Strength and power training for golf players

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INTRODUCTION

Golf has previously been viewed as a sport which requires little or no physical conditioning in order to be competitive at either the amateur or professional level. However, when examining the demands placed upon the body and the trends of injury, together with the mechanisms which cause them, within both the amateur and professional game, it is clear that physical training is required to prevent injury and also to enhance performance. This article aims to provide the strength and conditioning coach with a thorough analysis of the golf swing and also an indication of possible forces placed upon the athlete during the swing. This is followed by advice to the strength and conditioning coach on how to best prescribe strength and power training exercises in order to prevent injury and subsequently improve performance.

The golf swing

Glazier and Lamb3 give us a very detailed description of the golf swing. At address, weight is distributed almost evenly between the lead (54%) and trail foot (46%) (lead = left foot and trail = right foot for right handed golfer), as illustrated in Figure 1.

The first phase of the golf swing is also referred to as the take away, which involves the golfer rotating the pelvis approximately 45 degrees with no lateral movement away from the target. During this phase, the weight shifts towards the inside of the trail foot, as in Figure 2 (see next page).

To complete the back swing, the golfer continues to rotate the upper torso to approximately 90 degrees to complete a full shoulder turn. Here, weight distribution is very similar to that of the take away phase; the angle of the spine should also
remain constant with no anterior-posterior or lateral flexion of the spine and in a neutral position. During the back swing, the trail shoulder abducts and externally rotates by approximately 90 degrees; meanwhile the lead shoulder horizontally adducts and internally rotates, allowing the golfer to complete the backswing and have the club pointing towards the target and parallel to the ground. Here the shaft position may vary slightly due to club selection and swing length, as shown in Figure 3.

From the top of the backswing and into the downswing, weight is shifted back to the lead side, with the weight distribution being roughly 80:20 in favour of the lead side and with the weight being placed through the front portion of the lead foot. This is then followed by a rapid rotation of the pelvis towards the target, accompanied by triple extension of the ankle knee and hip of the lead side to assist with force generation against the ground. This is immediately followed by a rapid deceleration of the pelvis which then causes the upper torso to accelerate, followed by the arms and then the club, with the club head finally making contact with the ball, as illustrated in Figures 4 and 5. This rotational sequence – and the lever created at shoulder and wrist – result in the transfer of angular momentum onto the club head, which is hugely important with regards to developing high club head speed and ultimately in producing the desired shot distance and ball flight. As the player completes the follow-through phase, in which the lead hip internally rotates...
fully and the upper torso rotates through 180 degrees (from top of backswing), this results in the golfer facing the target on completion of the swing. Here the player requires a large amount of eccentric strength to absorb the rotational forces and decelerate the moving body parts, ensuring a stable and controlled finishing position as demonstrated in Figure 6.

A successful golf shot requires adequate amounts of distance and direction.\(^\text{17}\) Distance is ultimately determined by the speed of the club head at impact,\(^\text{17}\) whereas direction will be decided by player alignment and also the face angle of the golf club at impact. Research has indicated that the correct kinematic sequencing of the pelvis, thorax, arms and club can play a significant role in generating club head speed. The kinematic sequence of golf is similar to other proximal to distal movement patterns and involves the summation of speed principle to accelerate the club head through the impact phase of the golf swing. The summation of speed principle, first introduced by Bunn,\(^\text{1}\) states that movement patterns with the aim of maximal speed, should begin with the larger more powerful proximal muscles initiating the movement and then transferring the force to the smaller distal muscles, with the movement increasing in speed as this occurs. It has also been shown that better golfers achieve greater speeds during the swing and have better kinematic sequences,\(^\text{21}\) allowing the more distal segments to reach higher velocities at impact and ultimately leading to greater shot distance.

Example of speeds reached by the main body segments during the kinematic sequence of a highly skilled golfer can be seen in Figure 7 (see next page). The kinematic sequence also shows how the summation of speed principle impacts on the golf swing to allow the distal segments to achieve their greatest velocities at impact.

The ability to create these rotational speeds in the downswing begins with the golfer driving their feet into the ground in order to transfer energy up through the kinetic chain and onto the golf club. During the downswing, ground reaction forces of 1.5 to 2.0 x bodyweight have been observed when hitting driver and long irons.\(^\text{4}\) To transfer these forces created against the ground successfully into an explosive rotational movement pattern, such as the golf swing, requires large amounts of total body strength; it also requires coordination of key muscle groups to ensure no energy is lost and that kinematic sequence is executed in the correct order.
As a result of these velocities encountered during the downswing prior to impact, a considerable level of strength is required by the golfer to handle the forces exerted by the golf club; this is because large amounts of centrifugal force are produced by the angular velocity of the club head pulling away from the golfer during the downswing. If we look at the formula for centrifugal force, then we can start to calculate how much force is required to resist the pull of the club head away from the body and for the golfer to remain stable within the base of support. The formula for centrifugal force is as follows: 

$$ F = \frac{m \cdot v^2}{r} $$

where 

- \( m \) = mass of club 
- \( v \) = velocity of club head and 
- \( r \) = radius (length of shaft)

$$ F = 0.265 \times 2508 / 1.143 = 581N \text{ or } 59.24Kg $$

From this we can see that – based on calculations using a standard driver and European tour average club head speed of 112mph – a golfer faces a considerable challenge to maintain stability over their base of support. The lower back and wrist are the most commonly injured sites of the body among golfers; other injury sites include the elbow, hand and knee.

Forces in the lower back during the golf swing have been reported to reach up to eight times body weight, this being a combination of compressive, shearing and rotational forces on the lumbar spine, as in Figure 4, placing the intervertebral discs at risk of injury. Tsai et al indicated that golfers with a history of low back pain also showed decreased trunk extension strength, left hip adduction strength and poor thoracic spine range of motion. These physical restrictions result in the musculature and joint structures in the lumbar spine having to absorb large forces during the swing: this will ultimately result in injury.

Both elbow and wrist injuries are mainly due to having to cope with large forces being absorbed by the arms during the rapid deceleration of the club head during impact with the ball, turf or other surfaces such as thick rough, which can quickly bring the club head to a halt. The wrist also passes through large ranges of motion including flexion, extension and radial and ulnar deviation, which also places extra stress on the surrounding joints and tissues. This, coupled with high number of hours practice, can lead to overuse related injuries.

The glenohumeral joint, on both the lead

**Injury trends and mechanisms**

Overuse and technical deficiency have been stated as the two main causes for injury within both amateur and professional golfers, with amateur golfers more likely to injure themselves through incorrect technique whilst professional golfers are more susceptible to overuse injuries.
and trail side, is required to pass through a full range of internal and external rotation and also horizontal abduction and adduction during the golf swing. Restrictions within the surrounding tissues, coupled with a lack of strength in key supporting musculature, can place the shoulder at risk of overuse-related injuries including: subacromial impingement, rotator cuff pathology and possibly acromioclavicular dysfunction. It is most probable that increased practice hours or new swing changes are likely to exacerbate injuries within the shoulders.

Studies indicate that the location and spread of injuries between amateur and professional golfers are similar; however, professional golfers are more at risk of overuse injuries due to their high number of practice hours, whereas amateur golfers are more likely to suffer acute injuries due to poor technique.

Training the golf athlete

Following a detailed needs analysis in collaboration with the coach and the athlete to identify technical and physical weaknesses, the physical preparation programme is likely to focus on two main areas:

1) The removal of physical restrictions, which hinder technique and place the athlete at increased risk of injury

2) Improving strength and power which, in turn, will improve club head speed and shot distance.

With these goals in mind, the training programme should focus on improving mobility and reducing muscular strength imbalances in key areas of the body such as thoracic spine, shoulder girdle and lumbo-pelvic complex. The goal of such a programme is to prevent potential overuse injury, assist the golf athlete in improving technique and to develop the necessary strength and power qualities to produce, resist and absorb the high forces associated with the golf swing.

Traditionally, many golf athletes have focused their training around flexibility, hoping for performance improvement, including mainly static stretching interventions pre competition and practice, with little or no attention paid to other methods of physical preparation strategies such as strength and power training. However, the strong relationship between muscle strength, performance (score/handicap) and also driving distance and ball speed\textsuperscript{18} would suggest that golfers should be encouraged to develop their strength and power capacities to potentially benefit performance.

Unfortunately, a common misconception within the golf athlete population is that strength training will harm flexibility gains: this often discourages golfers from engaging in strength training programmes. However, if exercise selection is focused around multi-joint/multi-muscle movements moving through full ranges of motion, then strength training sessions inherently become a dynamic flexibility session capable of improving the participant’s flexibility and strength. This notion is supported by Morton et al,\textsuperscript{12} who suggests that an appropriately designed resistance training programme, performed through full range of motion, can be just as effective as a static stretching routine with regards to improving hamstring flexibility, hip flexion and hip extension.

Similarly, Lephart et al\textsuperscript{6} – following an eight-week golf-specific strength and conditioning programme – demonstrated improved mobility in torso rotation along with club head speed and driving distance. The programme included a series of basic lower body exercises and golf-specific movements using elastic resistance tubing. Although Lephart’s study focused on golfers with a handicap of 12.1 +/- 6.4, it is also suggested that already highly proficient golfers can improve their performance from participating in a golf specific strength training programme.\textsuperscript{15} Highly proficient golfers who have not yet participated in strength and power training programmes most likely possess a large window of adaptation due to a low strength and power training age. Therefore, it could be suggested that a more general strength and power training may also help improve golf performance.

Given the asymmetric nature of the sport, it is without doubt that golfers will develop sport-specific muscular imbalances. Common muscular imbalances found within golfers include upper and lower cross syndromes, negatively affecting joint position at both the shoulders and hips. In addition to anterior–posterior muscular imbalances, the S&C coach should be aware of muscular imbalances that can occur between the left and right sides of the body. Therefore, golfers should train throughout the year to limit the negative impact of

\textit{(text continued on page 21)
Figure 8.
The ‘Open Book’ exercise can be used as part of a dynamic warm up to target thoracic mobility in golfers in both gym and pre-practice / competition warm-ups.

Figure 9.
- Frames 1 to 2 the first pull of the clean develops leg and back strength essential to posture. Balance and set up position.
- Frames 2 to 3 the transition phase of the clean requires a rapid unweighting and transfer of weight acting through the foot similar to the movement required in the first part of the downswing.
- Frames 3 to 4 the second pull of the clean involves a rapid and powerful triple extension through hip, knee and ankle. The application of this downward force results in ground reaction forces which, in a similar golf swing pattern, will subsequently be transferred into the rotational forces which produce club head speed.
- Frames 4 to 6 the catch of the clean requires reactive speed, coordination, dynamic flexibility, balance, and eccentric strength. All of these are qualities required in golf performance and injury avoidance.

Figure 10.
Tornado ball rotations are an effective sports-specific exercise as the exercise develops isometric/ eccentric trunk strength as well as allowing the athlete to better withstand the centrifugal forces developed during the downswing and also absorb the deceleration forces post impact.
such imbalances on technique and also to limit potential injury. To do this, the S&C coach should aim to include both bilateral and unilateral exercises to limit potential strength imbalances and maintain postural integrity throughout the training and competitive year.

A dynamic warm-up

A well-designed golf-specific S&C programme should include a suitable dynamic warm-up, preparing the body for the training session which is to follow. We consider that this should include dynamic movements which focus on the elevation of heart rate, activation of necessary muscles, and mobilisation of key joints and rehearsal of preceding movement patterns.6

When training golf athletes, it is suggested that time is spent at the beginning of the warm up-targeting shoulder, thoracic spine and hip mobility. An example of an effective exercise for targeting thoracic mobility can be seen in the Figure 8.

Inclusion of the entire kinetic chain is also another important factor to consider when training to improve golf performance. This is due to the generation of force against the ground and the transfer of the resulting ground reaction forces through the lower body, trunk and upper extremities and finally, onto the golf club. An example of an effective strength and power exercise for golfers is the Clean, an example of which can be seen in Figure 9. In this exercise, there is sufficient coordination of several large muscle groups, working together in order to transfer force developed against the ground, through the body and onto the bar.

Performing explosive strength training exercises such as the clean/snatch and their derivatives will help increase the rate of force development qualities and also the inter-muscular coordination of proximal to distal sequencing similar to that in the golf swing. Given the similar characteristics of the golf swing and the clean with specific regard to force production and movement patterns, it would seem reasonable that the clean may have a beneficial effect on club head speed and driving performance.

The S&C coach may also choose to include more ballistic strength training exercises such as tornado ball swings (Figure 10), medicine ball hammer throws (Figure 11), or medicine ball discus throws (Figure 12) to focus on improving the summation of vertical ground reaction forces, linear weight shift and rotational forces that are all important for the sport-specific kinematic sequence which is required for elite golf performance.13

In addition to improving the sport-specific kinematic sequence, these exercises train...
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the athlete to develop the rotational speed required for the sport, as well as the isometric and eccentric trunk strength to absorb the deceleration forces also encountered post impact.

When developing overall strength for golf athletes, S&C coaches should look to select exercises which target the posterior chain, focusing mainly on thoracic spine and hips. Overhead squats (Figure 13) should be used as an effective total body strength exercise which not only develops whole body strength and stability, but can also target the mobility objectives of the golfer’s S&C programme, as the exercise develops thoracic, hip and shoulder mobility as well as improving strength of key stabilising muscles in both scapulae and glenohumeral joint.19

In addition to overhead squats, stiff leg deadlift (demonstrated in Figure 14) should be considered when designing a golf S&C programme, as this exercise can again help improve posterior chain strength and also the hip hinge ability of the athlete, which may in turn help to address any issues the golf athlete may be having at his or her address position during the golf swing. Improving the strength of the athlete’s posterior chain in this position may also help the athlete resist the strong pulling forces displayed by the club head during the downswing, impact and early follow-through phases of the swing.

Assistance exercises

Given the asymmetric nature of the sport mentioned previously, the S&C coach should be aware that many golfers will suffer from a muscular strength imbalance between the left and right sides of the body, which may potentially lead to possible overuse injuries. A range of upper and lower body unilateral exercises, such as the single arm cable row (Figure 15) or the conventional split squat (Figure 16) should be included to maintain muscular balance and symmetry throughout the scapulae and pelvic stabilisers respectively, in order to maintain postural balance between left and right sides of the body.

Additional thoughts

Some golf athletes may find the more advanced strength training and Olympic weightlifting movements challenging due to the mobility and postural demands.
In these cases, S&C coaches may wish to prescribe derivatives of the full clean and snatch movements, such as pulls from the hip or mid-thigh to improve the lower body rate of force development. Also variations of squatting movements such as back squat or front squat can be used to target peak force generation.

However, it should be the aim of the S&C coach to develop the necessary functional capacities in order to allow the development of optimal technique in the more advanced strength training and weightlifting movements. The S&C coach needs to invest sufficient time in order to remove physical restrictions and coach correct technique prior to adding additional load to these exercises.

Encouraging young golfers to engage in a resistance training programme as part of a long term physical development plan may be the most effective strategy to minimise the development of sport-related muscular imbalances as practice and competition demands increase. Encouraging young golfers to perform resistance training exercises and weightlifting movements under the supervision of an accredited S&C coach can also have a beneficial effect on motor skill development due to the high levels of intra- and inter-muscular coordination required, which may also lead to improved sport-specific skill acquisition and retention. This would allow the golf athlete increased opportunity to perform the large volumes of deliberate practice necessary to achieve their maximum potential with most likely reduced incidence of overuse injury hindering technical development.

It should also be noted that the mere inclusion of the exercises listed above will not automatically result in the desired physical adaptations. The teaching progressions, frequency, volume and intensity of all the exercises mentioned within this article should be carefully planned within the athlete’s periodised training plan, so as to ensure the optimal transfer of training effect takes place in order to enhance performance.

Conclusion

There is a plethora of training modes and methods which are available to the modern golfer and which will be feasibly effective in the short term. There is also a possibility that those blessed with genetic gifts will probably succeed, regardless of special physical preparation. However, they may still be at potential risk of chronic injury as a result of
many hours of deliberate practice. Therefore, S&C coaches and golf athletes who are in search of a long-term effective training plan, which will both help mitigate potential injury and contribute to performance, are advised to consider the inclusion of multi-joint and multi-muscle strength and power training exercises to be best prepared to cope with the physical demands and repetitive nature of the golf swing.

AUTHORS’ BIOGRAPHIES

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Barry Jones is a strength & conditioning coach for the Sportscotland Institute of Sport and has worked with athletes from a variety of sports. Barry is currently the lead S&C coach for Scottish Golf and provides S&C support to Scotland’s elite amateur golfers, including the 2015 European Men’s Amateur Team Champions and Boys Home International Champions. In addition to this role Barry is also responsible for the development of Scottish Golf’s long term physical development pathway within the Scottish Golf Academy. He has also worked with professional golfers on the European, Challenge and Ladies European Tours.

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References