Understanding the Kinetic Chain – Part One

My understanding of this unique description of the body's infrastructure has grown from a single statement from my early mentor Wilf Paish who, with this phrase, concisely guided me to a simple foundation to my training prescription – 'Train toenails to fingernails'.

As time has unfolded and training mistakes made and corrected (they are only mistakes if you don't learn from them) this stance has helped me enormously in my coaching career. I spent most of my coaching life serving as the provider of all four pillars of the athlete's needs - technical, tactical physical and mental - and just as these are interwoven into the complex fabric of the athlete's performance picture so I learned that just about everything else was connected.

It is in this context that my thoughts on the kinetic chain have been assembled. This journey took me from seeing the human body as a set of unique components that needed to be trained individually and then glued together by some coaching miracle, through to understanding that the synergy that creates human movement means that nothing works alone.

On reflection, I can understand why I started with this isolationist view. My tertiary education had put me in front of the forebears of modern sports science, a group of people who measured things and then played with all the numbers they collected. To measure they had to isolate and most things were presented to me neatly packaged in separate little boxes. I began my coaching career thinking that the energy release mechanisms of the body came in neat, separate packages – alactic / lactic / aerobic – and even thought that I could train them separately. Even today there are theories that focus on such isolation. In recent years there has been a focus on the muscles supposedly at the centre of core stability and researchers and many in the world of Sports Medicine advised that we should develop the skill of activating Multifidus and Transverse Abdominus as the key action. In Stuart McGill's *"Low Back Disorders"* he makes the statement, *"the reason for the clinical emphasis on the Multifidus may well be that the bulk of research has been performed on this muscle."* As educational as it was back then for me, sports science not only helped me but hindered me as I interpreted things in a 'paint-by-numbers' manner – just as it had been presented to me.

I was also taught the origins, insertions and major actions of individual muscles of the body. The result was that my teaching and coaching resembled this 'paint-by-numbers' process where I would choose individual muscle or small muscle groups and expose them to a training load and then hope for a miracle that the body would recognise the individual components and put them all together for me. Hamstring curls and leg extensions were a prime example as they appeared in my early exercise prescription – and it never really worked.

My career then put me under the wings of some very experienced coaches. These were men and women who spent their time teaching and coaching movements that formed a journey to sports-specific performance production. The explanation was quite simple for their exercise choice – *the sport / event demands 'all the body, all the time from top to bottom, front to back, side to side, in the correct order, at the right speed, at the right time – all the time'.* It seemed to them that if the contest demanded such a complex system of movement then the athlete should train that way.

Looking back I also think that these coaches simply had to find the time to do all this preparation in a world when athletes did their training after work. They had to 'get to the point' pretty quickly and so it was easier, and smarter to choose / create exercises that were multi-joint, multi-plane and multi-directional and encouraged all the body to get involved, rather than a piecemeal approach that took far too much time.

Now, here in the 21st century, we have all become appreciative of the incredible ability of our sports scientists and the overall medical profession as they use modern technology to research and confirm or otherwise those hard-earned teaching and coaching principles of yesteryear. They are blessed with the technology and opportunity to investigate and analyse what we, many decades before, worked out by trial and error.

There are copious statements from fellow professionals who, during their research, present illustrations of how this complex neuro-muscular set-up known as the 'body' conducts itself in a 'connected', 'toe-nails to fingernails' manner. Leon Chaitow a British Chiropractor stated, when speaking about the fascia:

"Any tendency to think of a local dysfunction, as existing in isolation should be discouraged as we try to visualize a complex, interrelated, symbiotically functioning assortment of tissues, comprising skin, muscles, ligaments, tendons and bone, as well as the neural structures, blood and lymph channels, and vessels that bisect and invest these tissues that are all given shape, form and functional ability by the fascia."- Leon Chaitow, 2011, JBMT 1-11

As he focused on the role of the fascia (an underrated component of the body's movement infrastructure) he clearly enabled us all to see the complexity and connection between all the components available to the human being in a physical setting.

Eyal Lederman in his book *Neuromuscular Rehabilitation & Physical Therapies* presented a strong case for training 'movements not muscles' when he stated, *"Muscles work in complex synergies – they never work alone. All muscles are important, even muscles that are silent."*

There are other descriptors and commentary that illustrate how the kinetic chain might be perceived. One cardinal rule that all teachers and coaches should keep at the forefront of their decision-making is that the body is self-organising. Right or wrong, the body will always attempt to complete the task even when parts of the 'chain' are compromised in some way. It may well 'pass the buck' between body parts as a physical puzzle is encountered and a body part fails to do its job. For example, according to Fryette's law of spinal (that big pillar that is involved in everything we do) motion, if motion is lost in one plane, it will steal it from the other two planes. The body will 'find a way or make one' and it is our job is to enable it to choose the most effective, economical and efficient pattern with which to solve the problem.

Vern Gambetta illustrates the phenomena of connection and linkage when he says, *"Movement is not an isolated event that occurs in one plane of motion. Rather it is a complex event that involves synergists, stabilisers, neutralisers and antagonists all at the same time to produce effective tri-planar movement".*

Joe Przytula, a world-class practitioner in New Jersey, USA, offers another illustration of how forces from all directions and planes influence what happens during motion. He was talking about issues with the Adductors but added a clear picture of other related structures and actions. *"Remember the adductors come off the pelvis; and forces coming 'bottom up' from the same side foot, & 'top down' from the opposite leg, torso, and arms also need to be taken into account. It sounds complicated, but it's really not. Trying to piecemeal individual muscles is what makes it seem complicated."*

The leading joint theory (LJT) – as described by Natalie Dounskaia (Exercise Sport Science Review, 2010 October; 38(4): 201-208) also infers the connectivity of the body parts.

The leading role is endowed to a joint that has mechanical advantage in the limb. Because of relatively high inertia and the increased musculature of the proximal limb segment, the mechanical influence of proximal joint motion on distal joints is much higher than the influence of distal joint motion on proximal joints. For this reason, the leading joint is often the proximal joint that acts similar to a whip handle, a single wave of which can cause complex motion of the cord.

However, the choice of the leading joint also depends on the task. If a task requires much smaller range of motion at the proximal than the distal joint, the mechanical effect of the proximal joint would be minor, and therefore, the distal joint may be more suitable for the leading role. In both cases, each movement is performed by exploiting a specific mechanical effect that can be generated through motion of a single joint.

These thoughts illustrate more about 'connection' and reaction along the kinetic chain. Dounskaia intimates that the role of one joint along with its properties, action and location when coupled with the specifics of the task creates the control of human movement in a cascade process. In sprinting, ground contact time is too short for proprioceptors to have any input. At high speeds, foot-ground impact force takes less than 50ms to reach peak magnitude and ankle inversion can reach 17 degrees in as little as 40ms. Under these conditions, the spinal reflex is too slow to initiate a corrective response. Frans Bosch believes that, rather than *reflexive*, this type of neurological input is contained in the muscles themselves. The latest research coming out of a recent Fascia Congress seems to support this. The "cross talk" that EMG technicians see on their monitors might just be a way that muscles communicate with one another. This is another example of how things are connected.

Understanding the Kinetic Chain – Part Two

From another viewpoint teachers and coaches who work at the 'coal-face' of sport are often the primary source of discovery when performance attainment is high on the agenda. Never underestimate the anecdotal lessons learned from these masters of movement efficiency, consistency and resilience production.

A good example of how the 'chain' sequentially produces the required movement and force can be seen in throwing activities. The Javelin Throw for example has some quite relevant cues that are used regularly by coaches:

"The throw has to be built up from the legs."

"The weight transfers from the back foot to the front foot."

"The Hip 'drive' creates torque at the shoulder. The Shoulder 'punch' creates torque at the hand"

"The slow-moving muscles (Legs, Hips and Trunk) work first with the faster muscles (Shoulder, Arm and Hand) moving last."

"Chin, Knee, Toe (the landing on the right leg after the penultimate stride), "Make a Bow" (drive right hip forward; leave right shoulder behind). "See it Go" (brace the left-hand-side, chest up).

These cues and clues presented by the coach to the athlete form part of the 'art' of coaching, the point of interaction between the two parties involved in the journey. There is never one way of doing anything when it comes to the coaching process and so the teacher / coach will explore myriad cues and clues as they try to find the one word or circumstance that the athlete reacts positively to. As science uncovers more about all the systems involved in learning a skill so this information is used by the coach to assemble the coaching 'tool-box' of guidance and discovery.

Science is there to make me a better artist – Bill Sweetenham

These are examples of a movement pattern and not robotic action of individual muscles. Within each movement, the muscles, connective tissue and bony structures (the levers) are continuously reacting to the influence of a range of factors e.g. gravity, direction, amplitude, speed, the arrangement of other body parts, metabolic energy providers, etc. Nothing works in isolation so the salient point is why isolate body parts?

Modern-day gymnasiums are the haven of many exercise machines and although some activities are suitable for them I see them as 'kinetic chain killers'. I have an adage that if you are sitting down to exercise then you chose the wrong exercise (apologies to Rowers and Cyclists!). Most sports do not take place in a sitting position so why do it? *Very often these machines confine you to one plane of movement (usually the sagittal plane) whereas in all field and court sports you will need to be effective in all planes, usually in all directions, at all times. Also, the design of the machine does a lot of stabilisation for you as one invariably leans on the machine for support (especially when fatigued). I am not sounding the 'death-knell' for machines, far from it. There are a number of machines out*

there that do allow for adjustment and do allow certain actions to be functional (pulleys, etc.) but in general terms, they interfere with the natural rhythm of 'connection' and 'reaction' – two major pillars of movement (modified and adapted from Gambetta, 2010).

'Build the athlete from the ground up' is something I say a great deal – often to the chagrin of listeners. I say it because of what I face each day as a coach as the athlete attempts to overcome a stage of progression in their journey to repeatable excellence. I have found out the hard way that if I allow a limitation to become permanent it will raise its ugly head just when I thought I was safe. This same principle applies to the 'kinetic chain'. If we work diligently on creating all-round movement efficiency and reject 'fast-tracking' or 'quick-fixing' where we dash ahead to sports-specific actions and postures prematurely, we might just have the time to see if things are working efficiently, economically and effectively along this movement 'chain' from 'toenails to fingernails'. In other words we will coach / teach with best-practice in mind.

Our job as teachers and coaches is to create a journey of adaptation for the athlete where they develop mechanical efficiency, mechanical consistency and finally mechanical resilience (effective, economical movement under speed, fatigue and pressure). To do this we must not only understand the parts involved in the journey but also the interactions and the consequences of these interactions. We must know what dysfunction is and what is not. Too often we spend all our time looking for dysfunction through copious assessments yet fail to understand that for most people there is no such thing as symmetry along this kinetic chain.

Dominant v's Dysfunctional

We should guard against seeing a 'dominant' body part as being automatically dysfunctional. In all sports, particularly those that involve striking, kicking and throwing, the athlete has a dominant side or limb that leads the technical aspects of the sports-specific movements. Rather than see this development as being a problem one should always remember that while the dominant side is doing its 'thing' the non-dominant is carrying out its important counter movement patterns.

In view of these findings, we propose that distinct neural control mechanisms are employed for dominant and non-dominant arm movements. J Neurophysiol 2002 Nov; 88(5):2408-21. Handedness: dominant arm advantages in control of limb dynamics. Bagesteiro LB, Sainburg RL.

We also make the mistake of falling for the new jingoistic language of the modern-day performance gurus and fall into the trap of disconnecting when we should be connecting. 'Posterior Chain' exercises are a typical example of this along with 'Activation' exercises. The posterior chain cannot exist without all the other so-called 'chains' being involved – it is all one complex chain of events when someone moves. I hear people talking about 'Gluteus activation' when it is common sense to know that if your Gluteus were not activated you would probably fall over! Dr Marco Cardinale summed up this fact when he said, *"Unless the patient/athlete under observation had spinal cord injury and/or is affected by a neuro-degenerative disease, it is physiologically impossible for the Gluteal muscles not to be active (or not to 'fire').*

Understanding the Kinetic Chain – Part Three

The Kinetic Chain and Injury

'He who treats the site of pain is lost' – Janda.

Obviously one of the first sites to examine when an injury occurs is the actual site of injury. Immediate first aid is rightly the common occurrence after trauma. However, trying to work out the reason for the injury is a far more complex journey and it is on this journey that we are assisted by 'connection'.

In his paper The **Influence of Abnormal Hip Mechanics on Knee Injury: A Biomechanical Perspective**, Christopher Powers stated, *'Given the fact that patients with knee dysfunction*

comprise a large portion of orthopaedic practice, there is a need to understand the risk factors associated with a knee injury as well as primary injury mechanisms. Research conducted over the last decade suggests that the causes of knee injury may have proximal origins. For example, prospective and retrospective studies provide evidence that hip muscle weakness is associated with knee injury. Furthermore, studies conducted by Zazulak and colleagues have reported that impaired trunk proprioception and deficits in trunk control are predictors of knee injury in female athletes. In a recent review of the literature, Reiman, et al, cited articles that provide some degree of epidemiological, neuromuscular, or biomechanical evidence to support the concept that proximal factors may influence knee loading and, therefore, contribute to injury.'

Here, Powers illustrates the influence of joints and muscles distal and proximal to the injury site as having a profound influence.

When a segment of the body fails to do the job it was designed for it is likely that the responsibility will be transferred to another part in the hope that it can do the task. This is known as compensational shift. In some cases, this transferred force or range component of the required action falls upon a body part that is ill-equipped to do the job and can easily overload.

In some injury situations, it is possible that the problem grew from a poor movement pattern which created compensatory movements as the body sought to solve the repeated puzzle of the sports-specific action or posture that it was continuously exposed to. By ignoring (or not looking for) movement inefficiency within the sports-specific action or posture the compensatory movements can begin a spiral towards injury. Be wary of creating the following journey:

Poor movement pattern + inappropriate training and load progression = compensatory movements and postures
Continue the same training = micro trauma
Continue the same training = degeneration and macro trauma
Continue the same training = catastrophic tissue failure

Growth and the Kinetic Chain

For all those dealing with the growing athlete this picture of a connected system of levers, each dependent upon what happens around it, is an important tool in the teaching / coaching toolbox. A watchful eye will readily see the growing child encounter their growth spurt. For the uninitiated, it may well be the time that you look on in wonderment as an athlete arrives for training looking, for the first time, like a giraffe.

Do not underestimate the changes that are taking place during this 2 – 3 year period and certainly be ready to adapt and adjust the manner of your teaching / coaching. This is not the place to enter into a detailed commentary on all the details of the growth spurt that leads to that critical period of peak height / weight velocity but it is certainly worthwhile mentioning issues that affect the kinetic chain.

As the long bones accelerate in their growth they often leave behind the growth of the muscle and connective tissue architecture. This can lead to a loss of flexibility and function for a brief time. Add to this the fact that the 'self-organising' body is trying to stabilise these 'giraffe-like' long bones by creating what one might describe as a 'protective stiffness' and the problem of inflexibility may well raise its head. A lack of flexibility at one joint will be transferred along the 'chain' as the body attempts to solve the movement puzzle.

For example, if the Ankle joints are lacking in range (often due to an injury, scar tissue, the growth-spurt or any other pathology) during a triple-flexion activity like landing from a jump, the body will self-organise and ask other joints to help out. Under these circumstances, we may see the Knees going into valgus to try to compensate for this lack of range. If the Knees change their pattern it will obviously affect the part of the body that the Thigh bones are attached to – the Hips. Now the Hips have to reorganise themselves for the changes beneath them during the 'shock-absorption' stage of the landing. Don't think it stops there – the Spine sits on the Hips and connects to the upper body

and will also have to react to the alien patterns of force production, reduction and stabilisation that is occurring further down the movement pattern towards the floor.

These 'ground reaction' forces can be considerable every time the feet contact the floor in gait or landing. It has been stated that Usain Bolt experienced 10.5 x bodyweight each time his foot hit the floor as he sped to 9.58sec for the 100m. These are not insignificant forces that the body has to tolerate and so there is the powerful argument that movement must be efficient and consistent and that the total body 'chain' should be resilient to the cumulative effect of these forces.

Learning to Move

Movement efficiency can also be described as the neuro-muscular process that puts the body in the right position, at the right time, all the time so it can effectively produce, reduce and stabilise force. Consider this process always in a multi-joint, multi-plane and multi-directional setting. This is clearly illustrated when one looks at the fundamental sports skills of running, jumping, throwing, kicking, catching and striking.

While the young person learns to move by solving puzzles there is also the support of the parent, teacher or coach who should be knowledgeable enough to guide the student to the most efficient answer to the puzzle. This is teaching / coaching at its best when the experienced adult guides the student to the best possible technical model of the movement while at the same time allowing the child to 'falter....adjust....discover....falter....adjust....discover' – a powerful process of learning. To help the teacher / coach the body has an infinite number of solutions with which to answer the question and at the same time is governed by certain muscular-skeletal factors which form the basis of the technical model being sought. For example, certain joints are designed for certain actions just as certain muscles are designed for certain tasks. These naturally occurring phenomena form the basis of our technical destinations.

It is interesting to assess comments derived from the research associated with movement learning for example:

..the individual's capacity to produce and control a wide range of movements bears a direct relationship to the scope of his or her problem-solving capacity. Higgins, 1991

The point is that neither skill, nor strategy, nor movement can be imposed - they are derived and evolve as a function of experience by an active participant.

The learner discovers relationships between biomechanical, anatomical, physiological and environmental variables by the application of existing resources (movement vocabulary).

...cyclic process of discovery, mastery and re-application. Whitehead, 1967; Ellis, 1976

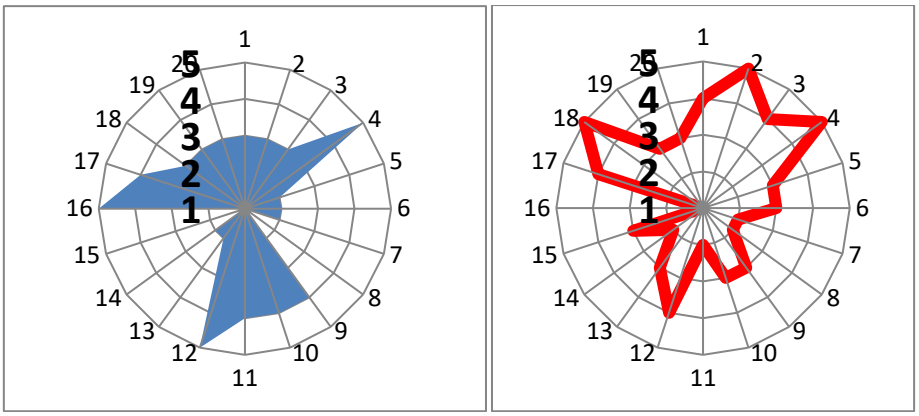
From this we can gather that one important means of developing movement efficiency is the solving of 'movement puzzles'. Put another way 'failure is an option'. The young person solving the 'puzzle' will recruit a series of tools to assist them and it is the process of solving the puzzle that leads to efficiency in the long term (consistency). In simple terms the following process is underway as the movement 'problem' is solved:

Gain insight into the task
Gain insight into the force problem to be solved
Fit the force problem to the movement
Progressively refine and gain control or mastery

For teachers and coaches to be successful in using this 'guided discovery' method with the developing athlete they will need one predominant tool – patience. Even though fixture lists will be present; local championships an attraction; 'trophy hunting' a trap, the key is patience. The main reason for this approach is the fact that the aforementioned 'growth-spurt' is unique in rhythm and timing for each

individual. For some it will be early and for others late in their maturation journey. Add to this the fact that in any given population of young people you will see early maturers and late maturers; fast adapters and slow adapters; fast learners and slow learners and fast recoverers and slow recoverers. With such diversity to accommodate it is likely that patience will be a necessity not just a choice.

In addition to this 'diversity issue' there is the fact that each developing athlete will present with a different movement competence than their neighbour. The following graphs illustrate the scores in as Physical Competence Assessment of two football players of the same chronological age.



The question that arises from this data is - *is the same training program appropriate for both athletes?*

So….after all this rambling the point is that the 'kinetic chain' is a complex collection of bio-motor components that work together – all the time. Each person adds to this complexity with their own unique neuro-muscular system that is different to their neighbours. Knowing this should assist the teacher / coach in their decision-making when it comes to exercise selection and prescription.

"One size does not fit all"

"Not only does the picture of the jigsaw-puzzle change but the pieces keep on changing"

"Train movements, not muscles"