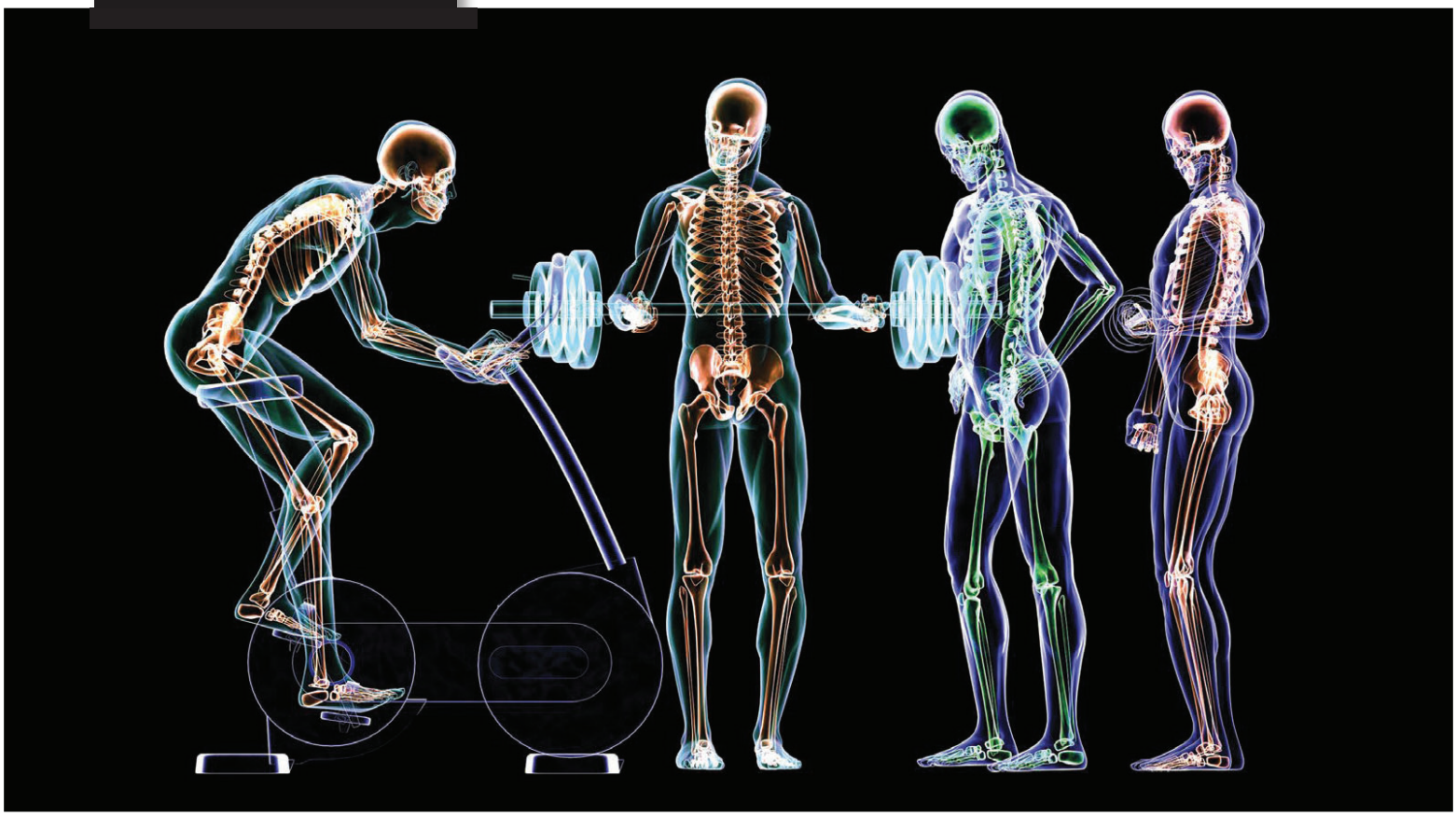


Understanding Human Athleticism

By Dr. Kiran Kanwar

Golf swing-related information abounds these days, so it is useful to ask a scientist what makes sense and what does not. This is especially true if he is someone who has researched human movement - much of it sports-related - from both an injury and a performance perspective. This particular scientist has also researched the golf swing, so he is the ideal person to weigh in on what matters most and what golfers should focus on and, conversely, what might not be suitable for their individual needs.

And that researcher is none other than Stuart McGill, a biomechanist of 30 years at the University of Waterloo. His website describes him as someone whose "Laboratory and experimental research clinic investigated issues related to the causal mechanisms of back pain, how to rehabilitate back-pained people and enhance both injury resilience and performance. His advice is often sought by governments, corporations, legal experts, medical groups and elite athletes and teams from around the world." Moreover, he has consulted for a number of top tour players over the years.

Having entered the field of biomechanics quite serendipitously, Dr. McGill was always fascinated by a single question — "How does the spine work?"— which eventually springboarded him into everything else that he has achieved.

He discovered, early in his career, that Borellian biomechanics (pioneered in the 17th century and known to consider the living body as a mechanical system of levers), really only applies to quasi-static situations, in which muscles act as pulleys around joints, with some muscles acting as agonists while others are antagonists.

When it comes to movement, however, Dr. McGill realized that it is the mechanics of the linkage of the body, in which muscles bind together through fascia, forming composites, and following the laws of linkage, while using stability and mobility. Thus the golfer is an "elastic" athlete, with the best players storing and recovering elastic energy in strategic pulses.

In fact he developed what was probably the most biomechanically and anatomically detailed model in the 1980s, demonstrating a depth of understanding of his ideas. His model could easily explain what has to be mobile and what has to be stable, for multiple multi-articular muscles, that are all bound in fascia and create movement together.

How does the 'linkage' work?

For instance, to be able to perform a strong push, working 'through the linkage', would require the torso (or core) proximal to the shoulder to be stabilized in order to unleash distal (arm, forearm and hand) mechanics, for a truly forceful movement. As such the body is continuously organizing stable and stiffened joints in sequences to unleash speed at distal joints and segments (in this case the club acts as the most distal elastic segment).

How is movement actually created?

When a muscle contracts, it creates both force and stiffness. If a muscle contracts maximally, movement cannot really occur because of the resultant stiffness. While measuring scores of athletes, he discovered that strength is performed in pulses. The best athletes, when creating speed and dynamic power, pulse then relax. In fact the great ones pulse and relax muscle six times faster than the average person.

Golf doesn't require strength. It requires storage and then recovery of elastic energy, just as one might use with a bullwhip. If a lot of force is put into a bullwhip, it will not crack at the end. But if it is moved with perfect timing and the right amount of stiffness and force in the proximal arm joints, it will crack.

Just prior to golf ball impact, if the mechanics have been organized correctly, the stored elastic energy can be unleashed into the club's shaft by the slowing down of the hips, pelvis, torso and finally the arms. This concept has not been explained by other biomechanists and, in general, Borellian biomechanics cannot explain fast, strong, powerful performance.

How did you get into golf assessments?

"I never set out to do a study on golf. It was driven by elite golfers coming to me with back pain and saying, 'What can you do about my back pain?' And I said, well, for me to understand the causative pathway, I need to see your golf swing. And then they said to me, 'Well, you're the first guy who's ever measured us in that way to try and understand how you produce the performance of golf.'"

So, his study of golfers was, in fact, a series of case studies, one after another. That's how he was able to recognize patterns. And then the more he got into it, the more he realized that there are some base patterns, but there's also very large differences in golfers, even at the top level. Those patterns apply all the way through the junior ranks, senior golfers and female golfers too.

What do you do next, after the assessment?

"I really work to assess the person and figure out what is required and what they're capable of producing; we have a good idea of how to train some base athleticism. I don't tune their final swing.

"At that point, I'll work with an elite coach. And there aren't very many, I hate to say this, who can then take the athlete and tune them for their specific phenotypes, anatomy, injury history, the architecture of their hips, to name a few. I need to document how they create the pulse before club/ball impact. For example, some are leapers (like Bubba Watson who actually leaps with hip extension just prior to ball impact) vs others who are turners and pulse with external rotation starting on the trailing hip and transferring to a pulse on the lead braking hip. That stiffness coming through the legs is the beginning of the crack of the whip to unleash the elastic energy through the linkage to the clubhead. And then there are the "smooth golfers" who make effortless swings but generally not for great distance.

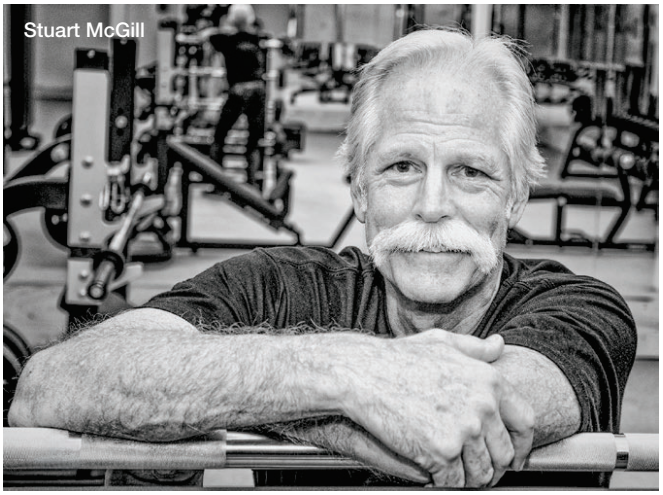
"My job is to get them out of pain and give them a base resilience and athleticism. I then work with the technique coach to complete the final tuning of getting them back on the tour with performance and resilience.

How should golfers know which patterns they exhibit?

"We put a lot of effort into assessing the person. And that assessment is at many levels." Dr. McGill prepares for each person by looking at swing videos before the golfer arrives, then spends several hours with them. First conversing with them. Then looking at their anatomy.

"Some people are naturally strong, and some people are naturally elastic, and some people are naturally neurologically quick. We develop different training programs recognizing their different traits and gifts.

"It also requires an understanding of injury history and mechanism - not all humans are equal."


Stuart McGill

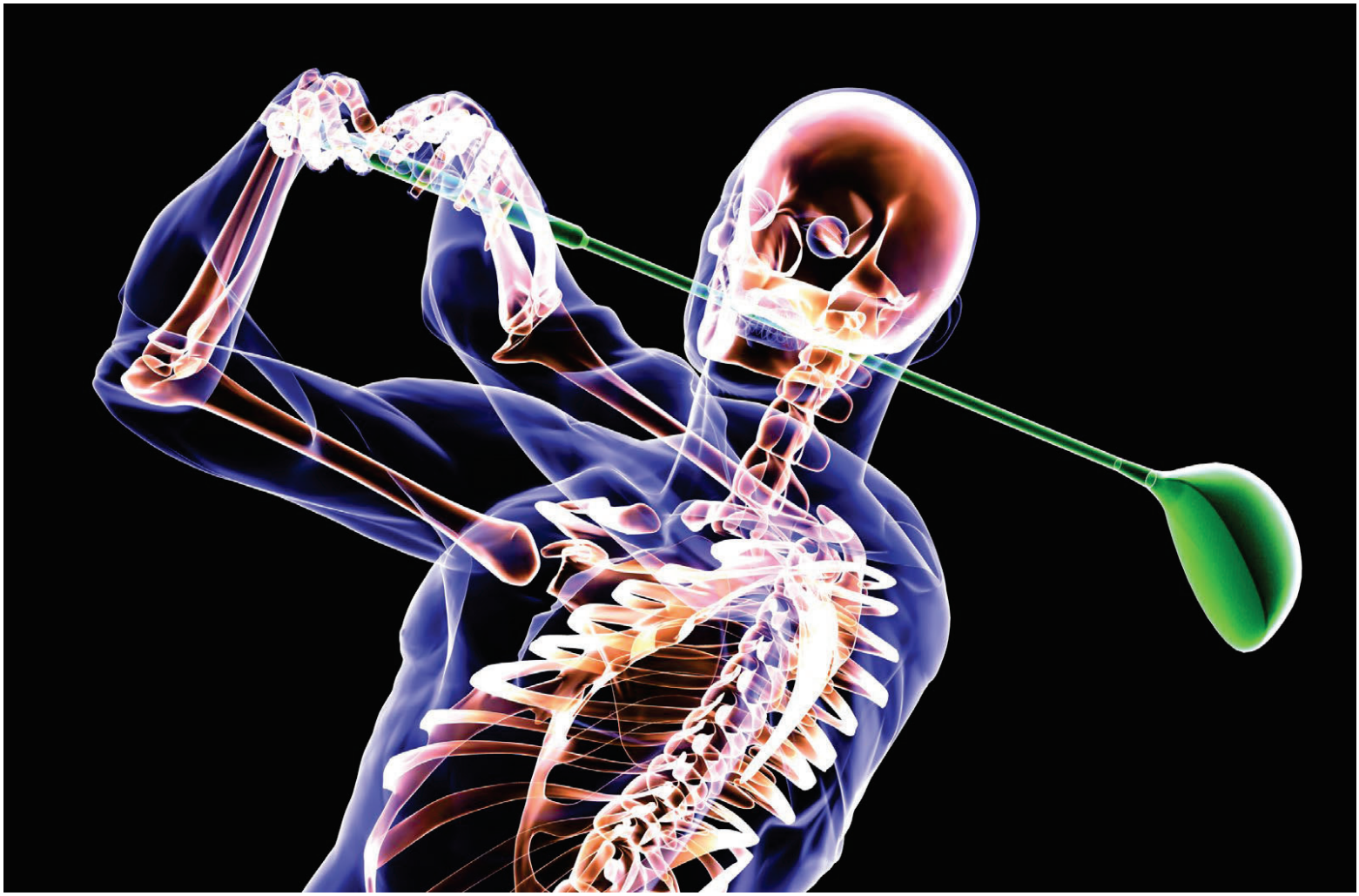
The most common patterns?

Golfers are usually categorized as primarily "twisters" or "turners" although there is a spectrum.

Twisters "really twist the spine and have a large X factor, storing elastic energy in some body parts and stressing some body parts to the point of pain in other parts.

"Turners will exhibit internal and external rotation of the hips with much less storage and recovery of elastic energy in the spine. If a person has tremendous internal-external rotation in their hips, that's fantastic and their style should optimize that."

To assess a golfer's athleticism, Dr. McGill uses force plates. "I measure whether it's a leap or an external rotation or just a smooth swing. Whatever it is, I follow the forces through the linkage. I measure the muscle activity through electromyography. Is the timing of the pulse right? What is the position of their spine and hips at the time of the pulse? And then I try and optimize the specific swing for that individual to reduce stress on the painful parts and optimize performance in a way that suits them."



Does typical golf coaching take all that into account?

"There are coaches that have in their mind the ideal golf swing, and then they get their students to learn their particular style."

As a result, Dr. McGill will often encounter this situation: "When I get a wonderful PGA golfer, whose livelihood it is to play golf in a sustainable way, meaning that it has to be physically sustainable, they've been screwed up by a coach who was teaching them a swing that may or may not give them a few more yards on their drive, but it doesn't suit their body, and they get hurt. And in my world, they come and see me with their backs."

How does your concept 'proximal stability for distal speed' help golfers?

One hallmark concept from Dr. McGill is his utilization of proximal stability for distal speed. If the operator of an excavator doesn't put down the stabilizers into the earth, when dirt is pulled with the bucket, the entire tractor moves. Well, that's not being athletic! However, if you hold down the base of the tractor, the bucket can now dig earth. That's an example of creating proximal stability to unleash distal athleticism.

Or, to use his arm-push example, the shoulder push force is created by the pec major muscle. Proximal to the shoulder joint, that muscle force bends the rib cage toward the shoulder. This is a waste. But if the torso is stiffened to arrest the rib cage movements, then 100% of the pec major muscle is used to rotate the upper arm. This results in much greater arm speed.

Similarly, in golf, if a force-plate trace were to show a golfer who just swung without transferring weight onto the foreleg to use as a brake, they wouldn't uncork the energy. "The key is, can a golfer create a brake just before ball impact and then unleash the elastic energy in sequence through the distal parts and finally to the club shaft and head?"

"What is needed is a tuned stiffness that should instigate the downswing, with a secondary pulse just before ball impact. If you measure someone who can hit a long ball, it's this pulsed strength that we're talking about. It's a timing issue of when appropriate muscle pulses occur and a strategy issue."

But what exactly is a 'pulse'?

Golf is impact at the end of the day. It's the violence of the clubhead hitting the ball. That's what you're trying to optimize. You want a high force of collision of the golf club and the ball. "Club speed is assisted with sequenced linkage movement from muscle contraction, but the contraction is tuned to store and recover elastic energy, together with a small pulse that initiates a form of "cracking the whip."

If a golfer has a slow pulse, the whip does not crack optimally. It's got to be just a brief little pop, and sometimes it's quite subtle. The pulse has to be coordinated and tuned to the stiffness of the person's body and the flexibility of the club's shaft. All of this matters because it's a mechanical system.

If it's too stiff, you don't get the speed. And if it's not stiff enough, you don't store and uncork the elastic energy. Somewhere in that system is an optimal amount. It's like tuning the suspension of a car – soften it to make it more compliant on rough roads, and stiffen it more in an F1 racing car travelling at speed on smooth roads. If you add more horsepower to a race car, you have to stiffen the chassis.

But stiffness is not what many golfers assume it to be – it is not something that needs to be stretched out! It is a muscle/fascia system stiffness that is constantly being tuned.

"I am referred golfers who have debilitating back pain - it's a combination of inappropriate strength training and inappropriate coaching of the swing itself, given their particular body type, their injury history and current pains." – Stuart McGill

What is the 'buckle' in the spine that you refer to as a power leak?

You're transmitting force through a linkage. In golf, the majority of the power is created in the hips about the internal/external rotation axis. Then it needs to be transferred through the spine. The hip power can be potentiated with spine elasticity. In physical terms, this means stiffness. Stiffness is tuned with muscle activation. Too much creates a rigid spine and too little creates a wet noodle - both of those rob performance.

Which are the main muscles for producing power in the golf swing and are they lead side or trail side muscles?

Every muscle in the body is involved. The body is a composite. All muscles are connected through the fascia, and the fascia stiffness is tuned with strategic muscle coordination. In this way, the old concept of muscles being agonists and antagonists disappears. They are all agonists.

For instance, the main rotational muscles of the core are the external oblique, internal oblique and transverse abdominis. One could measure the individual contributions of each of these muscles, but when they are bound in fascia, the total output is much larger than the sum of the three muscles. The fascia holds them together, so the muscles form a composite that creates superstrength and superstiffness. It works to put these muscles together in multiples, so when they're working as a composite, the force, the stiffness and the speed are all accelerated. Elite golfers form composites with their bodies.

Which muscles? For those (most golfers) with internal-external rotation of the hips as the dominant source of power, it's the hip rotators. Those who don't have that hip ability may make up for it by using their spines a lot, and they are more "X-factor, spine twisting' kinds of golfers. If they have back pain from twisting, they can't use that X-factor style anymore. If possible, coaching should focus on using a more hip-dominant or other spine-sparing type of swing.

Some golfers should avoid trying to create more power through ball throws and other such exercises. It requires the right amount of tuned pulsing power in the context of the distribution of stiffness, stability and mobility. Also, when pain or discomfort occurs, stress concentration matters. If there is going to be an injury, it will most likely be at the point of highest stress concentration.

What can a golfer do to produce more speed?

The backswing stores elastic energy. Pay attention to the dynamics of the skeletal linkage namely, the pulse, as they come into the ball impact phase; the strategy they use to create the whip, which results in clubhead speed. Then there will be controlled eccentric contraction in follow-through for control and accuracy. How is muscle pulsing trained? It depends on the athlete, but can be quite an involved process and is one of the more difficult athletic skills to train (explained in the video The New Science of Golf).

Tasks like Olympic lifting do train the pulse, but are rarely suitable for most golfers. Many ended up with debilitating back, knee and hip pain.

What are some truly egregious things you've seen in the golf swing and fitness coaching?

"I am referred golfers who have debilitating back pain - it's a combination of inappropriate strength training and inappropriate coaching of the swing itself, given their particular body type, their injury history and current pains."

Usually, when I see a golfer who's been told to have a huge lateral crunch, the hips are way ahead of being neutral at ball impact, so they're crunching with their spine to create that stop and brake motion to really uncork the energy out of the body. In fact, we have measured the crunch in some swings exceeding 100% of their voluntary lateral bend range and at top speed and effort. That is a coaching style that has disabled PGA players and college golfers through the spectrum. That's one of the primary mechanisms of the injured players coming to see me.

Or they've been given inappropriate strength training in terms of very heavy loads in things like squats and deadlifts without adequate time off to recover and not understanding that it wasn't sagittal plane deep squat strength that was the deficit. Instead, they would benefit more from internal-external rotation of the hips in terms of motion strength and speed.

So where can a golfer get really good information about how to maximize his/her swing as well as train appropriately for it? By going to Dr. McGill's website backfitpro.com and acquiring the video The New Science of Golf. AG

Dr. Kiran Kanwar, golf science consultant, is the developer of The Minimalist Golf Swing System – 100% scientific, simple, and specific. She has M.S. in sports science and nutrition, a Ph.D. in biomechanics, an anatomy a degree in Kinesiology and is an LPGA Master Professional. Visit her websites www.YourGolfGuru.com and www.mgs.golf.