GOLF BIOMECHANICS: IMPLICATIONS FOR PERFORMANCE AND THE LUMBAR SPINE

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INTRODUCTION: Golf is one of the most popular sports in the world today. It offers accessibility to a wide range of ages, physical abilities, and levels of expertise. Novices and experts alike desire maximal performance with the game of golf, and often encounter musculoskeletal injuries in their quest to perform at the highest level possible. The most common injury associated with golf is low back pain. The purpose of this paper is to review the physical conditioning approaches to minimize the incidence and severity of low back pain while maximizing golf performance, present information related to normal lumbar spine mechanics, and discuss the stress imposed upon the lumbar spine from the game of golf.

Characteristics Associated with High Performance in Golf: It appears that there are a variety of characteristics that separate the high- and low-skilled golfer (Keogh et al., 2009; Meister et al., 2011; Sell, Tsai, Smoliga, Myers, & Lephart, 2007). Characteristics such as flexibility (Sell et al., 2007), strength (Keogh et al., 2009; Sell et al., 2007), and others (Keogh et al., 2009; Sell et al., 2007) separate players of different ability. The differences in these physical abilities appear to manifest themselves in a number of swing characteristics, such as club head velocity (Keogh et al., 2009) and X-factor (difference in rotational orientation of shoulders and pelvis in a single plane; Cheetham, Martin, Mottram, & St Laurent, 2001; Meister et al., 2011).

Flexibility and mobility is an important component of golf performance, due in part to the large ranges of motion inherent to the modern golf swing (Smith, 2010). A reduction in flexibility restrictions appears to positively influence swing characteristics, including X-factor (Lephart, Smoliga, Myers, Sell, & Tsai, 2007), where high flexibility is necessary for adequate shoulder and hip separation. Greater X-factor appears to be a factor in increasing club head velocity and ball velocity (Myers et al., 2008), thus it is likely an important component for a golfer desiring to improve his performance. Some recent research has suggested that greater x-factor may not be as important of a component in high-level golfers for club head velocity (Kwon, Han, Como, Lee, & Singhal, 2013), although this does not diminish the importance of maintaining an adequate level of flexibility for golf.

The ability to generate large forces, especially from the lower body and torso is also paramount to a powerful golf swing and is characteristic of better golfers (Hellström, 2008; Keogh et al., 2009; Sell et al., 2007). The proximal to distal sequencing in the swing transfers the large forces developed by the lower body to the torso, shoulders, arms, and finally into the club; a greater ability to both develop and transfer forces to the club are of vast importance for long drives. In particular, strength in the midsection is probably an integral factor for a better transmission of forces from the lower body into the club (Loock, Grace, & Semple, 2013).

A golfer must develop forces quickly in the roughly 0.3 second-long downswing (Meister et al., 2011). A number of measures of explosiveness distinguish better golfers from lesser, indicating the importance of power and fast rate of force development to the golf athlete (Gordon, Moir, Davis, Witmer, & Cummings, 2009; Hellström, 2008). Golfers with near-scratch handicaps tend to have greater vertical jumping ability, and sprint power development than those with higher handicaps, for example (Hellström, 2008).

Golf-Specific Training: A number of studies have evaluated the efficacy of a variety of training methods for golfers, such as resistance training (e.g. Alvarez, Sedano, Cuadrado, & Redondo, 2012), plyometrics (e.g. Bull & Bridge, 2012), and flexibility (e.g. Lephart et al., 2007). Generally speaking, this literature has supported the aforementioned approaches to training. While these studies have provided some direction in the effectiveness of general methods, they have not provided direction in the specific means (e.g. exercises, sets, repetitions) of improving golf performance. For this, the practitioner should draw information from other literature not necessarily golf-specific for direction in specific exercises, programming decisions, and periodization strategy (e.g. Stone, Stone, & Sands, 2007). Pulling direction from this literature is paramount for properly organizing all of the training necessary for peak performance in golf, ensuring that performance is improved at an ideal rate, the fatigue generated from training is accounted for and managed and that performance is peaked at appropriate times.

Furthermore, golfers, as individuals, have differing needs for maximizing their training. While they can all benefit from improvement of flexibility, strength and explosiveness in golf-specific ways, there are specific aspects of each of those characteristics that are uniquely needed by a given individual. One golfer may have specific areas of his body that need improvement, or specific aspects of his strength that are lacking. Group research makes assessment of an individualization training program difficult by its nature. Thus, it is up to the practitioner to use available literature to organize and prescribe training that is individualized for a specific golfer, even when that available literature may not make it simple to bridge from research to practice.

Anatomy and Kinesiology of Lumbar Spine: The lumbar spine has a relatively thick vertebral body and apophyseal joint orientation mostly within the sagittal plane. This orientation restricts rotation while maximizing flexion of the spine. Functionally, one has about 40 degrees of flexion available from the lumbar spine, but only 5-7 degrees of axial rotation. Contrast this with approximately 30-35 degrees of rotation available in the thoracic spine. There are coupled, or combined, motions that occur within the thoracic and lumbar spine and in combination with the hips to maximize function with rotational movements. For example, clinical measurements of trunk rotation typically exceed 5-7 degrees mainly because of composite motion between the hips and spine. Therefore, when one has limited hip rotation, then excessive stress is often passed along to the lumbar spine during the golf swing. Segmental rotation greater than three degrees at any lumbar segment potentially imparts injurious forces to the apophyseal joints and disrupts collagen within the annulus.

Golf and Lumbar Stress: Lumbar stress encountered during the golf swing has been estimated by motion analysis systems (primarily optical and electromagnetic) with force platforms. The full modern golf swing has been shown to exert high forces in the lumbar spine for compression, and lateral and anterior shear. For example, during the full, modern golf swing, compressive forces approach 6 to 8 times one’s bodyweight (Hosea, 1996). Due to the magnitude and repetitious nature of the forces encountered, the mechanism of low back pain is most likely to be of overuse, and most incidences of low back pain are nonspecific in that the offending anatomical structure may never be identified. Fortunately, most low back pain occurrences improve without major medical intervention.

X and Crunch Factors: As previously discussed, the X-factor is important for golf-related performance, but it requires maximal trunk rotation. Higher X-factors are associated with concomitantly higher stresses to the lumbar spine, but may need to be modified during the rehabilitation of golfer with low back pain.

The “crunch” factor occurs for a right-handed golfer as the trunk moves into lateral flexion while the pelvis undergoes axial rotation toward the target. Several authors make a compelling argument for the impact of combined stress of trunk rotational velocity to the left with concomitant right side-bending (right-handed golfer). Morphological changes to the right-sided apophyseal joints attest to bone mineral deposition as an adaptive response to the stress imparted lumbar spine (Sugaya, 1999).

Interventions to protect the lumbar spine: One prophylactically protects the back during the golf swing by employing proper swing mechanics and with prior conditioning of the trunk musculature that implies proper core stability. Once the back is injured, then swing modification may be necessary while the region rehabilitates. Shortening the backswing is one modification that is relatively easy to employ, and is taught by instructing the athlete to take the club back approximately one-half of their normal swing. By shortening the "normal" swing for a golfer, one avoids having to learn a novel swing.

Shortening the one-plane golf swing has been show to ameliorate stress to the lumbar spine by reducing the X and Crunch Factors. Thus, reducing the backswing is associated with reduced axial rotational velocities, clubhead velocities (CHV), and therefore shot distance. Moreover, and most importantly, one also reduces the magnitude of lumbar compressive forces during the golf swing. Although shot distance is reduced, accuracy is improved with a tighter clustering of shots around the target.

Conditioning the trunk musculature: Golfers with a history of low back pain have diminished trunk and hip muscle strength (Tsai, 2010; Horton 2001). It is not clear whether the relative weakness occurs before the injury, or is a result of incomplete rehabilitation or continued neuromuscular inhibition. However, it is imperative to address trunk and hip muscle strengthening with a proper conditioning program to return the golfer to sport. Many activities to improve trunk strength during rehabilitation are progressed into more traditional core strengthening activities.

Conclusion: Golfers should have high fitness levels to maximize performance, which may also serve to avoid low back pain. However, if low back pain occurs, one must adequately employ interventions to reduce stress to the back while properly rehabilitating trunk musculature.

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