**Running Mechanics.**

We humans were, literally, “born to run”. Evolution built our bodies to walk ,run, stride for long distances at fairly fast speeds, probably to track down animals for food- and to run from them when they fancied us for dinner ! Compared to other large primates, we have a lot of running friendly characteristics e.g. shorter arms to balance the cyclic movement of the legs; lighter lower legs and thicker hips to allow the leg to swing like a pendulum; bigger and more complex feet to absorb shock and thick lumbar vertebrae also to absorb shock forces. Furthermore, our muscles, tendons and connective tissue act like natural springs, slings and pendulums that store energy during the gait cycle and then return it on the next step. Unfortunately, our sedentary lifestyle has seriously undermined our ability to use those natural gifts. We sit and lie so much that our hips have become tight, our hamstrings and calves shortened and our glutes weak. Our bodies have almost forgotten how to move the right way.

Running is a neuromuscular skill, performed in accordance with the principles of biomechanics and dependent on metabolic energy. And because it is a skill, it needs to be learned . Many runners and coaches tend to be sceptical about this as they argue that running is a natural activity which everybody learns in the same way as they learn to walk. But this ignores the fact that ,while everybody may be able to run, not everybody can run smoothly or efficiently. When inefficient movement patterns are refined out of a runner’s natural style through months or years of practice, movement economy improves, resulting in potentially greater speed or endurance. And so, we must try to identify the factors which will bring about greater running efficiency and prevention of injury. How do people pick up “bad” running patterns to begin with ? In learning movement, we often learn by imitation of what we see and from sensory feedback. But children don’t often get the chance to see world class runners . So,instead, we see joggers in the park or neighbourhood or we watch footballers who are notoriously awkward runners. ( Laro Byrne always noted the manner in which footballers carried their arms up high on their chests , thereby getting almost no benefit from arm drive. He’d say“ Send them out for a few 20 mile runs and their arms will come down soon enough”) Joggers often run with various parts of their bodies seemingly moving in all directions – except the most important one. Running with good mechanics transfers most of your effort into ***forward*** motion.

To understand the reasons behind proper running mechanics we need to learn ( or revise ) a few simple laws of physics. *( Dr.Jayme Rossiter will probably correct me on some of the following points -I will bow to his superior knowledge ! )* **1. A body in motion will stay in motion unless some force acts to impede its progress.** Every time your foot hits the ground, the foot-ground reaction acts to slow you down. Every millimetre that your foot strikes the ground in front of your centre of gravity will further increase the braking effect on your forward momentum. Your centre of gravity is the centre of your weight distribution and is located at the back of the pelvis. Most of us over-stride, that is we land too far in front of an imaginary vertical line dropped from our centre of gravity to the ground below us. This causes us to land on the heel of the outstretched leg and, as well as wasting energy, increases the risk of injury due to excessive shock forces. Our feet should hit the ground more directly under our hips**. 2. Stretched tissues store potential energy** . Our bodies are made up of sinewy connective tissues that stretch under the load of our body weight when we hit the ground. Just like a rubber band that snaps back to its original form, the rebounding tendons ,ligaments and fascia give back that stored energy and provide many of the forces needed to propel us forward.( Sport scientists refer to this as “the stretch shortening cycle” or SSC ) We can harness this elastic energy by keeping our connective tissues flexible and by “running tall*”. ( We first started to hear this phrase from young Clonliffe athletes returning from the US in the early 1970s, where they had been on athletic scholarship. Other variations on this same advice were “ Get your hips up “ or “ Get your butt up” ! )* **3. The Pendulum Principle.** A pendulum requires very little energy at the beginning of the movement to stay in motion. The most efficient way for our extremities to swing through the air is for them to act like pendulums. But pendulums require gravity to keep them moving because when they swing forward, they hold stored potential energy because gravity wants to swing them back to the bottom of the arc. With little muscular energy at the start of the arm and leg swing ,your extremities will return to their place of origin and save muscle energy.

Steve Magness, in his book ***The Science of Running***, compares the hips and core of an athlete to the chassis of a Formula 1 car. He says “ A strong chassis is key to a Formula 1 car’s performance, otherwise it would flex on its frame and wobble on its misaligned wheels. Similarly, running with weak hips ( wobbly axis ) and a weak core ( sagging frame ) wastes forward motion and energy is lost in excess body movement”.

Dr. David E. Martin and Peter Coe in their book ***Better Training for Distance Runners*** showthat during a 10 mile run a 130 lb. ( 59 kg.)runner with a 5 foot ( 1.52m.) step (or stride) lands 5280 times per foot. This has a force of approx. 612 tons or approx.625,000 Kg. ( 625 *tonnes* ) The greater the length or intensity of the run , the greater the stress and thus the risk of injury. But if an athlete wishes to improve, he simply must train extensively and he must be prepared to endure the enormous stresses to the lower limbs which such training involves. Therefore, he should take the necessary measures to ensure that his body is strong enough to withstand the stresses produced by long and or fast running. “ Loose biomechanics” can put a lot of stress on the body’s joints, ligaments and muscles - the kind of stress that ,in time, can lead to injury. Weight training, core work, plyometrics and general strength and conditioning were all discussed as means of strengthening the athlete’s body overall in a previous article for Coaching Corner. ***( cf.Complementary or Supplementary Forms of Training )***

Podiatrists regard running as ***“ an integrated series of anatomic rotations that propel the body through space***”. The kinetic chain of bones that cope with the impact forces upon landing, and the push-off forces upon take-off, extend from the spine to the foot. There are three distinct phases in a running gait cycle : **foot-strike , mid-support and take-off**. There are also three phases to the recovery period : **follow-through, forward-swing and foot descent**. Those last three phases are sometimes called *“the float”.* ( This, of course, is not the same as “a float recovery” which elite runners sometimes use in interval training ; this involves running the recovery phase at approx. 6 min. mile pace . Not easy ! ) While running ,the trunk should lean forward minimally ; this reduces the load on postural muscles, which will be stressed least if they keep the large percentage of body weight made up by the trunk and head ( 60% ) directly over the point of ground support. Running is a kind of bounding, as there is a period in the gait cycle during which the runner is airborne. Hip flexion and forward rotation of the pelvis start moving the thigh forward. Various studies have shown that **it is** **hip flexion**, achieved through action of the iliacus and psoas muscles **, which is the single most important contributor to forward limb motion**. Both stride frequency and stride length increase as we run faster ,with stride length increasing more than stride frequency. A runner’s most efficient stride length ( the length that is least energy costly in terms of O2 consumption ) typically occurs subconsciously**. Intentionally lengthening or shortening the stride length predisposes a runner to premature exhaustion from excessive energy utilisation. Runners should not attempt to increase stride length beyond that which intuitively seems natural for them. Neither should they try to get extra propulsion by consciously pushing off with the toes. Forward propulsion should come from the hip: once the hip is extended, leave the foot alone .** The most efficient runners decelerate least at foot-strike, have the least vertical oscillation and get maximal forward movement with every stride . **Foot-strike deceleration tends to increase with over-striding**. Decreased vertical oscillation and reduced deceleration at foot-strike both conserve energy **.It is increased lower limb strength that will result in the most energy-efficient stride length.**

**Hip stability is vitally important in running.** According to biomechanical principles , probably no part of the body is more vulnerable to tissue stress than the lumbopelvic region, which includes the fourth and fifth lumbar vertebrae. This region has a critical role in maintaining stability and balance when movements are performed with the legs and arms. It is “the hub” of weight bearing. The faster an athlete runs, the more powerful is his rotational arm and shoulder motion. This places increased demands on his pelvic rotational stabiliser muscles and ligaments. Some hip rotation is appropriate in helping to increase stride length , but if hip rotation is excessive, we get an inefficient force application on accessory muscles instead of the prime movers, which not only decreases running efficiency , but also increases the risk of injury in either the involved muscles or their tendons.

**Runners tend to have weaker abdominal muscles than lower back muscles** because the latter are developed from running but the former are not developed enough by exercises such as sit-ups. A practical tip is that, if doing sit-ups, runners should include strengthening of the oblique abdominals by adding a rotational component to the sit-up.

**Is running style important ?** Well, it depends on what is meant by “style”. Efficient running style is a blending of all the separate movements of the trunk and limbs so that , along with optimal mechanical efficiency, a runner also appears to use minimal effort for the task required. Such a runner will be described as “smooth”. So “running style” suggests a combination of biomechanics and visual appearance or form. **Consequently, if we try to improve a runner’s style, we should be searching for improvements in biomechanics that will help to reduce the cost of movement.**  Some people will say that runners like Zatopek did not have a very pretty style -but he was pretty effective ! Some people will argue that one’s so-called “natural style” is not only the best but unchangeable. This ignores the fact that the nervous system has great adaptive capabilities that can create improved movement. ( Suppose Zatopek had a more effective style ? Would he have been even greater than he was ? Admittedly, there isn’t much room for improvement for a guy who won the 5000,10,000 and marathon all in the same Olympics ! ) A study by Marjorie Beck (1966 ) of young American boys illustrated the plasticity of the nervous system. As the boys matured their running style changed; this was effected by improved biomechanics and good coaching and resulted in five distinct changes which made them better runners . These were: \***Longer running strides. \*Foot-strike coming closer to a point under the centre of gravity. \*More float time. \*Decreased vertical oscillation. \*Increased knee flexion at the end of forward swing**.

Obviously, the earlier in an athlete’s career that attention is paid to correcting faults, the better, as movement patterns are less ingrained. But constant attempts at correction should be stopped if they are only proving counterproductive. Let us look at some areas that can be improved :

**Foot placement :** When an athlete runs in a straight line ,successive foot placements should be parallel with each other and in the direction of running. This will help reduce rotational torque about the ankles and knees ,as well as minimise stride shortening from splaying the feet. Foot contact should occur on the outside edge of the foot and, depending on speed, either at the mid-foot or forefoot. The initial contact on the outside of the foot is not felt and instead should be thought of as a simple mid/whole foot landing. Initial contact should not occur on the heel – even when running slow. Heel strike results in a higher braking force ,reduced elastic storage and prolonged ground contact. Once landing has occurred, it is important to allow the foot to “load up”. Remember that it is only when the foot is on the ground that force is transferred into the ground. “Loading up the foot” means allowing it to move through the cycle of initial contact to fully supporting the body. Since initial contact is on the outside of the foot, the support will move inwardly. With forefoot strikers, the heel has to settle back and touch the ground to allow proper loading of the Achilles and calf-complex to occur. This complex acts like a spring : it stores the energy that comes from ground contact and then releases it when ground contact is broken. **A common mistake is to stay too high** **up on the balls of the feet, never letting the heel touch the ground**. When this occurs, the Achilles calf-complex is not fully stretched and you are losing out on the elastic energy return. Similarly, if the runner is “too quick with the foot”, meaning he tries to rush it off the ground ( believing that he should get the foot off the ground as quickly possible ) ,elastic energy is lost because the foot and Achilles are not properly allowed to store and release energy. Likewise, the arch of the foot stores elastic energy as it is initially compressed and then subsequently rebounds. *I remember being told as a young athlete that if I were “ a real runner” I “would never let my heel touch the ground”. Even though I was inexperienced at the time ,I instinctively knew that this was BS; I recall myself replying to this Style Connoisseur “ Have you ever tried to run a 10,000m.track race without letting your heel touch the ground ? ”. I felt vindicated when the shoe companies started making distance spikes with small heels. It was not easy to run a distance race on cement- like cinder tracks wearing what were, in effect, sprint spikes !* **Ankle Flexibility :** Improved flexibility of the ankle joints can result in longer stride length. African runners, especially those who ran barefoot as children, seem to have the greatest ankle flexibility. Their style generally shows the knee of the supporting leg well in front of the ankle, giving the foot a greater range of motion throughout take-off. The longer the heel remains near to or in contact with the ground while the knee moves forward , the greater the pre-stretch on the calf muscles. A muscle will generate greater shortening if it has been pre-stretched before tension generation begins. This will increase both stride length and power. **High Knee Lift** : Running at high speed requires a high knee lift. Marathon running does not . I can remember when Jerry Kiernan had a reasonably high knee lift, as one would expect from a sub-four minute miler.( Jerry ran 3:58 back in 1976 ). But as he abandoned the track in favour of long distance road running and, eventually, the marathon his knee lift became increasingly lower , indeed he became a classic “shuffler” . A shuffle style( or shuffle stride) is ideal for the marathon as it is very economical and conserves energy. Indeed, many Japanese coaches who are in charge of the professional Ekiden teams recommend a shuffle style. For middle distance track running, however, a much higher knee lift is required. Faster running has a “bounding” component, it has a rapid ballistic stroke during the forward-swing phase so that the heel of the swing leg nearly touches the buttock. Increased knee flexion produces a greater “*butt kick*” or “*heel flick*”. **(** *“Butt kicks” was one of the drills recommended in a previous article.* ***cf. Complementary or Supplementary Forms of Training ).*** Returning to the concept of the pendulum, referred to earlier : the high knee lift allows us the time needed to be sure that the “pendulum” has finished its forward swing and is moving backward when your foot hits the ground. The high knee rise brings your heel closer to your butt and shortens the length of the pendulum that is your leg. Shortening the swinging lever reduces the energy needed to swing it through the air and therefore reduces the work your hip flexors need to do to pull your leg forward.  **Hip Flexibility :** The pelvis is the next joint along the kinetic chain and it has a crucial role in running. Its large size accommodates large muscles and these generate the powerful propulsive thrust of the plant foot as well as the flexor thrust of the forward swinging leg**. Lack of hip joint mobility limits stride length.** The iliopsoas muscle group, together with the large gluteal muscles and the adductor muscles , require specific strengthening and stretching to ensure an athlete’s ability to complete long, powerful strides when running fast. Remember again the words of Ron Clarke : “A runner can never be too strong around the middle”. Excessive forward trunk leaning often occurs as a result of a lack of hip mobility, therefore an increase in hip flexion can often lead to a more vertical ,energy-efficient style. The extension of the hip is where the power comes from when running. The hip works in a crank-like or piston -like fashion. A strong hip extension results in more force application and greater speed; how powerfully and rapidly the hip is extended helps to control the running speed. Once the hip is extended, the foot will come off the ground and the recovery cycle will begin. **Upper Body Balance** : The shoulders and arms are very important also in running. Although they primarily provide balance while running at slow speeds, they increase in importance in assisting the leg muscles as running velocity increases . How often have we heard the exhortation “ Move your arms and your legs must follow” ? The arms are also required to work harder when running uphill. Elbows kept close in toward the body minimise the tendency for the hands and arms to cross the middle of the chest. The elbow joint is flexed at about 90 degrees . The arms should swing fairly loosely and be held naturally. The arm swing occurs from the shoulders, so that the shoulders do not turn or sway. The shoulders should not be hunched nor should the chest be thrust out in front. The hands should be kept loose and relaxed at all times with fingers slightly bent. The hands should never flop around limp lettuce ! **Position of the Head** : The head should be poised above the shoulders; the only exception to this is if the athlete is “dipping” at the finish. The head is very heavy and ,if not positioned properly, it can cause problems. If it is too far back ,it places a strain on the neck muscles; if it is too far forward, it can restrict the airways and make breathing difficult. Many of us will remember the appalling “head bopping” style of Paula Radcliffe in her early career. It is significant that she did manage to improve it enormously as the years went by ; I‘m sure that this improvement contributed in no small measure to her success.

While athletes at first may have to consciously practise techniques for improving style , over time they can become automatic instead of voluntary movements and thus improve style and form. Stretching and strengthening exercises, plus various drills\* are the best or indeed, perhaps, the only way to make these improvements a permanent feature. ( again cf***. Complementary or Supplementary Forms of Training*** in Coaching Corner ) . *\* Drills, performed in isolation, have very little actual transfer to running. They are not particularly useful for improving mechanics because they do not replicate the running form biomechanically, neurally or muscle recruitment wise. Instead, running form should be worked on while actually running .* ***( This will not be possible when doing a hard session or race*** *) . The runner should just focus on one factor or element at a time so that he does not become overwhelmed by thinking about all the elements of style and form.*