked position, and that as they extend at the knee joint, the muscle group must remain relaxed to permit the bones of the leg and the natural screwing in of those bones at the knee to do the work of holding the body erect.

7. Bent Knee Cautions. It is worth noting, that since muscles are either turned on (to contract), or left off in a relaxed state, race walkers will either demonstrate flexed or flexing knees or extended or extending knee joints. Cautions for flexed knees then are really a courtesy to athletes deserving to be red carded.

8. Straightened Knees and Efficiency. For the race walker, the straightened-knee-on-contact rule results in a more efficient utilization of energy. Energy is conserved with each forward step because less muscle activity is required to land with a leg that is extending rather than flexing at the knee. The locking mechanism of the knee does not require much muscle function. Also, by landing on the heel, with the toe up, the efficient race walker with enough forward momentum can ride the body over the locked leg, like a pole vaulter riding his pole. If the toe is kept off the ground, the fulcrum point for this rotation is a smaller point (the heel rather than the whole foot) and *forefoot loading* which initiates mid-stance is delayed, and the body continues to rotate forward utilizing gravity and its momentum.

9. Leaning Forward and Straightening. A race walker that leans forward from the waist generally has little forward hip rotation. Such technique may place the COM. in front the vertical position before heel strike. While such a walker may extend his leg at the knee in single support, the extension does not begin until after mid-stance, violating the requirement for extension before the vertical.

10. Over Striding and Bent Legs. The race walker that takes too long a step and "over strides," may make contact on a flat foot and may not be able to straighten his leg. A walker with too long a stride, that lands in extension, and then immediately flattens the foot, may also find that because of loss of momentum the knee will flex.

I. EFFICIENT RACE WALKING

Which of the three sources of forward movement is most efficient and smooth; the push, the fall, or lift and swing? Technically, the race walker must use all of these movements. Common sense would dictate that the use of the hip and knee flexors to lift and swing the weight of the leg (which is about one fifth of the body's weight) forward

requires less effort than pushing the whole body weight forward each step. As the body moves forward, the rear foot is pulled off the ground without the use of the calf and foot muscles to push against the total body weight. If contact is at the back of the heel and toe off is high, and if the arms raise the center of mass, shifts in the center of mass are reduced. Emphasis on proper motion of the swing leg reduces calf muscle and ankle joint motion.

To perfect technique, the race walker must make a compromise between stride length and turnover. Maximizing either will lead to illegality. Turnover utilizes the hip flexors, accelerates the body, and thereby increases momentum. It alone does not contribute to loss of contact. However, over striding and increased propulsion from pushing too much, and forward lean does. The race walker must optimize both.

J. A NEW DEFINITION THAT USES STANDARD BIOMECHANICAL TERMS

Five years ago, IAAF Council Member Cesar Moreno Bravo of Mexico, leader of the IAAF race walk study group, asked me how I would change the rules. My response at that time was that the rules were not the problem. In my opinion, judging would become uniform if the judges used biomechanics to make their decisions. Most have not.

The IAAF definition of race walking should be rewritten using the standard biomechanical terms in the glossary. Since judgments are made with the human eye only, and judgments are made as such for both loss of contact and knee extension, I have separated the part requiring judgment by the human eye into a separate clause, so that it will apply to both technique requirements. Using these standard terms a useful biomechanical definition might look like this:

Race Walking is a progression of steps observed by the human eye. Each step shall be taken so that the walker does not lose contact with the ground, and when in single support the, leg shall be extended at the knee. Flexion of the knee may not occur until past the vertical position.

K. NEW RACE WALK RULES.

Why does race walking need a definition in the first place? The other disciplines in Athletics and their respective events are not defined. Why should race walking be? Rather than replace the definition with another, even one that uses biomechanics to define the event, new rules may de substituted that delineate biomechanical parameters to be met by race walkers.

New rules must be phrased in clear biomechanical terms that set race walking apart from running. When translated from English into other languages the rules should remain as intended.

1. New Race Walking Rules:

1.) All calls in race walking are made by judges, who make their decisions based on their observation of a progression of steps. Observation is by the human eye alone.

2.) Judging calls are made independently and may not be appealed.

3.) With each stride, race walkers must demonstrate a momentary period of double support, where the toe of the rear foot and the heel of the front foot are in contact with the ground at the same time.

4.) When in single support, the stance leg must be extended at the knee and remain extended until past the vertical position. Once past the vertical position, the stance leg may flex at the knee.

5.) A race walker is in violation when loss of contact occurs.

6.) A race walker is in violation in single support when the stance leg flexes at the knee at any moment prior to the vertical position.

L. CONCLUSIONS:

This paper has had three goals: To clarify what is mandated by the IAAF definition of race walking; to present a biomechanical model based on that definition for accurate judging; and to educate coaches on how a mandated legal technique is also the most efficient way to race walk.

A judge that understands the definition of race walking must be able to express himself using standard biomechanical terminology. No judge should say, "The leg was not straight." Rather they will say, "The leg was not straightened." Preferably they will say the leg was not extended at the knee.

Secondly, by presenting the biomechanics of legal race walking, the race walk judge now has a model to compare legal race walkers with race walkers that are at variance with the definition. Using this model of a legal race walking, the judge can make observations and judgments about competitors who deviate from the technique mandated by the IAAF definition. The race walk judge needs no longer to rely on simple intuition: “I think the leg has straightened.” He or she can now understand what is required for the leg to be straightened before or at the moment of contact and how it is kept straightened through the moment when the body is vertical. The judge will no longer say, “I think the walker is off,” because he or she will now know the causes for loss of contact and how the judge can see it.

Finally, the race walk athlete, in addition to avoiding disqualification, can now work with his or her coach on efficient forward motion based on the proper extension of the leg at the knee and double-contact mandated by the IAAF definition of race walking.

ABOUT THE AUTHOR:

Gary Westerfield is currently one of two US members of the IAAF Level III Panel of Race Walk Judges. He has been an IAAF Judge since 1984. A retired educator (MA plus 60 hours), He currently officiates more than 100 athletic events a year. A former race walk competitor and track and field coach (high school, collegiate and club), he is currently president of USATF-Long Island, member of the Pan American Race Walk Commission and Chairman of the NACAC Area Race Walk Commission. He has coached numerous U.S. race walkers and was the USA Race Walk Coach Coordinator from 1984-88, and as president of WALK-USA, he currently coaches numerous nationally ranked under 23 year-old race walkers. In 1995, he co-authored the text: Walk Like an Athlete (Walking Promotions, www.racewalk.com).

FURTHER INFORMATION:

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