On Walking, Carrying Loads, and Efficiency

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The Physics of Walking

Why humans move like an imperfect pendulum

By Robert Kunzig

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In what one can only assume is Giovanni Cavagna's funniest home video, Cavagna, a jolly physiologist from the University of Milan, is standing in an aviator suit in the passenger compartment of an Airbus A-300. The plane, operated by the European Space Agency, has been cleared of its seats and filled with scientific gear. Cavagna is grinning and holding a pendulum, which is swinging at a steady pace. Next to him, his friend and longtime collaborator Norman Heglund is pacing steadily back and forth on a 10-foot-long platform. The plane is cruising at 30,000 feet or so over the Bay of Biscay, off Bordeaux, France. NASA has a similar plane called the Vomit Comet.

Abruptly, the Airbus starts to climb— so steeply that the horizon outside goes almost vertical. Normally at this point the pilot would jam the stick forward and throttle the engines way back, sending the plane over the top of its parabola and into a screaming dive. For 20 seconds or so, we would see Cavagna et al. floating around the padded compartment in zero gravity. This time, however, the pilot throttles back gravity to only 40 percent of its terrestrial value— to around what it is on Mars. Cavagna stays on his feet, but his pendulum starts swinging in long, slow, sloppy arcs. On the platform Heglund is now taking long, slow, floating steps. "You feel beautiful at .4 g," Cavagna says. "Walking on Mars would be great."

Walking on Earth, Cavagna says, is a bit of a struggle— and so is trying to understand the physics of it. Cavagna's Airbus experiments are but the latest in a long series; he has been studying our awkward form of locomotion for nearly 40 years. Very early on he figured out our basic strategy: To save energy, we walk like a pendulum. The problem is we do it badly.

A pendulum is a device that transforms kinetic energy of motion into gravitational potential energy and back. As it moves through the bottom of its arc, the pendulum's velocity and thus its kinetic energy— mass times velocity squared divided by two, or $mv^2/2$— reach a maximum. At the top of its arc, the pendulum slows to a stop, but at that point the potential energy— mass times gravity times height— is at its peak. As the pendulum falls back down, potential energy is converted back to kinetic energy. In a good pendulum the conversion is close to 100 percent, with only a bit of energy lost to the friction of moving through the air and that of the bearing from which it is hung. One nudge, and a pendulum keeps swinging a long time.

With each step you walk, you yourself become an inverted pendulum: You pivot around the foot that's on the ground, as if you were using that leg to pole-vault, and your center of mass, somewhere in the belly, describes an arc. As you plant a foot on the ground in front of you, the ground exerts a force back up your leg that slows you down, and you continue slowing as you rise up on that foot to the top of your arc. At that point your kinetic energy is at a minimum— but your potential energy is at a maximum. As you fall forward into the next step, that stored potential energy is converted back into kinetic energy, and you accelerate again.

"If the body were a perfect pendulum— if it could convert the kinetic energy into potential energy and back without wasting a calorie— walking would be nearly effortless," says Heglund, a physiologist at the University of Louvain in Belgium. "But you're only 65 percent of a perfect pendulum." In other words, 35 percent of the energy for each step has to be supplied afresh from the food you burn. Fish and birds do better: They burn less energy per unit distance than we do, even though birds are fighting gravity all the time, and fish have to fight their way through a dense liquid. "So why are we sweating? Where's the work?" asks Cavagna. "It's work we're doing against ourselves. It's a lack of coordination."

Somewhere in our legs, muscles are pulling against one another, wasting energy as heat. Even after four decades Cavagna is not sure where the waste happens— but he does know at what point in the stride. The tip-off came from some experiments that he, Heglund, and Heglund's Louvain colleague Patrick Willems did with women from Kenya.

Women of the Kikuyu and Luo tribes have a remarkable ability: They can carry on their head a basket of produce that weighs as much as 70 percent of their body. Heglund tried to match the feat, wearing a bicycle helmet filled with lead shot; he only got up to 15 percent of his body weight. "When that much weight gets out of balance, it feels like it's going to rip your head off," he explains.

The African women's most surprising prowess, though, is that they can carry as much as 20 percent of their weight with no extra effort— that is, without using more oxygen and burning more calories than when they carry nothing. Puzzled, the researchers had the women walk on a platform that records the forces exerted by the feet, and thus the kinetic and potential energy at each point of the stride.

There is one point, Cavagna's team found, at which load-bearing Kenyan women do far better than the rest of us. As we move through the top of one stride and start to fall into the next one, most of us pause imperceptibly for a few milliseconds: We're falling and losing potential energy, but we're not yet converting it to increased speed, because muscles in our leg are contracting and fighting the fall. The Kenyan women do the same thing when they're not carrying a load. But put a heavy weight on their head, and somehow they are able to shorten or even eliminate this pause— and thus to convert more of their potential energy into forward motion rather than muscle heat. With no visible change in their gait, their conversion rate rises from 65 percent to as much as 80 percent. In other words, they become better pendulums. Unfortunately, they have no idea how they do it.

For most people, the optimum walking speed— the speed at which our kinetic energy is in balance with our potential energy— is around 3 miles per hour. But short legs slow a walker down, and so does low gravity. On Mars, at .4g, you would glide along, lifting your legs more easily than you do on Earth and thus exerting less at any given speed. But you wouldn't be able to walk as fast because you would be falling much more slowly into each new step. On the moon, at around .17 g, in order for your kinetic energy to balance your minuscule potential energy, you would have to walk so slowly that you would hardly move forward at all. In 1969, when Neil Armstrong and Buzz Aldrin took their giant leaps for mankind, Cavagna wasn't at all surprised to see them bouncing (a kind of running) rather than walking. He had predicted as much in 1964.

The Airbus results teach one potentially useful lesson, Cavagna says: For a manned mission to Mars, spacecraft designers might consider pegging their artificial gravity not at 1 g but at the agreeable .4 g of their destination. Certainly they shouldn't choose 1.5 g's, which the Airbus pilot re-created for Cavagna's group by flying steeply banked circles. You walk faster in 1.5 g's, but you feel, well, surprisingly heavy. "You pick up your foot and start to fall forward, and you think you're going to fall on your nose," Heglund says. The video shows Cavagna jerking along like Charlie Chaplin and looking none too stable.

The next time Cavagna rides the Airbus, he plans to take 1.5 g's at a run; it will be like running with a backpack loaded with half his ample body weight. At age 67 and with a bad back, he is defying doctors to forbid him. "I'm not doing this because it's useful," Cavagna says. "I'm doing it because it's amusing."

For a discussion of earlier research on the walking of Kenyan women, see Biomechanics Watch by Carl Zimmer, in *Discover*'s August 1995 issue; this article is available at www.discover.com.

The New York Times

Improving the Way Humans Walk

The research of Cavagna and Heglund

By Otto Pohl
March 12, 2002
http://www.ottopohl.com/Stories/2002_Stories/NYTheads2.htm

Linnette Otieno, who lives near Nairobi, carries 65 pounds of firewood, about 35 percent of her body weight.

NAIROBI, Kenya — As dawn breaks, Linnette Otieno leaves her small house on Nairobi's outskirts and walks five miles to market. On her head is a load of firewood she plans to sell. The load weighs about 65 pounds. She hardly sweats.

"I've been doing this since I was 6," she explains as she hoists the wood onto her head with an experienced motion.

When she was growing up in her home village in western Kenya, she had to walk even farther to gather firewood, up to eight hours a day. By now, at age 35, she says long journeys with heavy loads are second nature.

Scientists have long wondered how women like Ms. Otieno are able to carry so much so easily. Now, in a study to be published shortly, two researchers from Europe describe the trick in detail: women from certain African tribes unconsciously modify their gait to walk using less energy. The energy they save is applied to carrying the weight.

The study, which follows two previous articles in the journal Nature, is the first documentation of humans' improving the economy of walking.

"Every person and every animal that we have yet tested has roughly the same walking economy, except for these African women," said an author of the study, Dr. Norman Heglund, a physiologist at the Catholic University of Louvain in Belgium. "We were pretty surprised."

Dr. R. McNeill Alexander, an expert on biomechanics who has written a number of books on human and animal locomotion, said the study could be an important step to understanding how to improve the human walk.

Using the results, he said, "we might be able to teach hikers with rucksacks and soldiers with heavy packs to save similar amounts of energy."

The research began when Dr. Heglund was working in Kenya in 1977. He became intrigued when he saw how easily the women walked while carrying heavy loads.

To test his observations, Dr. Heglund and his colleagues asked several women to walk on a treadmill, then measured oxygen consumption and heart rate while they carried a range of weights.

They found that the women could carry 20 percent of their own body weight with no additional exertion. "There wasn't even a blip in their oxygen usage," Dr. Heglund said.

In a control group at Harvard, he asked subjects to walk on a treadmill wearing bicycle helmets lined with varying amounts of lead. Oxygen consumption rose with even the lightest helmet.

Dr. Heglund found an old Army study documenting the amount of energy that recruits needed to carry heavy packs and found that it rose significantly when they carried the same weight that the African women bore without extra strain.

Looking for a hypothesis, Dr. Heglund turned to Dr. Giovanni Cavagna, a physiologist at the University of Milan, who had created a model of how reduced gravity would affect astronauts walking on the moon. Dr. Cavagna suggested he consider whether the women were changing the way they walked. That proved to be critical, and now, many years later, the two have written the new study explaining the phenomenon.

The walking human can be imagined as a small steel ball (the center of mass) propelled forward on top of two stiff wires (the legs). With each step forward, one end of a wire is planted on the ground, and the steel ball swings in an arc around the other end, just like an upside-down pendulum. As the ball reaches the end of its arc, the other wire is planted farther forward on the ground, and the process is repeated.

To maintain forward movement, the energy of the steel ball needs to be transferred from one pendulum to the other. In normal walking humans, only 65 percent of that energy is actually transferred; the rest is dissipated and must be replaced by additional muscle energy.

But the African women have a secret weapon, the researchers discovered. As they transfer their weight, they transfer at least 80 percent of their forward energy to the next step. Only 20 percent must be replaced by the muscles, leaving plenty of energy in reserve to carry the weight on their heads.

The secret of this efficiency lies in the difference between the two components of energy, potential and kinetic. Potential energy is stored by moving an object to a higher location, able to be released — as kinetic energy — when the object falls.

In a pendulum, there is a near- perfect back and forth transferral of energies: at the height of the pendulum's swing, the ball is not moving and all of the energy is potential; as it falls it is converted into kinetic energy; at the bottom of the swing all of the energy is kinetic. As the ball begins its movement back up the other side of the arc, the energy is transferred back into potential energy, and the process is repeated.

Since each step of a walking human can be understood as an upside- down pendulum, a similar transferral takes place. But the system is nowhere near as efficient as a pendulum. At the height of each step, the normal walking human begins to drop down, losing potential energy without transferring it into kinetic energy, which would generate additional forward speed. The African women, however, are able to minimize this loss through a tiny alteration of their gait.

Interestingly, they apply this trick only when they are carrying things on their heads. When they walk unloaded, Dr. Heglund found, they waste as much energy as all other walkers. It is only as they begin to balance heavy loads on their heads that they change their steps.

It's a tiny difference that is almost invisible to the naked eye, and "even the women don't know how they do it," Dr. Heglund said. But with a sophisticated training program, he went on, "you could train other people to do the same thing."

Walking Efficiency

Robert Vervloet
http://www.competitiverunner.com/vervloetwalkers_1.html

Thinking Backwards

Confucius Says; The Future Belongs to the Efficient

What makes my perspective of athletics different is that I make the mistake of thinking backwards. After years of running, listening to coaches, and reading vast amounts of any literature I could get my hands on, I always came away feeling that something was wrong with what I was told or read. My search to improve my running skills always hit a brick wall that myself and many others want to climb over.

In constant want of becoming a better and faster runner, current training mythology left me with plenty of speed drills to follow, stretching regimens, or strength training techniques to implement, but simply didn't satisfy my passion to improve. And if all traditional thoughts of training techniques couldn't satisfy my wants, then what was I missing?

Improving one's speed is currently dominated by a philosophy of coaching based upon the idea that being an elite performer requires natural talent and such talents can be developed, but not taught. You've either got talent or you don't goes traditional ideology. So my question is a little unique; how did the talented learn their talent?

In the world of running literature, proper running form is easy to learn if you follow the writers "secrets." Proper running form is something that all coaching and running books want to teach you because if you want to get better, then you know you've got something new to learn.

But what if you've followed the advice you've read or heard and still haven't set a new personal best in your favorite race time? Then what are you supposed to do? Your only other option is to push yourself to increase your speed, in hope your body mechanics will naturally find the efficiency means necessary to adapt and in end result improve your speed.

And if your body can't adapt to your speed push, you've just written the perfect recipe for injuring yourself. It's one reason speed drills alone can be highly counterproductive. Added speed to inefficient biomechanics is like increasing the speed of an out of balance engine. Your leg turnover is similar to the RPM's of an engine. If leg turnover is out of balance, eventually it'll tear itself apart no different than a car motor.

At the levels of research writing, the conclusion is that a runner will find a stride that's most efficient for them naturally whether we like that fact or not. We go back and forth from coaches to training tools like parachutes or plyometric techniques trying to push ourselves to go faster. But regardless of what we read, improving ourselves in reality is incredibly difficult to do.

We pacify ourselves in thinking that the great runners will simply remain great and our place will be to forever contemplate the designs on the bottom of their running shoes. But even the best in any subject have teachers. And in that truth, I decided to find out who taught the best runners and ask if I could learn from them as well.

With our running media hyping how Kenyan runners have dominated distance races for the past decade, didn't the question of how that happened cross your mind? How in the history of running did this whole new era in running dominance emerge? My question was in wanting to be a better runner, how could I find their teacher and learn the same skills these running icons possess.

For the last decade, runners from Kenya have been dominating marathon running and the theories abound as to why they're the sport's top athletes. My question was a little more focused. If experts claim to know the secret, then why haven't they created a runner capable of beating them considering that they've had over 10 years to try and do it?

With an incredible arsenal of technology available to the "experts" of running, it was obvious to me that they were looking in the wrong direction to create a runner capable of beating any of the top Kenyan athletes. So in what direction would someone else go to explain Kenyan running dominance?

Biomechanical Experts

That answer came in March of 2002, as Otto Pohl published in the New York Times newspaper the link to an answer. The story documented that for over three decades the biomechanic "experts" of running have kept a very unique secret from the running world. And that story is about the tribal women of Kenya who carry firewood for their survival.

Why the need for you to know their story? Because these women are able to carry 20% of their bodyweight in firewood above their heads and walk for up to eight hours a day. The astonishing fact is that they do it with no change in heart rate compared to walking without any added weight.

Since doing more work requires more energy, the women of Kenya are a complete mystery to biomechanic experts, which is why they've been left out of running literature for the past few decades. And no expert is really a running expert if they can't answer anyone's questions about how these women walk. So the solution to admitting the unexplained was easy for the experts; don't bring up the subject.

For well over 30 years, unlocking the secret of Kenyan tribal women has been the true

"Holy Grail" of biomechanics since their efficiency skills were discovered. The unique aspect for myself is how secret their studies of these women has been and how ignored their story, even since Pohl's article was published.

And for you it means a path to follow in understanding why Kenyans dominate distance running and how you can beat them. With the acknowledged unique skill of these tribal women, they're the unmentioned key to your running future. These women are teachers to the best distance runners in the world, and until today, have received no credit for their accomplishment.

Carrying the weight of firewood with no increase in energy consumption is impossible to do, so the women of Kenya accomplished what many of today's running "experts" deem impossible to do: thousands of years ago these women created their own solution for an energy consumption question; they physically alter their walking gait to carry the wood more efficiently.

With the "expert" opinion that creating a more efficient way to run is impossible to do, the fewer who know of these women, the less chance their secret will be explained. No expert wants to be proven wrong even though the potential model for a better running technique has been out there for thousands of years. What you don't know can't hurt the experts, or help you.

That's the joke for me, so who taught you to run? No baby gets taught to crawl, nobody gets taught to stand, nobody gets taught to walk and eventually run. In fact by the time you did figure out you could run your vocabulary was about five words total if you were lucky. Not exactly the communication skills to carry on a PhD level discussion of running biomechanics now is it?

Researchers will tell you that you develop your own running style naturally, but I think that you walk and run the way you do because you watched your parents and subconsciously learned from them how to take your very first step. I fully believe that they didn't give you any natural genetic advantage over anyone else. Your parents were simply a subconscious role model that you unknowingly followed, no different than picking up their accents of speech for you to talk.

If the cliché "*you have to walk before you can run*" is valid, then how can you not assume the world's best runners learned by watching the world's best walkers around them? If babies truly learn to walk through observation, then it explains how the girls who followed in their mother's footsteps were able to figure out their biomechanical advantage and carry their firewood as efficiently as their mothers do.

According to Pohl's article, even the women themselves don't know how they walk more efficiently. If the women themselves don't know how they do it, then how can they teach it? How does each successive generation of women learn this walking skill without any formal teaching?

So why wouldn't it seem logical that the boys observed their mothers as well and learned to apply their more efficient walking biomechanics to running? They may not understand their better efficiency because it wouldn't be until improved nutrition could be applied to their biomechanic advantage that they found themselves ahead of the world's running pack.

Everything you learned about running, I believe you learned from observation, and isn't "a natural gift" of talent as some profess. If girls from Kenya can learn a completely different way to walk through observation only, then it proves who learns from whom.

That to me is the farce of running experts telling their followers to mimic children as running models.

I have yet to meet a child who's won the Boston Marathon, so what makes them authorities on proper running technique? They struggle with the balance skills to carry a glass of milk across the kitchen without spilling, so where does anyone get the idea to let them teach you how to run? Or is it the experts want you to justify your own inability to run.

Our running technique hasn't changed for over 3.5 million years. From fossilized footprints in stone as proof, "experts," have danced around trying to come up with new ways to say the same thing over and over again and still get published. The experts haven't done anything new, and the untold story of the Kenyan women only proves that they really don't understand how we can walk and run let alone why we walk and run the way we do.

Gravity

Even such recent theories of "let gravity pull you forward" is wonderful proof of the same continued pontification. So why do I have to pay $2.45 for a gallon of gas? If gravity really pulls a human forward, it should pull everything forward. Gravity doesn't pull my car forward, because I have the credit card bill to prove it can't. Why are human beings the only thing in the world gravity can pull forward according to running experts?

According to legend, Isaac Newton was hit on the top of the head with an apple, not on the side of his head. So with theories describing gravity moving you sideways instead of pulling you straight down, then running's, "experts," should be getting Nobel prizes in science for rewriting the laws of physics.

Letting gravity pull you forward or calling it "controlled falling" means nothing to improving your running ability. We lean forward and push rearward to run. It was from that reality Isaac Newton derived his third law of motion in the first place. "Every action creates an equal and opposite reaction in the opposing direction." That reality has never changed, and regardless of writing, our current batch of experts hasn't changed those laws.

The unique part is that the women of Kenya unknowingly wrote their own perspective of Newton's law.

Every walker and runner leans forward. The further your forward lean, the less efficient you run. Even Michael Johnson may run as upright as humanly possible, but he's been measured to have three degrees of forward lean from perfectly vertical. It's not much, but it's still a forward lean. Until you face that reality, you can't change the way you run.

So while the experts study Kenyan runners, I decided to learn from their teachers. I took a leisurely stroll with the wood gathering women of Kenya and simply started taking notes. I wanted to learn what makes them so much more efficient and how I could extrapolate what they themselves don't know what they do.

In trying to unlock how they save energy, the most obvious difference is that they look like the walking dead. The only part of their body in motion is their legs. From the hips up, these women are perfectly motionless. They have absolutely no arm swing or torso rotation at all.

What separates the good from the bad or the ugly runner is simply how much energy you waste in every step you take. Wasted energy either limits your distance capabilities or inhibits your potential top speed. That's the underlying theme of what these unique women taught me.

That's why the goal of running isn't to be the fastest; it's to be the most efficient. The difference is subtle, so to watch these women walk carrying their firewood would leave any competent biomechanic in awe. The incompetent biomechanics simply turn their backs to the challenge of explaining them and pontificate once again that a better way to run doesn't exist. In that light, I feel like Toto pulling back the curtain to expose the wizards of running.

The question of these women is simply how they do it. For answer, these women waste absolutely no energy and laboratory testing proves it. Compared with a traditional walking gait, the most important measurement of efficiency is called weight transfer. That measurement is how well an individual can utilize momentum so the least amount of muscular energy is necessary to transfer their weight from one leg to the other.

An efficient traditional technique walker is lucky to transfer 65% of their bodyweight to their next step. Carrying the wooden bundles, the women of Kenya transfer 80% of their weight onto their next step using only their body's natural forward momentum to move efficiently from one foot to the next. That difference is an energy conserving ability that Kenyan runners learned and you can mimic as well. It takes very little muscular energy for Kenyan women to transfer their bodyweight forward. The women carry the wood with the saved energy and the runners run faster without their even knowing why or how they do it.

If these women are so efficient in walking, then why do we ignore them? Instead of pushing running speed as traditional coaching does, wouldn't it be a more logical approach to think that if we were to take the opposite ideology and focus on becoming a more efficient runner, that running faster would be a natural byproduct?

Speed doesn't guarantee efficiency, however increasing one's efficiency guarantees better speed and efficient walking women as the role model for the fastest running men proves it. With a backwards philosophy of pursuing efficiency instead of speed, I discovered a completely different, healthier, and faster way to run.

Eliminate Waste

The first question was to look at the most obvious aspects of our running technique and find ways to eliminate any wasted energy to forward motion. If the women of Kenya are truly the role models the best runners follow, then observing absolutely no arm swing created the first obvious difference between them and myself even at walking speed. These women opened my eyes to what defines proper arm swing in a runner by a wide variety of coaches.

Nowhere is the basic question I pose answered. Why do we swing our arms in the first place? If we swing our arms when we walk and the women of Kenya don't, then that difference is a vital reason to our running slower.

We refer to natural arm movement in walking and running as a, "counterbalance arm swing," don't we? So if you swing your arms in counterbalance, then what's so out of balance that you have to swing your arms and waste energy to counter it? Have you ever asked that of yourself or any running expert that question? How well balanced of a runner do you think you are?

If we swing our arms in counterbalance, then wouldn't the natural definition of perfectly balanced running biomechanics prove itself by not having to swing your arms at all? If your running technique were truly balanced, then nothing out of balance would need to be countered with any arm swing.

With perfect balance the women of Kenya don't swing their arms at all when they walk and that biomechanic efficiency becomes extrapolated into faster running speed by the men who utilize that efficiency.

When I tell my running students that I can increase their top speed by 20%, that statement is usually met with blank stares of disbelief. Yet if a runner is out of balance, and their counterbalance arm swing proves they're out of balance, that unnecessary energy is wasted trying to keep their imbalance in check. I just take that wasted energy and apply it to higher speed. And the core of what I teach is how to walk and run with absolutely no arm swing.

Every certified track and field running coach will tell you that you don't run in a straight line, in fact you don't even walk in a straight line, because we can't do it. The tribal women of Kenya do. Learn that skill and you'll run faster with ease.

The further your body naturally deviates from a straight line of forward momentum, the more energy you waste trying to maintain a straight path. That's the imbalance your arm swing is struggling to compensate for. It's the unmentionable reality to how we run.

Why Do We Run?

When I ask my students why they run they frequently reply with "Weight loss", "personal challenge", "my boss does it so I have to do it", "cheapest form of exercise I know", and a host of many other emotional reasons are their honest replies. Yet few truly know why we have to run.

I didn't want emotional reasoning from my students, I was seeking from them the biomechanic reasons we run. In it's most basic reality we run simply because we can't walk anymore. Starting from a standstill, if one begins to walk and slowly increase their speed, at some point you can't walk anymore. To speed up, at some point, because of your biomechanic limitations of efficiency, you have to run. That transition speed is crucial to any student of the running science.

Since every human is different, I'm not interested in your top running speed; I want to know how fast you can walk. Studies show that for any given distance, we use less energy walking than we would in running if the question is getting from one place to another. It may take less time to travel between any two given points in running, but the energy costs are higher.

The measurement is called bodyweight impact. Even with one foot still on the ground, an efficient walker hits the earth's surface with an impact force equaling about twice their bodyweight. Once we exert enough force behind our step to bring both feet off the ground, coming down is an impact force that doubles our walking measurements. Some experts will tell you that a runner absorbs 110 tons of impact force per mile. That's a lot of weight to lose in my book.

So if an average runner hits the ground with a force of four to six times their bodyweight in impact, then the math is simple. If I can walk at a speed you have to run, then I'm using less energy and moving with less chance of injury for the same pace. It's a wonderful trick to cross country running that my students utilize when racing uphill and they love to laugh about it. That's why walking efficiency is such a vital factor in training to be a good runner.

Given that the vast majority of runners have to stop walking and start running somewhere between 3.5 and 4 mph, excluding Olympic technique race walkers, that transition speed for any individual defines their true running biomechanic efficiency. Do you know your transition speed? Has anyone else besides me ever asked you that question?

Simply stated, if I can teach you to walk 20% faster, then teaching you to run 20% faster is easy. Applying strength and power to a faster and more efficient walking speed naturally generates an end result higher running speed.

Elite Walkers Teach Elite Runners

In a nutshell, I believed that the best walkers have proven to teach the best runners. All I needed was a reason to pursue that logic. And the weight transfer formula provided the science necessary to point the way.

If my thesis would be correct, then studying the tribal women of Kenya would lay an accurate foundation for explaining the Kenyan runners, as well as deriving a running model that others could build from.

These women walk still as a post from their legs up. They have to, given the added weight to their bodies. A motionless torso is required to balance the wood bundles overhead. In trying to keep their head perfectly still in motion to carry the weight, Kenyan women learned instead to alter their walking gait underneath that added mass to accomplish the biomechanic efficiency necessary to carry the wood.

Because of a traditional walker's natural imbalance, even adding mere ounces in weight amplifies their inefficiency and creates a measurable increase in heart rate. These Kenyan women carry with ease a weight load that equals the maximum limits set by the US ARMY for a soldier's backpack. And they carry it without even breaking a sweat.

Even if runners ignore the rest of this story, there isn't a soldier alive that wouldn't give up a week of desserts to learn the women's secret for their next 50-mile march. Even backpackers can mimic their secrets quite easily.

The women themselves don't know how they improve their walking gait, and without any wood overhead their gait reverts back to a traditional normal walking step no different than any other human on this planet. So in backwards philosophy then the secret isn't in the women, it's in the wood. Without the wood bundles to carry, they can't change into their efficient biomechanic processes or wouldn't have learned their efficient gait technique in the first place.

The physical gravitational picture isn't simply women carrying wood, it's actually wood being carried by women. The women take advantage of the wood's momentum with each step they take. From that perspective, their bundle of firewood overhead has it's own center of gravity and the women themselves have a different center of gravity.

The body's natural center of gravity for these women doesn't exist anymore because a new center of gravity is identified by the combined size of the two entities: they are one combined unit and recognizing that a completely new center of gravity exists created the opportunity for these women to develop a new walking technique around it.

Track and field coaches refer to this new center of gravity as the, "Center of Mass." Discus throwing and hammer throwers each have to adjust to their body's rotation around a center of gravity that lies somewhere between the weigh they're throwing and their own bodies. That's a new axis and center of gravity for the athlete to recognize, understand, and master to be successful with the event. As the body rotates through the air, the better control of the athlete's center of mass determines their throwing or rotational efficiency for further throws.

With Kenyan women, they shift the wood slightly forward so that they maximize creation of the combined weight and a more efficient center of mass. This new center of mass facilitates a longer and easier stride. The stride efficiency adapted to this new center of mass hinges around the observation that they have no natural upward motion when they walk.

Linear rise, vertical force, or simply "bounce" are all the terms used to describe the pendulum motion of pushing ourselves up with each step walking or running to come down on our next step as we walk or run. Humans do this because of the body's forward lean when we walk and run. The women don't need to push themselves upwards because their entire gait cycle of each step occurs behind the new center of mass.

As Kenyan women don't expend the energy pushing the added weight up, and thus no energy is wasted to absorb the impact forces of landing. That difference describes their weight transfer efficiency. Once the wood is removed, then, like everyone else, their body's natural center of gravity is redefined and in result they walk no different than you do.

In teaching students to integrate the Kenyan running efficiencies, they jokingly refer to it as the "model's" technique because the end result looks so much like how the best runway models of New York move.

By walking with their feet crossing over in front of them, runway models get rid of the natural bounce in their walking stride. Why? They have to. No photographer wants a frilly dress bouncing up and down and ruining the natural flow of the clothing for pictures.

However because of our natural forward lean, their crossover walking technique extrapolated into running is impossible to do. Forward lean of a model's foot placement over-cross locks out the ability to increase a stride length necessary to run.

The women of Kenya however utilize their own version of a models walk with a radical change in balance. While noting that these women have no counterbalance arm swing, they also walk like a model with one foot almost perfectly in front of each other.

What the Kenyan women learned is that the shortest distance between two points is a straight line, thus the closer your foot placement can be rotated towards that goal, then the longer your natural stride length. The women of Kenya walk highly similar to a model with only one slight modification that runway models can't accomplish.

Pull, Don't Push

With a center of mass further forward than their bodies own natural center of gravity, these Kenyan women can also do something supermodels can't do; they can pull their weight. The most efficient walkers in the world don't lean forward and push backward, they actually lean backwards and pull themselves forward onto their next step. It's still within Newton's laws of gravity, but it is a whole new chapter of exploration for athletes to ponder.

The ideology of letting your feet pull you forward upon contact allows a runner to remove the energy naturally wasted to keep the upper torso upright during the running process. Pulling one's weight also is a natural way to remove unwanted foot pronation or supination in a runner's technique.

In a very subtle difference of pulling one's weight, the biological advantage is that the gluteus muscle group becomes the primary firing muscles of moving the body forward instead of the expert opinion that the quadriceps are more important.

The Gluteus Maximus is arguably the strongest muscle of the human body yet traditional running technique athletes don't use them at all in the weight bearing leg during their gait cycle. The women of Kenya and their running countrymen use their glutes far more efficiently than traditional runners do. Considering that everyone follows the Kenyans running, why they haven't noticed the muscular differences of their glutes is merely a chuckle to me.

Using the glutes more efficiently also allows the quadriceps to fire more effectively because it takes way the resistance to fluid movement that is naturally in the kneecap and thus elimination of any patella pain. The idea of pulling their weight is how the Kenyan women walk efficiently, and how I teach knee surgery patients to walk and eventually run again.

To test this theory I recruited a group of volunteer firemen from the Portland, Oregon fire department. With 60lbs of equipment (reflecting 20-25% of the individual's bodyweight) in clothing, oxygen bottle, mask, and axe, seven of the ten member test group were able to mimic the Kenyan walking technique with less than an hour of teaching. Learning the skill of forward pulling to walk resulted in no change in heart rate compared with walking without the added equipment weight.

With firemen, the increase in walking efficiency and lowered heart rate means decreased oxygen consumption needs giving them the added time with an oxygen bottle to search a little longer for a missing building occupant, fallen comrade, or stay inside a building a little longer with a hose to minimize fire damage. Most important to me, a Kenyan walking technique provides the few extra breaths they get from their oxygen bottle that means being able to escape a burning building when all hell is breaking loose.

For the runners of Kenya, they too run with a different center of gravity than any other running athletes. For them, the advantage is nowhere near the efficiency numbers of the Kenyan women carrying firewood, but they are more efficient none-the-less.

When I can teach a runner with a 154 beat per minute heart rate a new center of gravity to run from, their heart rate running at the same speed can drop to only 142 beat per minute rate in less than an hour of training. You tell me if that doesn't mean anything to a marathon runner.

By utilizing an altered center of gravity, learned from the best walkers in the world, beating the Kenyan runners isn't as impossible as one thinks. If the cliche of walking before running is true, then I've merely found the path walked by the world's best distance running athletes and answered the questions I asked to what could make me a better runner. In offering that skill to others, willingness to learn is another story !

About the Author

Robert Vervloet states he is a running coach certified with USTAF. His passion is working with distance runners and long jump for field events. According to the author, he has privately trained injured runners for over 5 years and has been researching sports injuries for 13 years.

Clearly a controversial sports trainer, Vervloet say his running technique has been referred to as "Genius" by Tony Veney, sprint coach for UCLA.

Video

The following video links were provided by Mr. Vervloet to illustrate his technique:

Click on the video images below to view video directly in this PDF (you may get a security warning - it is safe to allow them), or click the text links to view the videos on the web).

 — http://www.competitiverunner.com/images/MOV04673.MPG

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