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THE IDEAL GOLF SWING: AN EVALUATION OF ITS MECHANICS AND RELATIONSHIP TO INJURY RISK

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ABSTRACT

This paper describes the ideal golf swing and the development of a 70-item checklist (Golf Swing Scale) for evaluating the swing mechanics of a golfer. The checklist includes 25 items for the static component (grips, set-up, and stance) and 45 items for the dynamic component (backswing, downswing, impact and follow-through) of the ideal swing. As many factors contribute to the risk of golf injury, both formal literature and informal sources that describe the types and causes of these injuries and how they are related to swing mechanics were reviewed. A critical review of the literature was undertaken to describe the types of injuries attributed to the golf-swing and some of the reasons for these typical injuries. Finally, countermeasures for preventing or reducing the risk of these injuries are discussed with recommendations for further research into the relationship between swing mechanics and injury risk.

In the sport of golf, one of the more commonly used motor skills is the basic golf-swing. This is used for up to 50% of shots including tee-shots (i.e., shots from the tee to obtain ball distances ideally more than 200m) and approach shots on to greens up to 150m. Although the golf-swing is essentially the same or similar for both long and short shots, different types of golf clubs are used to assist in achieving an accurate result. That is, clubs differ in length, weight, and club-head angle depending on the desired target distance.

With changes in equipment over time (e.g., materials used for making club-shafts and heads), the golf-swing has been modified to maintain or increase hit distance and accuracy. Changes have been made from the original "classic" swing (originating in Scotland) to the "modern" swing. One main difference is that the modern swing is purported to use more parts of the body to gain greater power at the expense of creating a more stressful action to the body, especially the lower-back (James, 1996; McCarroll, 1994). Consequently, an increased risk of injury has been associated with both incorrect and poor golf-swing mechanics (Adlington, 1996; Batt, 1993; James, 1997; Jobe et al., 1986; Kohn, 1996; McCarroll, 1990, 1994) and poor mechanics can make over-practicing especially hazardous (Hosea & Gatt, 1996). The most common

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complaint of amateur and recreational golfers is lower-back pain and the modern swing technique is suspected of being the major source of this problem and other complaints (McCarroll et al., 1990).

This paper begins by describing the ideal golf-swing and provides an objective measure to evaluate a golfer's technique with the ideal swing prescribed by coaches. A critical review of both formal literature and informal sources that describe the types and causes of golf injuries believed to be associated with the golf-swing is then presented. Finally, recommendations for further countermeasure development, research, and implementation to prevent swing-related injuries from occurring are given.

The Ideal Golf-Swing

Information regarding the modern or "ideal" golf-swing mechanics has been addressed in golf coaching books, take-home videos, and self-help materials to assist players to develop better technique. The "ideal" swing refers to those movements required to consistently and safely hit the golf ball a maximum distance with accuracy. However, few studies have formally analysed the various components of the swing in detail.

James (1996) described the golf-swing as an athletic movement involving the spine or trunk of the body as a link between the legs and arms, which connects to the golf club. With the feet placed at shoulder width distance apart, the legs act as a platform around which the trunk can rotate. During address of the ideal swing, the body's position should be bent slightly forward at the hips. As the swing commences, the golfer rotates to the right (for right-handed players) by coiling the trunk and turning the shoulders, hips, and knees about the lower legs. As this occurs, the forward bend is maintained and some of the body weight is transferred to the right foot and the head is kept steady. As the back-swing continues, the left arm is raised and swings across the trunk. Upon reaching the top of the swing the rotation is reversed by shifting the weight to the left side (by moving hips towards the target) with the downswing, while forward bending is maintained until the club impacts with the ball. Rotation continues to the left side during follow-through and the spine progressively extends until a static reverse "C" finish position is held with most weight on the left foot with balance maintained on the right toes. Similar to swing descriptions found in the literature, this description only implies the correct movements necessary for accuracy with no objective way of measuring different skill levels.

In the development of a more explicit description of the golf-swing, behavioural aspects were analysed with the most appropriate movements identified by initially reviewing golf coaching related literature (Sherman, 1997). A written and diagrammatic golf-swing description was developed and the content of this was validated by the opinions of expert golf coaches and sport scientists. This procedure produced a behavioural summary that discriminated two respective positional phases of the ideal golf-swing: a 25 component static *pre-swing* phase (for grips, set-up, and stance positions), and a 45 component dynamic *in-swing* phase (for backswing, downswing, contact, and follow-through). These 70 constituent components were then organized into a checklist format the *Golf Swing Scale* (see Tables 1 and 2). This includes a brief description of each component which could be judged by experts using a three-point scale on which the actual execution of the component could be compared relative to the ideal. That is, while viewing a swing, components of the swing judged as being "ideal" and like the checklist description would result in a score of 3, close to the "ideal" as 2, and not at all like the "ideal" as 1. The most ideal golf-swing would score a maximum of 210 points (70x3). The contents of the checklist were further validated in an empirical study that examined the relationship between the accuracy of ball landing positions (relative to a target) of both expert and amateur golfers with corresponding video analyses of their swings. The results of this study showed that the checklist was accurate in distinguishing better golfers (Sherman, 1997). Although other studies have also addressed the "ideal" mechanics of the swing, they have not validated their work other than by analysing the swings of professional golfers (Adlington, 1996; Stover et al., 1976).

Table 1 Static Component Items Included in the Golf Swing Scale Checklist (For right-handed golfer)

Component	Description
Grip	
Left Hand	
1.	Club shaft under heel of palm
2.	'Vee' formed between thumb and forefinger is directed towards right collarbone area
3.	Left arm relaxed and not tense
Right Hand	
4.	Right hand lower than left hand (for preferred right hander)
5.	Right hand thumb pad sits on top of left thumb
6.	Right hand little finger rests across or interlocks left hand index finger
7.	Right elbow below and inside left elbow
8.	'Vee' formation of right hand directed towards right collarbone area
Set-up Routine for Stance and Aiming Position	
1.	Shoulders square and parallel to target line
2.	Hips square and parallel to target line
3.	Knees square and parallel to target line
4.	Toe line parallel to target line
5.	Both arms hang down toward ground in a relaxed position
6.	Golf ball remains close to centre of stance
7.	Body weight evenly distributed between the feet
8.	Right foot square or turned slightly away from target
9.	Left foot turned towards target (one foot width)
10.	Knees in line over shoe laces
11.	Forward lean to balance weight evenly over both feet
12.	Line is formed through shoulders, knees and centre of feet
13.	Feet shoulder width apart
14.	Viewing from front, neck and spine form straight line
15.	Formation of a spine angle with top of spine further from target than the base

Table 2 Dynamic Component Items Included in the Golf Swing Scale Checklist (For right-handed golfer)

Component	Description
Half Backswing Position	
1.	Body weight transferred to right side
2.	Body weight transferred to right foot heel
3.	Knees remain flexed
4.	Up to 90 degrees angle between left arm and clubshaft
5.	Clubface square (parallel to left forearm)
6.	Hands opposite centre of body
7.	Extended shaft plane pointing between toe-line and golf ball
8.	Spine maintains correct spine angle or slightly increased
9.	Head maintains same height level
Full Backswing Position	
1.	Shoulder turn 90 degrees or more to spine
2.	More weight transfer to right leg
3.	Left heel remaining on ground or slightly raised
4.	Spine maintains same angle with lower spine closer to target than upper spine
5.	Hands positioned over the right arm bicep muscle
6.	Right elbow pointing down
7.	Club face parallel to the left forearm
8.	Head maintains same height level
Half Downswing Position	
1.	Weight evenly distributed on both feet
2.	Left foot (heel) supporting left side weight
3.	Hips returned to square position
4.	Knees remain flexed, weight returning to left side
Ball Impact or Contact Position	
1.	Weight evenly distributed on both feet
2.	Left foot (heel) supporting left side weight
3.	Hips rotated and open slightly towards target
4.	Spine angle maintained. Top further from target than bottom
5.	Left arm and club shaft in straight line
6.	Right elbow slightly flexed
7.	Head remains facing down at ball
Half Follow-through Position	
1.	Right arm fully extended (straight)
2.	Left elbow slightly flexed and turned down
3.	Left leg extended
4.	More weight is transferred to left side
5.	Right foot heel up, toes down
6.	Clubhead recoiled
7.	Head facing down towards ball tee area
Finish Position	
1.	Weight on extended left leg
2.	Right knee fully turned toward target
3.	Right foot fully turned with heel up
4.	Hips square on to target
5.	Shoulders facing left of target, right shoulder closer to target than left
6.	Body (head and spine) upright and straight over left leg
7.	Both arms flexed, hands behind head adjacent left ear
8.	Head facing target area
9.	Final position balanced (held)

Relationship Between Swing Mechanics and Injury Risk

Although many golf injury reports have attributed the occurrence of injury to poor swing mechanics of the golfer, this hypothesis has not been formally tested (Mallon & Hawkins, 1994; Sherman & Finch, 1997). Studies that have suggested that better swing mechanics can prevent injuries have been reviewed and are summarised in Table 3. Some of the more scientific studies that have evaluated golf-swing mechanics are based on objective models derived from sensitive electrical impulse equipment. For example, in one study electrodes were placed on back and hip muscles to identify the movement and muscular forces to the lower spine (Hosea & Gatt, 1996). This study showed that greater swing variations, usually associated with amateur golfers, affected the lumbar or lower spine during the swing. These findings supported earlier studies that found stress levels in the lower spine were much higher among less skilled players (Abernethy et al., 1990; Hosea et al., 1990).

Table 3 Postulated relationships between swing mechanics and injury

Reference	Swing mechanics
Mallon (1997)	Swing adjustments will reduce shoulder injuries
Pietrocarlo (1996)	Biomechanics of the foot are necessary for the proper transference of weight in the golf-swing to avoid injuries
Guten (1996)	Correct feet positioning with equal weight distribution on legs for stance and less knee flexion during swing is important to avoid stress on knees
Kohn (1996)	The sounder the swing mechanics the less chance of incurring an elbow injury
Stover & Stoltz (1996)	Changes to parts of the swing are helpful for senior players suffering from arthritis and to reduce stress
James (1996)	Correction of technical faults may be important in recovery and prevention of low back pain problems
James (1995)	Any variation from the ideal swing is thought to bring with it increased stress to the body and are more pronounced with amateur golfers. Swing mechanics can be important in the overall assessment of injury
Mallon & Colosimo (1995)	More efficient golf-swings reduce the possibility of shoulder injury
Stover, et al. (1976) (see Mallon & Callaghan, 1994)	Golfers with total hip replacements should be encouraged to use classic swing as opposed to modern swing
McCarroll (1986)	Acute and chronic problems can be reduced by correcting swing mechanics
Stover & Mallon (1992)	Poor technique is considered to be a cause of injury, although scientific verification for this assertion is scarce

Because of the relationship between stress to the body and injuries, it has been postulated that poor swing mechanics could lead to an increased risk of injury. Furthermore, the stress on the lumbar-spine during a swing also predisposes a golfer to muscle strains and other associated problems. Compared with professional golfers, amateurs usually develop higher stress loads on the lower back because of poorer swing mechanics (Hosea & Gatt, 1996) and it is argued that golfers should strive to improve their swing mechanics.

To improve the mechanics necessary to acquire a more ideal golf-swing, it has been suggested that amateur and recreational golfers should take lessons from a qualified professional golf coach (Mallon & Hawkins, 1994). During their training, qualified coaches develop specialist skills for analysing the golf-swing and methods to assist learners to not only perform better, but also to prevent injury. A number of authors argue that by having golf tuition from a professional coach, a player can achieve a more ideal swing that reduces the amount of swing variation, thereby correcting technique faults to help prevent and recover

from injuries (James, 1996; Mallon & Hawkins, 1994). However, the value of golf lessons as an injury prevention measure has not been formally demonstrated (Sherman & Finch, 1997).

Recent papers that described the prevention and treatment of elbow and knee injuries in golfers have also attributed injury problems to poor swing mechanics. As shown in Table 4, depending on the phase and component of the swing, injuries to different parts of the body can occur and these have been summarised according to the available literature. For example, according to Kohn (1996), deviation from the ideal swing plane of the backswing (i.e., the line that the club moves through as it is swung back) and the compensatory movements to bring it back on plane can cause typical elbow injuries. Knee injuries can be caused from excessive knee flexion and incorrect stance causing unequal distribution of weight on both legs during the swing (Guten, 1996).

Table 4 Summary of the relationships between types of injuries and different phases of the golf-swing

Golf Swing Phase	Injury Risk Factor	Types of Injury
Pre-swing		
Grip	Poor/Incorrect grip	Wrist and predisposition to injuries in later phases
Set-up/Stance	Poor posture, incorrect line-up with ball, unequal distribution of weight	Knee, lower-spine, foot
In-Swing		
Backswing/downswing	Deviation from swing plane	Elbow, back, wrist, shoulder
Impact	Hit ground behind ball	Wrist, elbow, hand
Follow-through	Poor finish position posture	Lower-back, hip

For more senior golfers, Stover and Stoltz (1996) suggested that grip and stance modifications, head position, golf ball placement, and active changes to footwork during the swing can all reduce the stresses on knees, hips, spine. However, no studies were cited as providing formal evidence to support these claims. As mentioned previously, injuries to the wrist from playing golf are not rare to either the professional or amateur golfer. According to Murray and Cooney (1996), the majority of these injuries are due to overuse mainly of the wrist flexor or extensor tendons. To prevent these types of injuries, Murray and Cooney (1996) suggested that golfers should:

- not hold too strong a grip (i.e., not have the left hand positioned clockwise on the golf club handle too much)
- not over grip the club (i.e., not hold grip too tight)
- not use equipment that is in poor condition.

McCarroll (1986) conducted a survey of 226 professional male and female golfers. Based on this, he developed a listing of the relationship between the anatomical areas where injuries occur with the particular component of the swing. As summarised in Table 4, the take-away or backswing was associated with injuries mainly to the back and wrist; the impact phase (i.e. the downswing and impact on ball) was associated with injuries to the wrist, back, and elbow; the follow-through was mainly associated with injuries to the back. It should be noted that although the downswing covers a similar range to the backswing, it is three times faster and twice as many injuries occur during this phase (McCarroll, 1994).

In summary, the more common golf injuries such as low back pain, wrist and elbow problems, and shoulder injuries can be partially or fully attributed to the golfer's swing mechanics. Therefore, an important research need is the development of the ideal mechanical model of the basic golf-swing that should be prescribed to avoid the risk of injury. This should involve correlating injury occurrence to particular aspects of a poor swing.

In conclusion, as a result of this review we recommend the following points for further research, development and implementation:

- Formal study of the relationship of the poor golf-swing and its components to injury risk needs to be undertaken.
- Extend the work already undertaken by Sherman (1997) to investigate the relationship between injury risk and swing mechanics.
- Reinforce the importance of taking golf lessons from professional coaches for golfers at all levels of play to improve swing mechanics. This should benefit performance as well as satisfy participants.
- Formally evaluate the effectiveness of golfing lessons as an injury prevention measure.
- Conduct preliminary studies of the swing mechanics of both professional and amateur golfers, with and without injury, to determine the common faults that cause particular injuries.
- These preliminary studies would be retrospective in nature and the important findings should be confirmed in prospective studies of injuries in golfers.
- Players with injuries likely to be related to their swing mechanics should seek professional advice regarding the improvement of their swing.

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