Golf Instruction

101

An Outline of the Basic Knowledge Required to Become an Effective Diagnostician and Teacher

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Contents

Preface

In 1984, I travelled to meet with Davis Love II, who was one of the founders and lead instructors for the Golf Digest Schools and worked from the academy located in Sea Island, Georgia. I had been a golf professional for fifteen years at this point; however, this was my first experience with a world-class teacher. Mr. Love possessed so much knowledge, and had a skill set that was so far above anything I had been exposed to, that my perceptions of what one had to know and be able to do to become a good teacher were completely altered. I was motivated to learn as much as I could.

The very next year I met Chuck Cook, who was also a lead instructor for the Golf Digest Schools. Chuck has worked with many players on the PGA Tour including Tom Kite, Payne Stewart and Corey Pavin. I was absolutely amazed at how quickly he could get his everyday students to hit better golf shots. In fact, after observing Chuck work with some students at a PGA of America teaching seminar, one of my close friends said he was convinced the whole thing was fixed because he had never seen anyone able to get such positive results with students after seeing them make only a few swings. Up until then we were both from the school of thought that one "had to regress to progress." How wrong we were, and how fortunate we were to learn differently.

As I continued to travel around the United States during the winter months, I witnessed many of the world's finest teachers including David Ledbetter, Greg Mchatton, Martin Hall, Jim Flick, Tom Ness and Craig Shankland. I learned very quickly that there wasn't only one right way to play, or to swing, and that human beings had different learning styles, body shapes, tendencies, goals and objectives. To be successful, the teacher had to know how to tell them apart and then adapt accordingly. I also learned that not all the best teachers taught the same way, but they all had the capacity to identify the most effective route in which to get optimal results from their students. A primary example is how Chuck was able to work successfully with such diverse players as Pavin, who had a weak grip and played from an open clubface position; Kite, who tended to play from more square or neutral positions; and Stewart, who played from more shut or closed positions. In addition, they had different personalities, likes and dislikes. Chuck would always say that he had a hard time getting Tom to play golf because he loved to practise so much, whereas Payne loved to play more than just practise. Tom learned and played better using videos and an analytical–type approach, whereas Payne wanted to know how things should feel and could care less about the shape of his divots or exactly how much tilt there should be in his spine at address. In spite of these very contrasting styles Chuck was able to work successfully with all three, as evidenced by their respective victories in the US Open. Chuck's success was due first and foremost to the tremendous knowledge he has of swing mechanics, without which he could not possibly have been as effective a teacher and coach. However, he also had that magical capacity to motivate and communicate in a manner that catered to the varying styles of each player.

I have had the privilege to do many Golf Schools with Chuck since we first met, both here in Canada as well as in the United States and Europe. He was always more than willing to share his knowledge with me and to discuss how best to teach and disseminate information to a student. We have become good friends and much of what follows has been learned with his guidance and help.

Introduction

During the course of their studies, medical students are taught the premise that when diagnosing a patient "you are able to see and understand only what you know." This same premise applies to golf instruction. The common denominator is the knowledge base from which you work. The more knowledge the teacher has of swing mechanics or of the "science of the golf swing," the more empowered he or she becomes to effectively read and analyze the motion.

Therefore, the objective of this thesis will be to clearly demonstrate that without a complete and thorough understanding of the science of the golf swing, one will not be able to properly diagnose the motion and, consequently, to correctly identify the root cause of the swing fault. Therefore, the teacher's ability to achieve long-term results with any student on an ongoing basis, regardless of the student's ability, is, at best, left to chance or guesswork.

To accomplish this, the following subjects will be examined: the laws of elementary physics and geometry (which govern the swing and the flight of the golf ball), a study of the motion of the body and the action of the golf club (which produce the three components of ball flight: distance, direction and trajectory) and a methodology for observation and adjustment of the motion (error detection and correction). The above will be supplemented with the appropriate photos and graphics.

Only once the prospective golf instructor has a thorough awareness and understanding of this subject matter can he or she begin the more difficult process of learning the "how to" or the "art of teaching." The development of that skill set is truly a study unto its own, and therefore will not be a part of this thesis.

The Three Components of Ball Flight

Ball flight is defined by the three variables of distance, direction and trajectory, and is the direct result of the forces and conditions that exist at impact. Ball flight is also subject to, and influenced by, the type of spin imparted to the ball, the spin rate, the velocity of the ball and external and technological factors. External factors would include such things as wind, air temperature, humidity, altitude and the lie of the ball. Technological factors would include ball type and construction, clubhead design and shaft material, etc.

Distance

For all shots in golf, whether they are in the air or on the ground, the ball can travel the desired distance, or one that is either too short or too long. As a teacher one must understand how distance is created and how it is controlled so that it can be either increased or decreased as required. Generally speaking, students will either be short and straight or long and wrong. Under spin tends to shorten the distance the ball travels on the ground but increase the length of carry during the ascending portion of the ball's flight. Side spin will increase the roll on the ground if the axis of spin is from right to left for a right–handed player, and vice versa for a left–handed player. However, any type of sideways spin will produce less vertical lift. A ball spinning on an axis top over bottom or with over spin produces more drag and less lift, and consequently is not useful, except for those shots that are intended to roll on the ground (i.e. putting). The greater the air speed or velocity of a ball the more effect any spin will have on it once in flight.

Direction

The golf ball can travel in a straight line, or in a straight line and then begin to curve, or it can begin to curve either way immediately (Appendix I, Fig. 1). The straight ball flight is the purest and most efficient (i.e. the shortest distance between two points is a straight line). In order for the ball to fly straight the club must be travelling down the target line with the clubface absolutely square to this same line at separation or when the ball leaves the clubface. These two conditions will result in the golf ball being evenly squashed, or compressed against the clubface, thus eliminating any side spin from being imparted to the ball. The strike is not glancing or oblique in any way since the clubface is neither open nor closed in any degree at the moment of separation. Under spin will be the only type of spin on a straight shot that flies with normal trajectory.

The golf shot that turns from left to right for a right–handed player (slice) is the result of the clubface opening or being open to the direction in which the clubhead is travelling at impact. An open or opening clubface also adds loft, which will decrease distance and add backspin. When the ball starts left of the intended line of flight (for the right–handed player), the path that the club is swinging on is from out-to-in and thus much steeper than the desired approach, the net result of which is the imparting of more under spin

to the ball.

Finally, the shot that turns from right to left for a right–handed player (hook) is the result of a clubface that is closed or closing to the line on which the clubhead is travelling. This closed or closing face reduces loft, creates more side spin and less under spin, which reduces the effect of drag in flight and increases the effect of roll on the ground. When the ball starts to the right of the intended line of flight (for the right–handed player), the path on which the clubhead is travelling is from in-to-out and shallower, resulting in less under spin being imparted to the ball.

Trajectory

Similar to the distance component of ball flight, there is a desired trajectory for a typical golf shot—that is, not too high or too low. Generally, a closed or closing clubface produces a lower than desired trajectory, while a face that is open or opening results in a trajectory higher than desired. The relative angle and position of the club's shaft to the ball at impact will also affect the trajectory—the more it leans back or away from the ball at impact, the more loft will be added to the clubface, producing a trajectory that will be higher than desired. Conversely, the more the shaft leans forward or ahead of the ball at impact, the less lofted the clubface will be, producing a lower than desired trajectory. (Note: these conditions at impact can be created as required or when needed to produce a trajectory that allows for the ball to fit through a particular window or opening, and/or to fit certain playing conditions, terrain or pin locations)

The apex of the trajectory produced by each club should be the same, although as the clubs get longer and have less loft, this apex will move further away from the player and progressively down the target line. This will only occur if there is a corresponding increase in clubhead speed as the clubs increase in length and decrease in loft; otherwise there comes a point where the distance between clubs will not change because there is not enough speed through impact to create the necessary backspin required to produce lift.

How the Action of the Club Affects Ball Flight

Please refer to the chart in Appendix II (Fig. 1) for the five conditions that follow.

1. Clubface Alignment

Clubface alignment has the single biggest influence on the direction in which the ball flies. If the clubface is square to the direction or path that the clubhead is travelling on then the ball will go in that direction (the path can be either straight along the intended line, or to the left or the right of it). The outcome is absolute, and will be the same each time this condition is present at impact. On the other hand, if the clubface is open or opening in relation to the path on which the club is moving, then the ball will slice or turn to the right (for the right–handed player), whereas if it is closed or closing then the curve on the ball will be from right to left. Once again, this is absolute and will happen each and every time. Loss of directional control can be directly related to clubface alignment regardless of who is swinging the club.

In order for the clubface to be square at address, the leading edge or bottom scoring line on the clubface must be at a ninety degree angle to the intended line of flight (Appendix III, Fig. 1). Once in motion, the clubface is square if its relationship to the ball or the inclined plane line does not change until a point approximately half way between waist height and the ground (Fig. 2). At this point, the trailing arm begins to fold and the clubface starts to open (Fig. 3). The clubface will continue to open (as the trailing wrist cocks back against the forearm) until it reaches a point where it is ninety degrees open to the inclined plane line (Fig. 4). This position and relationship to the arc or plane line is referred to as square, and remains the same as the club continues to the top of the backswing (Fig. 5) and then back again to a point about waist height in the downswing, where it begins to close to the arc (Fig. 6). The clubface continues to close until it squares up again when the ball separates or leaves the clubface. Its relationship to the arc remains the same after impact (just like it did on the take away, Fig. 7) until the lead arm begins to fold upward and the lead wrist begins to hinge, at which point the face begins to close until it is ninety degrees closed to the plane line (Fig. 8).

2. Club Path

When discussing path it is important to think in terms of the shaft of the golf club as well as the clubhead. The path that the shaft travels on, and more importantly its orientation to the target line as it moves around the player, affects not only the direction in which the ball flies but also the ratio of ball-to-turf or turf-to-ball at impact. For example, the proper path and plane will have a contact ratio for an iron shot (assuming the ball position is correct) of ball first then the turf (divot). However, improper path and plane can result in contact having a ratio that is all turf and no ball (a fat shot), or all ball and no turf (a thin shot).

First, it is important to note that the shaft must be either pointing to or parallel with the target line—or

base line of the inclined plane—at all times for it to be "on plane." Any other orientation to the target line is referred to as "off plane." The plane is dictated by the lie angle of each club. Therefore, the plane is steeper with the shorter clubs and becomes progressively flatter as the clubs increase in length and the lie angle flattens (Fig. 9). When the path is too much from out-to-in for the right-handed player, the clubface must be open or opening to make the ball turn or slice towards the target. If the face is square, the ball will be pulled left of the target. If it's closed or closing, the ball will start left and then turn or hook even more in that direction. Conversely, when the path is too much from in-to-out, the clubface must be closed or closing in order to make the ball turn or hook towards the intended target. If it's square, it will be pushed to the right, and if it's open or opening it will turn even more so in a left to right direction (Appendix II).

The more out-to-in the path, the steeper the angle at which the clubhead approaches the ball and the more likely contact will be with the ball first then the ground or turf. The more in-to-out the club travels, the shallower the path becomes. This in-to-out path causes the club to bottom out too early (when the ball is positioned correctly in relation to the low point in the arc) and produce contact ratios that are either "all turf and no ball" or "all ball and no turf." Both paths are generally associated with shaft planes that are too upright and off plane at impact.

3. Club Speed.

Speed is a condition that is measured and important at one point only in the golf swing—impact. The speed being generated by the motion either fits the shot at hand, or it doesn't and is too fast or too slow. What is pertinent for teaching is knowing how clubhead speed is generated and how it is controlled. There are three ways in which to produce speed: hitting, which involves the use of muscular force; swinging, which is accomplished through the use of centrifugal force; and a combination of the two. Identifying body type is a key factor in evaluating which style may be best suited to a student.

Those who are strong and less flexible tend to make better hitters, as their body types are often better suited to creating speed through the hinging and unhinging action of the wrists and arms. This method can be likened to the action used or employed by a shot putter (Figs. 10 & 11) or that of an ancient catapult. Swinging, on the other hand, is more suited to those who are supple and flexible and not necessarily strong muscularly. These body types are best to rely on rotation to create centrifugal force, such as that which would be produced by swinging a weight at the end of a string in a circular motion (Fig. 12). The faster and tighter the pivoting or turning motion, the more speed can be created. This applies to golf motion provided it remains timed or sequenced properly.

4. Point of Contact

There are five possible points at which the ball can come in contact with the clubface at impact. The sweet spot or percussion point is the point at which contact is most centred or balanced, and one that does not produce any twisting, vibration or undue torqueing of the face. The ball can also contact the clubhead fore and aft of the sweet spot or above and below it. Contact aft of centre pushes the heel of the clubface backward and twists the toe forward, thus closing the face and producing a shot that will start to the left of the intended line (for a right-handed player). Conversely, contact fore of centre pushes the toe backward and twists the heel forward, thus opening the face and producing a shot that will start to the right of the intended line. Contact above center produces a higher ball flight while contact below centre produces a lower flight. All points of contact not centered cause a loss of distance and directional control.

5. Angle of Approach

The angle at which the clubhead is moving, as viewed from in front of the swing or at right angles to the base of the inclined plane line, is important because it relates to how the club is travelling in relation to the ground. Is it swinging reasonably level at impact, or in an excessively downward arc or an excessively upward arc? The more in-to-out the path through impact, the more the clubhead will be swinging upward; the more out-to-in the path, the more it will be swinging downward through impact. This is completely a function of the plane; the more out-to-in the path, the steeper the approach, and, conversely, the more in-to-out, the shallower the approach. In addition, the shaft lie angle of each club dictates the plane; the more upright the shaft, the steeper the plane line becomes, and the deeper the divot, whereas the flatter the shaft lie angle, the flatter the plane and the shallower the divot. When the club shaft is on the inclined plane line, the approach to the ball will be closest to level at a point on the ground that is just below the lead shoulder socket. Ball position, therefore, must be directly related to this low point in the arc. For those shots that should have a ball-then-divot relationship, or descending approach (i.e. iron shots), the low point of the arc must be on the target side of the ball. This position would translate to a spot on the ground that would be between the lead cheek and lead shoulder socket (Fig. 13). For those shots that should not produce a divot (i.e. fairway metals and the driver), a ball position directly under the shoulder socket or slightly forward of that point would produce a level-to-ascending approach.

The Three Components of Action and Motion

Action and motion are produced by three components:

1. The hands and wrists.
2. The arms.
3. The body (shoulders, torso, hips, legs and feet).

The Hands and Wrists

The hands and wrists simply work as the joints, tendons and muscles of the body have designed them to; the hands hold the handle of the club, and the wrists hinge and unhinge. This hinging action is a source of power. The primary function of the grip is to control clubface alignment. The hands must be positioned on the club such that at impact the clubface is square, the back of the lead wrist is flat and the back of the trailing wrist is bent (Fig.14). In order to achieve this condition at impact, neutral grip position is required. Whereas the heel pad of the lead hand is on top of the handle (Fig. 15), and the thumb of that hand is on the aft, or backside, of the grip. [Note: Address and impact are two very different positions. The correct position at impact will have the hands four to six inches forward of their starting position at address. Therefore, the thumb on the lead hand must be positioned on the backside of the shaft to facilitate and assist in squaring the face at impact (which is where it would be positioned in a neutral grip, Fig. 16). If, for example, the thumb was positioned on top of the grip (as it would be in a weak grip), the clubface would open to the intended line when the lead wrist flattens through impact.] The body of the lead hand is then turned to meet the thumb so there is no gap between it and the upper part of the forefinger (Fig. 16). Two knuckles on the lead hand should be visible from the playerís perspective. The trailing hand is placed on the handle so that the palm of that hand plugs into the thumb, and the palms face each other. This will result in both hands being turned to the left or to the right of centre by the same amount (Fig. 17). A strong grip would have both hands turned more away from the ball (more to the right for a right-handed player, and more to the left for a left-handed player) than the neutral position (Fig. 18). A weak grip would have the hands turned more towards the target (Fig. 19).

Wrist position will also influence clubface alignment at impact and at the top of the backswing. A neutral, or square, wrist position at the top of the swing will have the lead wrist flat and in line with the clubface (Fig. 20). A cupped lead wrist will produce an open clubface at the top of the backswing (i.e. more than ninety degrees open to the plane line) even though the grip is neutral (Fig. 21). The combination of a weak grip and a cupped wrist position will produce a clubface that is so open it becomes dysfunctional (Fig. 22). It is important to note that this same cupped wrist position at the top of the backswing will offset a strong grip and produce a clubface position that is square (Fig. 23). An arrangement of this nature (where two components offset each other to produce the benchmark position) is called a compatible variation. This may not be the

most efficient or consistent way for most to employ; however, compatible variations are used successfully by many of the world's top players. It is also important to point out that even though this compatible variation satisfies the benchmark requirement of a square clubface at the top of the backswing, the strong grip will still have to be counterbalanced to square the clubface at impact (see Correcting and Adjustment: Clubface Alignment).

A bowed lead wrist at the top of the swing will close the face with a neutral grip (Fig. 24) and produce a dysfunctional clubface position with a strong grip (Fig. 25). When the grip is weak, a bowed position will offset it and square the face (Fig. 26). Here again, the same counterbalancing will be necessary at impact if this variation from the benchmark position is employed (see Correcting and Adjustment: Clubface Alignment).

The wrists also act as a source of power by creating leverage through a cocking and un-cocking action. On the backswing, the trailing wrist folds back against the forearm (Fig. 27), flattening the lead wrist in the process (Fig. 28). This position is maintained until just after impact, at which point the bend or hinge in the back of the trailing wrist releases through the ball. The timing of this release determines how much energy or power is transferred to the ball (in general, the earlier the release, the less energy or power is transferred into the ball at impact, the steeper the plane and the shallower the approach). Once this release is complete, the lead wrist hinges back against the lead forearm (Fig. 29) and the trailing wrist begins to flatten (Fig. 30). There is absolutely no twisting or rolling of the hands or wrists associated with this action.

The Arms

The arms are also a source of power. They operate in front of the torso and pivot at all times (Figs. 31, 32 & 33). In the address position, the arms must hang vertically from the shoulder sockets, with the left elbow pointing to the left hip and the right elbow pointing to the right hip (see Static Positioning of the Three Components). There is no twisting or rolling associated with the movement of the arms; they simply swing up and down in front of the torso as it rotates. This action is similar to the method one would use to hatchet a piece of wood with either the trailing arm on the backswing or the lead arm on the forward swing (i.e. a cocking and uncocking of the wrist coupled with a folding and unfolding of the arm at the elbow in a straight line up and down in front of the shoulder joint). During the backswing, the trailing arm folds into a ninety degree angle and maintains a pushing attitude on the lead arm. This relationship is maintained until approximately waist height on the downswing, at which point the trailing arm begins to straighten. The timing of the release of this angle in the trailing arm is similar to the release in the trailing wrist as it also determines how much energy or power is transferred into the ball (the earlier the trailing arm straightens prior to impact the less energy or power will be available for release into and through the

ball). The arm then continues to straighten until just after impact, at which point both arms are pulled into an extended position. The lead arm then begins to fold in the same manner as the trailing arm did on the backswing. It is important to note that the trailing arm is bent at impact and directly in front of the trailing hip (Fig. 34), with the shaft of the club in line with the forearm (Fig. 35). This position supports the shaft through impact and ensures the maximum transfer of energy and power into and through the ball.

The Body

The body is the engine of motion. It supplies power through rotation and centrifugal force. The pivoting of the torso, coupled with the turning of the shoulders around their axis (the spine) and of the hips make the weight move in the direction of the rotation. The feet and legs facilitate this action by providing support and balance, while the hips assist in centring the axis of rotation. Some lateral slide is required to connect the pivot into the ball and socket joint of each hip. The amount of lateral slide on the downswing is determined by how connected the trailing arm is to the torso on the backswing (Fig. 36). The less connected, the more vertical the pitch of the plane becomes (Fig. 37), necessitating more lateral motion along the target line (on the downswing) to time the reconnection of the trailing arm to the torso and to get the shaft of the golf club back on the inclined plane line (see Sequencing the Three Components).

Static Positioning of the Three Components

The three components (hands and wrists, arms and body) must be positioned correctly when they are static, or in the address position. All motion that follows from the starting position is directly affected by how these components are set up. A faulty set-up can be the root cause of inconsistency, poor contact, loss of power and directional control and compensations would have to be made "in swing".

In order for the hands and wrists to function properly, the grip must be neutral. Neutral alignment will have the feet, knees, hips and shoulders positioned parallel to the base of the inclined plane line (Fig. 38).

When the set-up is viewed from the front, the lead shoulder will be higher than the trailing shoulder simply because the lead hand is positioned higher on the club (grip) than the trailing hand. The correct tilt of the spine (approximately five to ten degrees off centre) is created by a slight shifting of both hips towards the target. The proper set-up will have a backward "K" look to it (Fig. 39) with the top of the axis positioned behind the ball. This starting position will facilitate the transfer of weight behind the ball as the body turns and pivots on the backswing.

In order for the torso to rotate properly and the shoulders to turn on the correct plane, the spine, which is the axis, must be straight at address and throughout the range of motion. Too much curve in the spine at address will result in either too much head movement or rocking of the hips as the swing moves in either direction. The amount of axis tilt must be such that the lie angle of the club shaft intersects the spine at ninety degrees (Fig. 40). Depending on body shape and leg and arm length, the correct amount of tilt will vary from twenty to forty degrees and result in the chest being aimed or pointed at the ball. Since the lie angle of the club determines the path and approach of the club-head to the ball, the relationship between the shaft and spine must be established without fail (see How the Action of the Golf Club Affects Ball Flight: Club Path. If this relationship is not properly established and maintained through impact, the power generated by the motion will be directed either outside and above the ball (when the axis tilt is too vertical), or inside and below it (when the axis tilt is too horizontal).

If the tilt of the spine is too upright in the address position (or there is insufficient bend from the hips, (Fig. 41), the arms will not be able to hang vertically from the shoulder sockets (Fig. 42). This will tend to produce a downswing where the arms swing back to the ball from above the inclined plane line, creating a plane that is too steep and a path that is too out-to-in (Fig. 43). Conversely, when the spine angle is too flat in the address position (or there is too much bend from the hips, Fig. 44), the arms will tend to reach out too much in the address position, causing an exaggerated in-to-out swing path through impact (Fig. 45).

Sequencing the Three Components

The motion of the components is sequenced in the same ways many other sports. Proper sequencing of the motion results in producing maximum power and directional control. Consistent results in terms of contact, velocity and accuracy can only be achieved if the action or motion is timed properly and occurs in the correct order. The wind-up and delivery motion used by a baseball pitcher, or that used by the batter to hit a ball, is the same as it is in golf. The body turns first, then the arms swing and fold and finally the wrists cock. In the forward motion, the body reverses direction by turning first, followed by the arms unfolding or straightening and the wrists uncocking.

An important point is that the sequence of motion in the golf swing (or any other sport for that matter) will feel different for different people. Some will feel that the clubhead moves first, others will feel itís their hands that started, and still others will feel like their torso initiated the action. What it feels like is not as important as what is the actual order and sequence of motion, since this will dictate how accurate and powerful each swing will be. The benchmark for sequence in the golf swing is as follows:

The body begins by turning away from the ball, with the arms and hands following. The clubface remains square to the ball until the trailing arm begins to fold (Fig. 46), after which the trailing wrist begins to hinge back against the forearm. The cocking and folding action of the wrists and arms is complete by the time the club reaches waist height (Fig. 47). The shoulders continue to turn until they have rotated ninety degrees from the base of the plane line at the top of the backswing, and the hips have turned by approximately half that amount (Fig. 48). The downswing begins with the rotation of the body, complemented with some lateral motion of the hips to connect the pivot into the lead hip socket. This move is best initiated with the trailing shoulder, which moves down (because the ball is on the ground), out (because the ball is on the target line and not on the line the body is on) and forward (since the ball is positioned in relation to the low point in the arc, which is under the lead shoulder socket). As forward rotation occurs the correct sequence begins to create a condition between the pivoting body and the club referred to as lag (Fig. 49). This is a condition where the clubhead and the shaft begin to trail—or lag—behind the hands and arms, and is a potential source of power. As the pivoting of the body continues, the angle between the club shaft and lead forearm becomes more acute. Once the trailing elbow is in line with the rear, or trailing hip, the trailing arm begins to straighten. However, the trailing wrist remains cocked or bent. At impact both the trailing arm and wrist are bent, and the lead wrist is flat (Figs. 35 & 50). This condition is imperative at impact and the true secret for good ball striking. Also at this point, the shoulders and hips have turned to where they are now open to the target line, although the shoulders are less so (Fig. 50). Only after impact does

the trailing arm straighten, followed by the flattening of the trailing wrist (Fig. 51). Both arms are pulled into an extended position at a point just after impact. The lead arm then begins to fold and hinge upward in front of the torso. As the lead leg straightens, it becomes the axis around which the trailing side of the body pivots past the leading side into a finish (Fig. 52). Any other order or sequence of events will not produce the conditions at impact necessary for maximum distance and control.

Observing the Action and Motion of the Club and Body

As I said in my introduction, to "know" is to be able to "see." Knowledge of ball flight components and an understanding of how they are directly related to the action and motion of club and body is the pre-requisite for error detection and correction. An accurate diagnosis is the result of the manner in which the action and motion is observed—systematically and with purpose. A checklist similar to the one below should become the process by which the teacher or coach makes an evaluation or assessment of the student prior to any adjustments being made.

1. Read and observe the flight of the ball:

i) Is the flight straight, straight then curving, or curving directly? Does the trajectory fit? Correlate the ball flight with the five conditions at impact (see Appendix II).

2. Verify each of the following and how they correlate to the ball flight:

i) Posture. What angles are in place?

ii) Orientation of the shaft to the inclined plane line; is the shaft under or over the plane line as it travels to the top? At the top of the backwing, is the shaft laid off (under the plane line), across the line (above it) or parallel to the base of the plane line (bench-mark mark position)?

iii) Position of the clubface and lead wrist at the top of the swing. Is the face open to the arc, square or closed? Is the lead wrist cupped, flat and level, or bowed?

iv) Path through impact. Is it in-to-out and up, out-to-in and down or in-to-out-to-in and reasonably level?

v) Angle of approach and ball position. Is the club moving relatively level in relation to the ground, or is the approach too vertical or too shallow?

vi) Set-up. What angles are in place? What is the grip position?

vii) Motion. Is the motion timed properly and in sequence?

The information generated by using this process for diagnosis is invaluable. A very clear picture will evolve of exactly what transpired through impact and what compensations and variations (both compatible and incompatible) were present throughout the range of motion. Adjustments can then be made as required and with confidence to correct the ball flight error.

Correction and Adjustment: Clubface Alignment

The methodology that follows can be used to correct errors with distance, direction or trajectory by adjusting static positioning, sequencing, clubface alignment, club path, club speed, point of contact and angle of approach, either individually or in some combination with one another.

1. Clubface Alignment

Errors with clubface alignment are best corrected by adjusting the grip and/or wrist position.

When the clubface is open or opening

i) Strengthen the grip. This is the most effective manner in which to correct a clubface that is open to the line on which the clubhead is swinging.

ii) A flipped wrist position at impact (where the lead wrist is cupped, Fig. 53) will compensate for an open face, as will having a rolled wrist position (where the lead wrist is flat but rolled to the left for a right-handed player, Fig. 54). The problem with these two solutions is that flipping requires one to uncock the wrists early on the downswing, which drastically reduces lag and makes it more difficult to hit the ball solidly. On the other hand, rolling the wrists and forearms to square the face is difficult to time on a consistent basis.

When the clubface is closed or closing:

i) Weaken the grip. This is only useful when an extremely strong grip is employed and there are no other options. It's important that the correction not be overdone and the grip position made too weak. It is most often preferable to err on the side of the grip being too strong.

ii) A bowed wrist position at impact (where the lead wrist is flat but arched outward, Fig. 55) will counter-balance a closed face as will an anti-rolled wrist position (where the lead wrist is flat but rolled to the right for a right-handed player, Fig. 56). Here again, one can play using these two variations, although a bowed position will tend to hit the ball on a very flat trajectory and is difficult to use with the longer, less lofted clubs. The anti-rolled position is preferable, but like the rolled position, requires perfect timing and is consequently subject to under or over correction on the downswing.

2. Club Path

Corrections to the path are best made by adjusting the orientation of the base of the plane line to the intended target line.

When the path is too much in-to-out

i) Verify alignment of the feet, knees, hips and shoulders. Are they square to the intended line of flight?

ii) Verify ball position. Is the ball too far back in relation to the low point of the arc? If so, the path will tend to be too much in-to-out.

iii) Verify set-up. Does it have the correct amount of tilt in the spine away from the target (i.e. backward K)? When the top of the spine has too much lean

away from the target at address (Fig. 57), the path will tend to be too much in-to-out (Fig. 58).

iv) Verify posture. Does it have the correct amount of axis tilt forward and over the ball from the hip sockets at address (i.e. club shaft intersects the spine at ninety degrees)? An axis tilt that is too horizontal (Fig. 44) will make the arms reach too much in the address position, which will force them to compensate by swinging from in-to-out through impact (Fig. 45).

v) Adjust and balance the amount of lateral or rotational action of the hips to match the pitch of the backswing plane. If the shaft is travelling on or under the plane line and there is too much slide or lateral motion on the downswing (and not enough clearing or rotary action with the hips), then the arms will get trapped behind the torso as it pivots, producing a swing that will be too much in-to-out (Fig. 45).

vi) Adjust pivoting motion. If the trailing side stalls or hangs back and does not rotate properly (too much lateral slide, Fig. 58) then the path through impact will be too much in-to-out. The correct pivoting motion is best achieved with the proper use of the rear shoulder, which moves down, out and forward through impact. This action ensures the trailing side will pivot past the lead side into the finish (Fig. 52).

vii) Verify that the upper portion of the lead arm remains connected to the pivot or torso on the forward swing (Fig. 59). If the lead arm separates from the torso (upper inside portion of the lead arm loses contact with the upper portion of the chest and rib cage, Fig. 60), then it will swing out too much through impact.

When the path is too much out-to-in

i) Verify that the alignment is square or neutral.

ii) Verify ball position. If the ball is too far forward, the path through impact will tend to be too much out-to-in.

iii) Verify that the set-up has the correct amount of tilt in the spine away from the target (i.e. backward K). If the top of the spine is set too close to the target at address, then the path will tend to be too much out-to-in through impact (Fig. 61).

iv) Verify that the posture has correct amount of axis tilt forward over the ball from the hip sockets. If the posture is too vertical (Fig. 41), the arms will hang too close to the body at address, forcing them to swing out-to-in through impact (Fig. 43).

v) Adjust and balance the amount of lateral or rotational action of the hips to match the pitch of the backswing plane. If the shaft is travelling on or above the plane line and the hips clear too early (prior to the appropriate amount of lateral motion having taking place) then the arms will be forced to swing too much out and over through impact (Fig. 43).

vi) Adjust pivoting motion. If the trailing shoulder goes up (Figs. 62 & 63) instead of back (away from the ball and target line straight back over the heel, Figs. 64 & 65) on the backswing, then the shoulders will tilt rather than turn. This will result in the pitch of the plane becoming too vertical, producing a path

that will tend to be too much out-to-in (Fig. 43).

vii) Verify that the upper portion of the trailing arm remains connected to the pivot or torso on the backswing (Fig. 36). The more the arm separates or leaves the torso (Fig. 37), the more vertical the backswing plane becomes, and the more out-to-in the path tends to be through impact.

3. Club Speed

Corrections to the speed of the clubhead are generally done by modifying the length and rate of rotation and/or by adjusting various release angles.

When there is insufficient speed:

i) Adjust the action of the three components: the hands and wrists, the arms and the body. Does the backswing motion travel far enough to maximize the effect of forward momentum on the downswing? The more forward momentum, the more potential there is to increase the rate of clubhead speed.

ii) Verify the action of each component. This action should be such that it creates maximum leverage (i.e. the trailing wrist cocks back ninety degrees, the trailing arm cocks up ninety degrees, and the shoulders turn ninety degrees, Fig. 66) and, hence, the greatest potential to produce speed.

iii) Verify the sequence of motion. The correct sequence and timing will create the most acute release angles (lag), and thus maximize the potential to generate clubhead speed.

iv) Adjust the rate of rotation to its maximum limits. The faster the rate of rotation the more speed can be generated. (Note: the rotary action in a golf swing can only be increased to that point where the sequence and timing of the motion is not adversely affected, otherwise there will be a corresponding loss in distance and directional control.)

v) Increase levels of physical fitness and strength.

vi) Verify that the equipment being used is the best match and fit for the student to produce length (i.e. type of ball, shaft flex and length, loft, lie and launch angle).

When there is too much speed:

i) Adjust the action of the three components by reducing their length of travel in the backswing, hence, reducing the affect of forward momentum on the downswing.

ii) Verify the action of each component so that it creates less leverage (reduces the cocking and folding action on the backswing).

iii) Verify that the sequence of motion is such that it creates a wider release angle in the trailing arm on the downswing. The wider the angle, the less leverage and lag, hence, the less speed can be produced.

iv) Adjust the rate of rotation. The slower the rate of the pivoting action, the slower the motion and the slower the clubhead will travel.

v) Verify that the equipment matches the objective of reducing length (i.e. change type of ball, loft, etc.).

4. Point of Contact

Errors in point of contact are generally corrected by reducing clubface rotation, or by adjusting and maintaining the axis of rotation and various swing radii.

When the contact is towards the heel

i) Adjust swing path, which is too in-to-out (see Correction and Adjustment: Club Path).

ii) Reduce clubface rotation. If the face is opened or opening at impact, then contact will tend to be towards the heel or neck of the club, which can result in the ball striking the hosel of the clubhead. This point of contact produces a very oblique strike referred to as a "shank." Most shots of this nature are a result of a severe in-to-out path that raises the shaft above the inclined plane line and thus aligns the hosel with the ball at impact. This in-to-out path is most often accompanied by a clubface that is closing to the line on which the club is swinging (a closed clubface is present in all shanked shots). Shanks can be easily remedied by reducing clubface rotation and adjusting the swing path to be more out-to-in and on plane.

iii) Adjust the set-up to be farther from the ball.

iv) Maintain the spine angle throughout motion. If the spine (axis) moves closer to the ball on the downswing, then the ball will strike towards the heel of the club.

v) Verify that the radius of the lead arm is correct at address. If the posture is such that the radius is faulty (too short at address), then as the radius grows longer through impact, contact will move more towards the heel of the clubhead.

When contact is towards the toe:

i) Adjust for an out-to-in swing path (see Correction and Adjustment: Club Path).

ii) Reduce clubface rotation. If the face is closed or closing at impact then contact will tend to be towards the toe of the club.

iii) Adjust the set-up to be closer to the ball.

iv) Maintain the spine angle throughout the range of motion. If the spine (axis) moves farther from the ball on the downswing then the ball will strike towards the toe of the club.

v) Verify the radius of the lead arm at impact. If the radius has shortened due to a bending at the elbow or wrist joint at impact, then contact will be towards the toe.

When contact is towards the top of the face

i) Adjust for an out-to-in path (see Correction and Adjustment: Club Path).

ii) Adjust ball position in relation to the low point of the arc.

iii) Maintain the spine angle. Moving out of the posture towards the ball creates a strike below the ball (or one that is referred to as "fat") and contact will be towards the top of clubface.

iv) Verify that the radius of the lead arm to the ball is correct (see (v) in contact towards heel).

v) Adjust the amount of lateral slide. The more lateral slide present in the downswing, the more the hands have to time the strike with a "slap" as the body moves by the ball. This slapping action is inefficient and will tend to result in the ball contacting the top (a fat shot) and bottom (a thin shot) of the clubface.

When contact is towards the bottom of the face

i) Adjust for an in-to-out swing path (see Correction and Adjustment: Club Path).

ii) Adjust ball position in relation to the low point of the arc.

iii) Maintain the spine angle (axis). Moving up and out of the posture away from the ball will cause contact towards the bottom of the clubface.

iv) Verify that the radius of the lead arm at impact is correct (see (v) in contact towards toe).

v) Adjust the amount of lateral slide (see (v) contact towards top of face).

5. Angle of Approach

Errors with the angle at which the clubhead approaches the ball are corrected by adjusting the pitch of the plane, modifying the release angle and centring the axis of rotation.

When the approach is too shallow

i) Adjust the ball position to be further back.

ii) Adjust the axis of rotation at address by positioning the top of the spine closer to the target. This will increase the pitch of the downswing plane (see Correction and Adjustment: Club Path—too much in-to-out).

iii) Create more lag and a later release. On any given plane, the later the release, the steeper the approach will be to the ball.

When the approach is too steep

i) Adjust the ball position to be further forward.

ii) Adjust the axis of rotation at address by positioning the top of the spine farther from the target. This will decrease the pitch of the downswing plane.

iii) Decrease the pitch of the downswing plane (see Correction and Adjustment: Club Path—too much out-to-in).

iv) Create less lag and an earlier release. On any given plane, the earlier the release, the shallower the approach will be to the ball.

Conclusion

The author's research and personal observation of several of the Top 100 Teachers' working with their students over the past twenty years supports, without exception, that the results achieved with players of all skill levels, both in the short and long term, was and is directly related to each instructor's thorough understanding and knowledge of the science of the golf swing as presented in this thesis.

Examples in support of this would include:

• Butch Harmon adjusting the release angle (widening) on Tiger Woods' downswing, which prevented Woods from trapping his arms behind his rotation, thereby improving his directional control. In addition, the two worked to improve Woods' distance control by creating less leverage through reducing the amount of wrist cock. Harmon also adjusted the width of the backswing arc (widening) of Jose Marie Olazabal to create more leverage and club-head speed.

• Craig Shankland adjusting the grip position (from weak to neutral) of Rafael Navaro on the Champions Tour to improve his directional control (it allowed him to square the clubface at impact with his pivot, rather than with his hands).

• Martin Hall adjusting the plane (path) of LPGA Tour player Lisa Hackney's swing (less in-to-out) to improve contact and directional control.

• Chuck Cook adjusting Tom Kite's ball position (by moving it back) to reduce clubface rotation through impact and hence, the curve on the ball. Also, Craig Harmon adjusting the ball position of Jeff Sluman (by moving it forward) to facilitate a better release through impact.

• Todd Anderson adjusting the posture (the hips were too much under the shoulders at address—i.e. too slouchy) of PGA Tour player John Rollins to where the hips were pushed back enough to create the correct spine angle, facilitating a better pivot (more behind the ball at the top of the backswing). This, in turn, led to improved directional control by reducing the amount of hand action required through impact to square the clubface.

• Jim Flick adjusting both clubface position (from closed to square) and the pitch of Tom Lehman's downswing (to be more vertical), which produced a more desirable trajectory (higher) and decreased the curve in the flight of the ball (less hook).

• Dean Reinmuth adjusting the set-up position (alignment) of Grant Waite. His tendency to align to the right of

target would force him to swing off plane (under and too much in-to-out through impact, producing excessive roll of the clubface through impact) as well producing too much curve (hook) in the ball flight.

• David Ledbetter adjusting both the posture (to be taller) and clubface position (to be less closed) in Aaron Baddeley's swing to improve his directional control and eliminate his tendency to have too much curve in the ball flight (hook). He also adjusted the arm swing (making it more connected to the pivot in each direction) to make Ty Tryon's swing more compact and allow him to have better distance control.

One must also realize that all of the knowledge in the world is of no use unless it is complemented with an appreciation of such things as how people learn, what motivates them to learn, what type of learning environment is best for them and, finally, what effect and influence differences in sociological, physiological and psychological factors, as well as gender, can have on learning. Only once the "art of teaching" is understood can one know how best to impart the information to the student so that it can be understood, processed and integrated. Those who command a thorough understanding and knowledge in both the art and science of teaching golf will be able to achieve the most success with students of all skill levels.