Science And Golf

Science has actually contributed very little to the discoveries made in golf. It usually only confirms what has been proven through the endless trial and error experimentation that takes place every day on golf courses throughout the world. The greatest contribution of science has been in the refinement of innovations after a scientific analysis has shown that it works and why.

Thousands of subtle muscle movements are involved in a golf swing that takes a little less than a second from start to finish and a collision that is completed in 0.0005 seconds. All of these movements are to be learned in motor memory and required to perform in the right sequential order with precise timing.

Science has shown that if the clubface is ½ degree less than square to the ball, the ball can go off course by 20 yards. Additionally, if the downswing is the slightest bit curved, the ball can slice 30 yards off course and travel a much shorter distance. Furthermore, a difference in velocity could mean a ball landing a few feet from the hole or rolling off the green, a change as much as from 110 miles an hour to 111 miles an hour. Finally, if the ball is struck ¼" too high, it will weakly dribble its way into the fairway whereas striking it ¼" to low will shoot the ball up to the sky landing the ball short of the target.

Weather consideration has to be taken into account. If one is expecting to adjust a shot for a 20 mile an hour headwind that mistakenly turns out to be a 30 mile an hour headwind, a 120-yard approach shot will drop 20 yards in front of the green instead of at the pin. Characteristically, golfers use a lower trajectory shot that is less affected by high winds than the high arching shot, the tradeoff is that the lower trajectory/higher velocity shot will have more difficulty to stop as quickly.

Golfers are of all ages and the golfer's game changes in relationship to flexibility, strength and mental sharpness. The bone continues to grow until the late teens or early 20s with the greatest width and density peak occurring at the age of the 30-35, and from then on, the bone density starts to decline. Posture is continuously changing due to gravity. With bad posture, biomechanics change as do swing dynamics.

Science and physics of the perfect swing has been a challenge for golf athletes, instructors and investigators. Although computerized models of physics, velocity, levers, momentum, distance, speed, range of motion and flexibility have been calculated, it has become difficult to apply this information to every individual. The reason for this is that everyone possesses unique physical characteristics (height, weight and body frame; as well as differing athletic skills such as speed, quickness, strength, flexibility) making these unique differences difficult to take into under one instructional model.

Science has always focused on the power of the swing using a

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Wrist Joint, Fingers and Hands
Hip Joint and Pelvis
Ankle & Knee

Musculoskeletal Disorders
Cervical Pain
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Lower Ankle Sprains

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Overview of Motor Vehicle Accidents

Understanding Stress
Athletic Anxiety

Other
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Case Management in Subacute Settings
The Road To Recovery Following A Stroke
Viewpoint of Subacute Care
MindDrive
MindDrive Study

Posture

Postural Muscle Pain

Posture And Gait: Kinesiology Application To Motion

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formula where power equals force times velocity. Power for golfers has a different role than for professional weightlifters. Powerlifters use strong ballistic movements to generate an explosive velocity from all of the muscle groups acting simultaneously. The golfer generates power through sequential movement of force through the larger muscle groups into the smaller muscles and an accelerated motion in order to gain the highest club-head speed at the moment of impact. Golfers have to sequence muscles contacting and relaxing almost fluidly in order to prevent them from interfering with the acceleration process.

Golf has been studied on the basis of physics trying to determine how much power or energy is required. Power is defined by work done over a period of time. A physicist, Ted Jorgensen the author of **The Physics of Golf**, calculated that 32 pounds of muscle needs to be generated for a typical professional golfer's swing to deliver two horsepower of energy. Calculating large and small muscle groups, he reasoned that the 32 pounds of muscle force cannot be exclusively generated by the arms and shoulders whereas he found that most of the power had to come from the legs, buttocks, back and abdomen.

The golf swing power is a fine-tuned control of muscle contraction and relaxation where a seamless transition from backswing to downswing maintaining the transfer of momentum from one muscle group to the next. This is an extremely difficult task to master and more so to encode in muscle memory.

The mechanics of the backswing and downswing prepare the golfer's club to strike the ball at impact with the clubface square with the highest energy transfer or velocity. The dynamics of the collision are explained in terms of energy or momentum. Momentum is defined as mass times velocity. Optimal momentum and energy transfer come from proper linear and angular alignment.

Using the example of a boxer striking an object, they find that striking through the object to a point further in allows them to achieve the highest momentum and energy to accomplish their action. One reason amateur golfers have vastly different collision dynamics is that they may not have developed the skill to strike through the ball. At the moment the clubface strikes the ball, only a small fraction of energy is transferred to the ball as the club-head, after impact, decelerates from an average of 100 miles an hour to 90 miles an hour. This collision lasts approximately 0.0005 seconds, which is a very short time frame for transfer of energy and momentum.

Physics has always modeled the golf swing to a double pendulum or a two-lever action. One lever is formed by the shoulders, arms and wrists rotating in the upper chest. The second lever is the club rotating through the wrist cocked and un-cocked. Coordinating the timing of these two levers is one of the most difficult things to teach and learn.

The golfer's downswing has been analyzed and has found that the action of the left arm is critical. The pull of the left arm provides the acceleration relative to the shoulder joint. The left arm should pull the golf club and body toward the ball. Then, as the left shoulder slows, the hips and legs push the body and club toward the ball. This combination of movements is usually quite unnatural and difficult to teach to the novice golfer.

The momentum achieved through the downswing provides an energy momentum transfer that generates a club-head velocity. This club-head velocity at impact is the key. Those golfers that have a well-timed fluid transfer of energy or momentum achieve the highest possible club-head velocity at impact. Tiger Woods

describes his explosive swing focus on that his legs and hips drive forward, whereas, his upper body simply unwinds. He described this momentum transfer process in the framework that the lower body starts the whip action, the legs and hips drive forward delivering linear momentum, and the upper body unwinds delivering angular momentum.

Speed and acceleration are two separate and important concepts. Speed or velocity is a reference of distance over a period of time. Acceleration is a changing increasing speed, not constant. Acceleration is the key point of impact that allows for maximal ball strike.

The example for continued acceleration is demonstrated with Mark McGwire in baseball. He did not have the fastest bat speed, however he did have the greatest velocity immediately after the ball was hit. McGwire had continued acceleration with great muscle mass that resulted in more momentum being transferred to the ball.

Kinesiologists, scientists who study the body movement and mechanics, have demonstrated that poor mechanics prevent golfers from achieving a smooth constant acceleration. Studies show that most recreational golfers reach a top speed of acceleration too soon and, as a result, the club-head actually starts to slow down right before contact.

Kinesiologists through body mechanics have found that precision timing of hundreds of muscle contracting and relaxing in a proper sequence is critical to promoting acceleration. Observing an athlete with jerky swing motion often represents a problem of muscles fighting each other or co-contracting causing deceleration.

Acceleration although important to optimize the power of the swing can also be a detriment at the expense of accuracy.

As one tries to achieve optimal acceleration, muscles are asked to exert maximal power in a very short time which results in rushing the shot, overstretching the muscles, difficulty in maintaining proper motor learning of timing as may lead to balance problems. The key to a powerful golf swing is to promote as much force as possible within an accuracy of striking the sweet spot, the zone of highest energy transfer. Miss-hitting the sweet spot creates a significant error in ball flight dynamics.

Maintaining balance is critical in the transfer of weight from the backswing to the downswing. Most golfers are under the impression that the weight shift occurs from the left foot to the right foot during the backswing and returns from the right foot to the left foot in the downswing. This actually is a misnomer. What should happen is that the right leg should shift its weight from the toe to the heel in the backswing and, to a lesser degree, from the heel to the toe of the left foot.

During the downswing, the weight is redistributed primarily in the left foot from the toe to the heel and, to a lesser extent, the heel to the toe of the right foot. For this to occur, the hips, back and the shoulder must rotate into toward the leading side. At the end of the downswing, the majority of the weight should be distributed into the left heel. Executing this proper weight shift move, increases the club-head/ball impact speed by 14.4%. This 14.4% improvement changes a drive that would normally travel 200 yards to travel 229 yards.

The Cause Of Spring-Loading

The backswing is more important than the downswing to achieve stored energy or spring-loading. The backswing incorporates the properly executed wrist cock, weight shift and rotational action. When the backswing is executed properly, the downswing will occur almost naturally. The key should be for one to practice the development of a smooth rhythmic transition from backswing to downswing.

Cocking And Un-Cocking

The wrist action is very complex. In golf the wrist has two primary actions: cocking and un-cocking.

Studies were done by Jorgensen to analyze various wrist-cocked angles of 90, 110 and 130 degrees. The findings showed that the larger the wrist cock angle just prior to the downswing generates the greatest swing velocity. This, of course, assumes good flexibility such that the wrist cocking motion is natural and comfortable. If the wrist cock angle is not natural or exaggerated, it will be difficult to maintain a good swing tempo.

Physicist Alastair Cochran, the author of **Search for the Perfect Swing,** found that, as the shoulders and arms are still moving upward to the top of the backswing, the hips actually begin moving forward approximately 0.1 seconds before the club-head reaches its furthest backswing position. This furthest position is the point of greatest coiling power. This principle of the body moving forward as the club is moving backward dramatically improves the ability to store and release this elastic energy. One can visualize this concept in the motion of trying to snap a towel by starting its movement forward and just prior to the towel going all the way back.

Once one masters the backswing skill of cocking, then comes the downswing and un-cocking. Un-cocking is the pushing down with the back and wrists through the downswing. As velocity increases during the downswing, there is a natural tendency to un-cock early due to the increasing pull or torque of the wrist. At the start of the downswing, one feels only 15-20 pounds of pull from the club; however, as one completes the downswing near ball contact with the club moving 80-100 miles per hour, this torque is increased to 70-90 pounds. This significant increase in torque being four-fold encourages the forearm muscles of letting the wrists go and conscious effort should be made in order not to release the wrists.

Grip Pressure

The goal of the golf swing is to efficiently utilize the muscles for peak performance. Amateurs have been found to grip their clubs much more tightly than professionals. Studies of grip strengths show that professionals exert about 25% of the maximal force in their grips, whereas amateurs grips are much higher, up to three times as tight.

Unfortunately, having a very firm grip contracts in the wrists, forearms and upper arms, which reduces the fluidity of energy transfer from backswing to downswing. Tight grips have been found to reduce velocity which compromise control and accuracy.

Athletes build their muscle and motor memory from input. Basketball players play with the ball bouncing and rotating in their fingers before shooting a free throw to sharpen the sensitivity in their fingertip nerve endings. Professional golfers employ a similar

technique. Professional golfers roll their hands around the grip before settling on the final hold in order to activate their sensorium. By maintaining a relaxed grip, they continue this sensory communication between their fingertips and the brain, which promotes more effective feedback, as well as provide a more consistent pre-swing visualization.

Sam Snead was quoted that the lighter the grip at the top of the backswing, the greater the muscles in the arm stretch and the farther and faster they can contract, thus, accelerating the swing more effectively.

Swing length has been discussed with the thought that the longer the swing, the greater the force exerted on the club. Unfortunately, studies found that the extra time and distance of the backswing results in only very marginal increases in club-head velocity at impact at best.

Visualizations

Although this is contrary to most instructors and golfing books that claim that every shot, especially the misses or missed shots, should be mentally processed.

The key to successful practice that promotes proper motor learning of muscle memory, is to only emotionally remember successfully achieved mechanics. Avoid any negative emotional response for a misplayed shot in your golf swing.

Visualization starts the motor learning as it sensitizes the brain preparing it for the complex movements of muscles for the golf swing. As motor learning and visualization become more engrained, one becomes more natural in the process. With the positively charged emotional response to this motor learning, one approaches to what athletes call "the zone". "The zone" is having the confidence and the relaxation of the brain and its learned muscle memory perform the skill that you ask of it without any distractions that may disrupt their automatic movement.

Confidence

Due to the excellent training, physical conditioning, flexibility and understanding mechanics in sports, athletes have become fairly equally matched in their physical skills. In one-on-one competition, the primary determinant for winning in equally matched physical ability is found on the basis of the mental confidence that is one player has confidence that he will beat his opponent.

In confidence, the greatest threat is second-guessing or last-second changes in the preparation for the shot. Last-second changes create confusion for the nervous system and the brain, which ultimately changes the timing, mechanics and fluidity of the action.

“The Zone”

“The Zone” can be explained as nothing more than the relaxed state of concentration and heightened confidence. Golfers experience a dual sense of a heightened level of mental concentration, yet a very relaxed muscle state. In “the zone”, golfers mention the feeling that the complex athletic movements were performed automatically. Comments such as “everything feels smooth”, “your senses become sharper”, “you see all things

clearly", "you can see the light of every putt" become familiar to those who have been in "the zone".

Four Things To Avoid

1) Do not **over practice.**

Practice should be approached to strict concentration in order to cement a muscle memory with positiveness and without major adjustments. The brain will encode this action. As one finesses their swing, a better synchronization of brain activity occurs and tighter brain maps become improving the confidence level.

Practice for the golfer should be limited to no longer than half an hour. Greater than half an hour creates decreased concentration, alertness, distraction thereby creating confusion for the brain.

Equally important is to focus on one aspect of the golf game for that half hour incorporating minor adjustments. An example would be performing short chips from the fringe of the green on an uphill slope to the cup, practicing from deeper and shorter grasses with slightly different distances; however, the primary focus would be chip shots. The goal is to encode a muscle memory for this type of shot while only incorporating the positive outcome of the best strokes.

2) **Do not over rely on your eyes.**

People over rely on their eyes. An excellent way to improve motor memory is to practice with your eyes closed.

In putting, practice from the same distance until you drop three in a row. Now, close your eyes and try the same putt but do not open your eyes until you think the ball is within inches of the cup. This drill improves other sensory input such as listening to the ping of the contact, noticing the feel of the speed of the pendulum motion of you arms as well as the feel of the fingertips at the point of contact, especially in the sweet spot.

3) **Do not over focus.**

When approaching a swing, do not overly focus on the ball until you are set and ready to swing. . Focusing too early and too intensely will diminish the ability of the eye to center on the golf ball.

4) **Do not over think.**

Allowing practice to incorporate proper motor memory, the movements should become automatic and reflexive. The golf swing for a professional is as natural as is walking for the general population. They do not put any conscious step-by-step thinking into swinging a golf club, as we do not dwell on the mechanics of walking. Over-thinking leads to second-guessing, which erodes confidence.

Should you have any further questions regarding this article, please direct your questions or comments to "Ask the Doctor" section.