Efficient Running

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Let’s start from an observation that may seem obvious, but which may not receive enough attention for that very reason: the **ambulation** of the genus *Homo*, to which all of us belong as humans, sets us apart from all other biological species on earth. This unique characteristic results from another distinctive trait of our species, our **erect posture**.

From this starting point we have developed **two types of locomotion** which are distinguished from each other above all by the needs that they answer to: walking to go slowly and running to go quickly. This highly efficient form of locomotion has been joined by other mechanisms that have been refined in the course of our evolution: excellent internal temperature management through perspiration, the replacement of fur with adipose tissue, the development of a strong tendon in the neck and convergence of the femurs.

All of this has transformed us into one of the world’s best ambulators and endurance runners, basing our survival and evolution on this quality in particular. (1) - (2)
What were these specific **survival** needs? Basically, the transition from nutrition based on fruit, berries and seeds to nutrition based on protein components from meat.

Academics tell us that certain changes in climate caused a slow yet radical change in habitat – and above all vegetation – giving rise to our species’ first food revolution. This put us in competition with other extremely specialised predators such as felids and canids. (3)
The most recent theories concerning the evolution of our species see *Homo* living for many tens of thousands of generations as hunter-gatherers with a predatory strategy based on prolonged sprinting (rather than lightning dashes like felids and canids). An average hunt and chase extending to 10–15 km on average, with an expenditure of 3,000–5,000 kcal/day, is estimated for the hunter-gatherers closest to us (4).

The purpose of the above is to explain the direct, extremely close relationship between the goal to be achieved (gathering berries as opposed to catching prey), the efficiency of energy expenditure and the motor activity that we engage in – or should engage in! Over the course of approximately two million years of evolution, these motor schemes have become absolutely indispensable in terms of individual survival and the reproduction of the species, to the extent that they have become part of the genetic heritage passed down from one generation to the next. They have become **basic motor schemes**.
A “basic motor scheme” defines the “neuromotor map that allows a given movement to be initiated”. In other words, it’s the predetermined, innate pathway along which the nerve impulse travels from brain to muscle to produce a given movement – and only that movement – because it’s the best response that our body can provide to a precise demand for efficiency in order to survive.

They are called “basic” because they are proper to the human species and necessary for its survival. They are the foundation on which every individual builds the motor skills that make them unique. The main basic motor schemes are:

- sliding
- rolling
- crawling
- walking
- running
- jumping
- gripping
- throwing
- climbing
Walking vs Running

Two of these motor schemes are closely connected with adult locomotion: walking and running. The obvious question is why do we need two motor schemes for moving over the land? Why don't we have a single scheme used slowly for going slowly and quickly for going quickly?

Walking and running are very different from one another and in certain respects even opposite to one another.

Biomechanical and physiological studies of the two movements indicate that though they are superficially similar, walking and running are very different from one another and in certain respects even opposite to one another.

This is because they have two different goals, as suggested previously. One is required for slow movement with the least energy expenditure possible and the other for rapid, efficient movement in order to come out on top in the endurance race with the prey.
The decisive role that the efficiency of our thermoregulatory system plays in this race must also be borne in mind, and in this case too, readers should refer to the works by Morris and Lieberman for further details on the subject. (1) - (2)

We will now take up a concept already hinted at above, but which is extremely important in understanding running: motor schemes are “predetermined neuromuscular pathways that are already active at birth” and these pathways are the same for all members of a given species at a given point in evolution.

There is therefore an original reference model for both running and walking, common and equal among all humans.
This model is the basic motor scheme and it also contra-
dicts the common opinion that everyone runs the way
they want to.
This doesn’t only apply to people. All horses, for exam-
ple, trot or gallop according to the same leg-support
sequence and the same motor scheme. There are no
horses that gallop however they want.

The Differences

There are many differences between the walking and
running motor schemes, but the fundamental difference
that gives rise to all others is the **flight phase**.

Walking doesn’t involve separation from the ground,
since at least one foot is always in contact with it. It
makes ingenious use of the forward and downward
motion of the centre of gravity, which is high due to our
erect posture, to generate motion with extremely low
energy consumption.

Running, on the other hand, features a flight phase and
subsequent landing. The fact that landing and the
subsequent thrust have to be managed has a big effect
on the forces in play. This also changes the solutions
that we adopt to absorb and generate these forces.
Forward motion is produced during flight, whereas a process of energy accumulation occurs in the leg-foot muscular and tendinous system during the landing phase. This energy is then released in elastic form during the thrust phase, contributing to the generation of the subsequent forward motion together with the muscular thrust proper.

But the flight phase isn’t the only thing separating walking and running. We’ll look at the others in order to identify the particular characteristics of running.

We could summarise the differences as follows:

- the **propulsive forces** (“falling” when walking, bounce and thrust when running)
- how the foot comes into **contact with the ground**
- step frequency (**cadence**)  
- the way in which the foot is directed towards the **next step**
The different ways of coming into contact with the ground result directly from the different propulsive forces employed by walking and running. As we’ve seen, walking is based on the forward and downward motion of the centre of gravity. To stop this motion from becoming a fall, the foot is placed far in front of the pelvis, because contact in front of the centre of gravity produces backward thrust, a stopping force.

Running is instead based on the forward thrust generated both by elastic return and muscular force, so the foot makes contact with the ground almost directly beneath the pelvis in order not to slow forward motion and to pass from landing to thrust as quickly as possible.
Contact Between Foot and Ground

The way in which the feet come into contact with the ground results directly from the flight phase. When walking, after “falling” forward, the weight of the foot is on the ground, and the foot needs to handle an impact which is, naturally, equal to the individual’s body weight. When running however, the foot makes contact after a flight phase and the impact to handle equates to about double the body weight. This means that support biomechanics and landing biomechanics differ.

When Walking

When we walk, there is an initial contact of the heel, or rather, the outer heel. All of the outer foot then comes into contact with the ground, up to the metatarsal behind the little toe. At this point, pronation of the foot occurs, so that it rotates on its longitudinal axis, progressively coming into contact with the ground through all the metatarsals, up to the one behind the big toe.

At this point, the weight of the body is positioned vertically above the point of support.
The foot flexes at the level of the metatarsal and the weight passes to the big toe, which completes the thrust to bring the centre of gravity onto the next point of support. This mechanism of the foot coming into contact with the ground is a rear-forward “roll”, that is, from heel to toe.

When Running

In the landing phase of running, the foot comes into contact with the ground at the outermost metatarsal, behind the little toe. This is followed by rotation on the longitudinal axis, called pronation, which progressively brings all five metatarsals into contact with the ground, allowing for better distribution of the impact on five joints as opposed to one.
Contact then continues with the heel, which recruits another shock absorber to handle the impact, the arch. This flattens, dynamically extending the foot. This mechanism not only permits the shock of contact to be absorbed with the greatest number of joints available, but above all storage of much of the energy dispersed in the landing phase in the elastic system made up of plantar fascia, Achilles tendon and calf, making it available for the thrust phase.

This mechanism calls for quite a complicated explanation from both a physiological and biomechanical perspective, with specific references to types and times of muscle contraction and lengthening. We’ll attempt a summary, however.

The foot, tibia and fibula make up a system with two lever arms, a fulcrum – the ankle – and a musculotendinous system that connects them like an elastic band: plantar fascia, Achilles tendon and calf.

When the foot is about to come into contact with the ground, the angle between foot and leg is greater than 90°, so this band is loose. The angle starts to decrease upon impact under the effect of the body weight, and the band lengthens progressively, storing energy until the point of greatest extension.
This corresponds to maximum ankle bend, the point at which the pelvis passes over the point of support.

The landing phase ends here, and the thrust phase begins. The angle between foot and leg starts increasing again and the band shortens and returns to its typical dimensions, releasing the energy stored. This mechanism guarantees a significant energy saving, since the more mechanical the process (with a near-0 caloric expenditure, tightening the band) the less a chemical component (muscular contraction) is required. This would, in contrast, use up the body’s internal energy resources.

**Step Frequency, or Cadence**

As far as step frequency, also called cadence, is concerned, there are appreciable variations even within the same motor scheme. We can however provide some broad reference figures.

Slow walking can of course involve very low frequencies, while vigorous walking can reach 120 steps/min or as many as 150–160 steps/min in top-level sport. Running involves frequencies from the 190–195 steps/min of a high-level marathon runner to the 240–250 steps/min of a sprinter.
Step frequency is a factor of great importance when considering efficiency in running. Low frequencies, between 160 and 180 steps/min, translate into long stretches on the ground, and hence excess load on the knee and hip joints, as well as reduced – or even absent – elastic reactivity, so that the thrust is entrusted almost entirely to muscular activity.
Direction of Foot Towards the Next Step

The differing ways in which the two motor schemes direct the foot to the next step result directly from the different frequencies required. When walking, it occurs through an alternating motion, with the hip as its fulcrum and the leg long, since low frequencies do not require particularly rapid movements.

When running, however, a long leg would be very counterproductive in terms of both force and speed when moving, due precisely to the much greater frequencies involved. The solution is to shorten the leg, bending the knee and bringing the foot beneath the buttock. This gives us a short limb that moves forward quickly from its rear position.

Efficient running, resulting from the basic motor scheme, is based precisely on maximising elastic response. This involves almost no energy expenditure, minimising the thrust from muscular action, which instead expends a great deal of energy. (5)
Sprinting, Efficient Running

Everything that we’ve said up to this point leads to two simple but essential considerations.

All humans have an innate sense of how to walk and run efficiently, a capacity transmitted at a genetic level.

There is an archetype, an original model, for running as humans, with an identical biomechanical basis for every person, and this is the basic motor scheme.

For years, we’ve studied hundreds and hundreds of videos of amateur runners and compared them with professional runners and masters of the technique. In the end, we found the real champions of efficient running, the humans who demonstrate flawless application of the basic motor scheme: children.
Children run like Kenyan champions. Or rather, adult Kenyans run as if they were still children. You can tell the difference simply by watching a child run, if you have a trained eye: children run with their feet coming up close to their buttocks and with very high step frequencies, but above all you’ll never see a child run slowly – never.

But most adult runners, for reasons linked strictly to lifestyle and the prevailing culture surrounding running, apply a technique far removed from the basic motor scheme, which increasingly resembles the scheme for walking.
To start walking efficiently again, we first need to know the differences between walking and running, so we know what to do but above all what not to do. The purity of the two basic motor schemes must be restored, so as not to blend them into a third, hybrid scheme that’s unnatural, inefficient and has adverse effects on our physical health in the long term.

Lastly, we need to reinstate the true goal of running, the reason our ancestors evolved to have two different means of ambulation: *going quickly*, as quickly as possible!
The common view in the modern incarnation of running is that the decisive, challenging element is to run for a long time and over long distances, completely neglecting the importance of sprinting, really sprinting, the kind of running that allowed our distant ancestors to wear out their prey. This tendency to increase distance and time at the expense of speed leads modern runners to effect a mixed motor scheme that transfers many elements of walking into the scheme of running.
Our proposed training method is inspired by the evolutionary and biomechanical ideas explained above and is based on the following concepts.

- Walking is different from running.

- Sprinting is a demand for maximum efficiency, allowing the basic motor scheme to be restored by putting it into effect.

- Using the basic motor scheme promotes self-correction in motion, improves mechanics and performance and reduces the risk of injury.

- Fast sprinting in combination with walking allows the motor schemes not to be confused, but reinforced in their different original neural pathways.

In conclusion, in order to retrieve the basic motor scheme of running, it’s much more corrective and instructional to alternate very brief stretches of high-speed sprinting, brief stretches of more typical sprinting and stretches of brisk walking, in varying measures according to the goal of training.
Some recent studies seem to show that training stimuli that reproduce alternations of rhythm recalling the activity of our hunter-gatherer ancestors provide more intense, high-performance adaptation responses. (4) This method also allows distinctly higher muscular and cardiorespiratory work compared to gentler running.

Once the motor scheme has been reconsolidated, we can then determine the running speed in relation to the distance to run.

BIBLIOGRAPHY
