Low back pain in golfers: a literature review of golf swing mechanics, injury, and prevention

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Abstract

Objective: The golf swing, much like many other athletic movements, imparts tremendous stress on the body, particularly in the lumbar spine. It is no surprise that low back pain (LBP) is one of the most common injuries plaguing golfers today. The swing types chosen by the golfers have been implicated as a possible cause of such injuries. The purpose of this article is to review the three types of golf swings, their effect on biomechanics, and their role in LBP. This article will also look at injury prevention measures the golfer may want to consider.

Data Collection: PubMed, EBSCO, and Google Scholar literature searches were performed using various permutations of the following keywords: golf, injury, low back pain, golf swing, biomechanics, spinal anatomy, prevention, modern swing, and classic swing. Articles were screened and selected based on their relevance to low back pain in golf, injury prevention, and the effects of swing mechanics on low back injury/pain. Only articles dated later than 1985 were selected. Primary references were also included from the initial selection of articles. Websites were used to compile statistics on demographics, and relevant texts were also utilized.

Data Synthesis: The information was compiled to provide a consensus on the mechanism of injury of the golf swing. Research articles were chosen based on validity and reliability to formulate a cohesive outlook on the cause, treatment, and prevention LBP in golfers.

Conclusion: The golf swing is a very complex series of movements, and the type of swing the golfer utilizes seems to be the driving force for injury. The "classic" swing utilizes less torque between the upper and lower body. There is also less extension in the spine during follow through. The "modern" swing, designed to produce more power, utilizes more torque and has increased extension during the follow through. This excess torque produces forces on the lumbar spine that, if the participant is not properly conditioned, can lead to muscular and overuse injuries. Treatment of these injuries must go beyond focusing on the area of complaint. Providing a more complete treatment plan and incorporating strength/conditioning programs seem to yield the best outcomes.

Key Words: Golf, injury, low back pain, golf swing, biomechanics, spinal anatomy, prevention, modern swing, classic swing

Introduction

The game of golf has come a long way since its beginning in Scotland in 1457. It has spread across Eastern Europe, the Americas, and even into Asia. It is a game that can be enjoyed regardless of your age, gender, race, or ethnicity. Golf provides exercise and social interaction and, with its handicap system, all skill levels can play and complete with each other.

Today, there are more than 25 million golfers in the United States alone.[1,2] This number is expected to rise to 55 million participants by 2020.[1,3] The undoubted popularity among older individuals is a point worth mentioning. Statistics from the National Golf Foundation[3] demonstrates that the most important increase in participation is by those aged 50-59 years, and that those greater than 50 years of age account for greater than 25% of golfers in the U.S. This could potentially create additional health issues with the combination of degenerative changes in the spine and the forceful stresses applied to it during the golf swing.

About 80% of adults will have low back pain (LBP) at some point in their lives.[4] It is one of the most common presentations seen in a chiropractic office.[4] Coincidentally, the low back is the most common site of injury in golfers.[5] The incidence of LBP in male golfers is 25-36% and 22-27% in female golfers.[6] The particular swing style the golfer utilizes, whether it is the "classic swing" or the "modern swing" has been implicated as a possible cause. In 2000, the estimated annual direct and indirect cost for LBP was $100 billion.[4] As a practitioner, this would be something worth looking into.

The chiropractic profession is well known for its treatment of spinal conditions, of which LBP is the most common. The chiropractor needs to be aware of the stresses that golf places on the body and understand the mechanics of the golf swing and how it may be a potential cause of back pain. The purpose of this research is to review the epidemiology of LBP in golfers and to discuss the role of the golf swing in the development of LBP.

Discussion

Anatomy

The low back, or lumbar spine, consists of five lumbar vertebrae which sit atop the triangular shaped sacrum. These vertebrae are larger in size than those of the cervical spine and thoracic spine. The spinous processes are broader, the transverse processes are long and slender, and there is an additional process called the mammillary process. The facet joints of the lumbar spine are situated in a sagittal orientation. This allows for lots of flexion in the lumbar spine but not so much rotation.[7]

In between each vertebra is a disc. This disc is made up of a fibrous outside, the annulus, which connects to the vertebral bodies. The inner part of the disc, the nucleus pulposes, is a semi-gelatinous mass which contains water. These discs allow for movement between vertebral segments and acts as a shock absorber for forces placed on the spine. However, these intervertebral discs are very sensitive to rotation.[7]

The static stabilizers of the spine are the ligaments. The anterior longitudinal ligament runs down the anterior aspect of the vertebral bodies. The posterior longitudinal ligament runs down the posterior aspect of the vertebral bodies which means it is located inside the spinal canal. Capsular ligaments are located around the facet joints (which is a common location for pain). Then there are three ligaments which connect the posterior elements of the vertebrae. The ligamentum flava which runs along the anterior surface of the neural arch, the interspinous ligaments which run from spinous process to spinous process, and the supraspinous ligament which runs atop the spinous processes.

There are also many dynamic stabilizers of the lumbar spine. These include the stabilizing muscles like the multifidi, intertransversariae, and the rotatores. It also includes the muscles which produce motion like the erector spinae and the quadratus lumborum. This will become more important as we discuss the mechanics of the golf swing.

The golf swing

The golf swing is a series of complex movements that involves the movement of the upper body around a fixed pelvic base. The start position of the golf swing is known as the address position, where the player prepares to hit the ball. The backswing phase follows and is the process where the club is taken back to store potential energy in the body. This phase brings the club backwards and ends with the club parallel to the ground. The downswing phase is then initiated to bring the club back towards the ball to transfer the energy of the swing to the ball at impact to propel it towards the target. After impact, the club swings forward in the follow through phase and finishes up beyond the parallel (Fig 1).[6,8]

Figure 1. The phases of the golf swing. A. Address position. B. Early backswing. C. Top of backswing. D. Mid downswing. E. Prior to impact. F. Mid follow through. G. End follow through.

Not only is the golf swing a complex series of movements, it is very much an art form. It is as unique as the individual utilizing it. Despite the image of a single type of swing, the swing can be tweaked through the use of different equipment and modified based on the physical characteristics of the individual. While each golfer has their own unique swing, there are predominately two swing blueprints used, the "classic swing" and the "modern swing".

Prior to the 1960's, the classic swing was the predominate swing used by golfers. It wasn't until the early sixties that Jack Nicklaus began altering his own swing to increase his distance and separate himself from other players. This new type of swing has become known as the modern swing and is characterized by greater torque between the upper and lower body. This is the

preferred swing in today's golfers as this is a more powerful swing which increases distance and allows for higher ball flight which stops the ball closer to where it lands.

"Classic" swing

In the classic golf swing, the back swing phase was characterized by a large upper body rotation and also a relatively large pelvic rotation. This pelvic rotation resulted in the left heel lifting off the ground, in the right-handed golfer, and was a feature of the classic backswing. The shoulders and hips would then turn towards the ball to start the downswing phase. The end stage of the follow through was characterized by the whole body facing the target and a relatively straight back. Video footage of players of the first half of the 20th century reveals a forward momentum at the impact and follow through, almost enough for the player to walk forward after hitting the ball.

The classic golf swing with rotation of the shoulders and pelvis, lifting of the front foot, and straight follow through with momentum going forward

"Modern" swing

In contrast, the modern swing exhibits a complete shoulder turn that is similar to that of the classic swing. However, the pelvis does not turn during the modern swing and remains facing the ball. A large torque occurs between the moving upper body and the stationery pelvis. Hip movement starts the downswing phase (not the entire body like in the classic swing) and the end of the follow through is characterized by a body position known as the "reverse C". This position creates a great degree of hyperextension in the lumbar spine and has been proposed as a mechanism for many of the overuse injuries noted in the low back of golfers. This reverse "C" positioning is believed to be a generator of LBP in many professionals. Jack Nicklaus, Fred

Couples and Greg Norman have all had back pain during their careers and all three were users of the modern swing.

The modern golf swing with shoulder rotation, stationary pelvis, lots of torque, and the reverse "C" follow through.

TABLE I. Differences between classic and modern swing

	Classic swing	**Modern swing**
Address	similar to modern	similar to classic
Backswing	late wrist cocking	early wrist cocking
Top of backswing	equal shoulder and pelvic rotation large movement of body to right only left toes in contact with ground	limited pelvis rotation limited body movement to right all of left foot is on ground
Downswing	whole body initiates downswing	hips initiate downswing
Impact	hips equal with shoulders small amount of right trunk flexion	hips ahead of shoulders large degree of right trunk flexion
Follow through	low back in neutral straight position momentum directed forward	hyperextension in lower back momentum directed upward

Due to a perception that this new modern swing is causing more and more players to have back pain, there have been modifications made which blend elements of the modern swing with elements of the classic swing. This type of swing has become known as the "Hybrid Swing", and it aims to decrease the forces placed upon the spine. The swing incorporates the large difference in rotation of the shoulders compared to the pelvis of the modern swing, but the follow through is similar to the classic swing in that the spine is straighter and not in the reverse "C" position. This follow through allows the trunk to continue to rotate counter clockwise in the right-handed golfer, allowing a greater time for disbursement of swing forces and a reduction in the profound hyperextension position of the low back.[6]

Biomechanics and kinesiology of the golf swing

Many people view golf as less physical and demanding than most other sports. However, the golf swing generates an incredible amount of force. Axial twisting alone has been identified as a risk factor for low back disorders.[1,9,10] In addition, the lumbar spine is exposed to significant compression, anterior-posterior shearing, torsion, and lateral bending forces during the golf swing.[11] Hosea and Gatt performed a study to determine the forces on the lumbar spine during the golf swing.[1,12,13] Kinetic data of subjects wearing reflective markers over the T5, T10, L1, and L3 spinous processes, in addition to the wrists, elbows, shoulders, hips, knees, ankles, and fifth metatarsal heads, was captured using four synchronized video cameras with high speed shutters. Myoelectric data was collected using surface electrodes on the rectus abdominis, external oblique, and paraspinal muscles at the level of L3. Forces around the L3–L4 motion segment were extrapolated from the collected data. Compression loads of up to eight times a person's body weight, or about 6,100$\pm$2,413 N in amateurs and 7,584$\pm$2,422 N in professionals, were found to be produced during the golf swing.[12,13] These forces are almost as high as the forces experienced by Division 1-A college football linemen when hitting a blocking sled as determined by the same authors in a similar study.

As mentioned earlier, the facet joints of the lumbar spine are situated in a sagittal plane which restricts rotation. These same facet joints also serve to resist more than 50% of the anterior-posterior shear load.[14] Estimated peak shear loads of 596$\pm$514 N have been recorded during the golf swing in amateur golfers, yet similar shear loads of 570$\pm$190 N were capable of producing

pars interarticularis (which is a part of the pedicles which make up the neural arch of the spinal column) fractures with cyclic or rotational loading in cadaver specimens.[1,13] Only two or three degrees of intersegmental rotation are required to produce microtrauma in the lumbar facet joints.[10,15]

Two aspects of the modern swing that may be an injury generator is the reverse "C" follow through and the excessive lateral bending of the trail side during the forward swing. An epidemiologic and radiographic study of elite golfers by Sugaya et al.[5] demonstrates how excessive lateral bending may produce LBP. They surveyed Japanese tour professionals at four different tournaments and found 55% to have a history of LBP. Over half of the symptomatic golfers complained of localized pain in their trailing side. They then performed radiographic analysis on 26 of those golfers and found significantly greater trailing side vertebral body and facet joint arthritis when compared with age-matched controls.[5] This is the only radiographic study that could be found pertaining to golfers. Other radiographic studies have been performed on athletes of other sports. Generally, athletes show more disc degeneration and joint arthrosis than those of the normal population. It cannot be determined if the swing utilized by golfers is the primary reason for the LBP. There are other components that must be considered.

Range of motion studies have be conducted on professional golfers with LBP and without. Vad[16] found that those with pain had significantly decreased lumbar extension and lead hip (left in right-handed golfers) internal rotation. Lindsay and Horton[17], in a study of professional golfers with and without lower back pain found that those with lower back pain displayed more lumbar flexion at address and exhibited significantly greater left-side bending on the backswing. Those with LBP also had less trunk rotation during range of motion testing. This resulted in an excessive rotation of their spines during the golf swing.[17] A further study on abdominal activation in elite male golfers with chronic lower back pain and asymptomatic controls found that abdominal muscle activity and muscle fatigue characteristics were quite similar after repetitive golf swings.[18] However, those with chronic lower back pain experienced increased lower back pain following repetitive golf swings. This would suggest an aggravation of sprain or strain on some part of the musculoskeletal system.[18] However; at no stage did these studies determine what golf swing type subjects displayed.

The changes in spinal motion due to different club lengths by the same player have also been studied. Lindsay, Horton and Paley[19] found that in the address position, the 7 iron club produced more flexion than when using a driver. Given that the difference in length of the shaft of the two clubs was 18 cm and the use of the driver was performed with a tee, this finding is not surprising. An increase in left side bend range of motion and right side bend velocity during the swing was also seen in the 7 iron.[19] A possible explanation for this is that with a 7 iron swing, the increased flexion at address and upright swing plane along with the weight shift to the right side, results in greater left side bend at the end of the backswing. This then results in greater right side bend velocity during the downswing and impact phases to achieve the correct impact body position.[19]

Treatment

While most golf related injuries are not serious, they are nagging and pose a hindrance to performance. That being said, most injuries are due to sprains and strains or from overuse, repetitive movements. Pain from these types of injuries will subside on their own in about 2 to 3 weeks[4] and can be treated with ice, rest, and nonsteroidal anti-inflammatory medication.

One might argue that chiropractic adjustments and soft tissue mobilization can be an effective treatment for golf related injuries. However, there is a lack of clinically significant research to support this. A study published in *The Spine Journal* did conclude that combined chiropractic interventions slightly improved pain and disability in the short term and pain in the medium term for acute/sub-acute LBP.[20] It went on to say that there is currently no evidence that supports or refutes that these interventions provide a clinically meaningful difference for pain or disability in people with LBP when compared to other interventions.

In a protocol for the evaluation of chiropractic manipulation on lumbar muscle activity and kinematics on tasks, Lehman and McGill[21] evaluated the effect manipulation had on the golf swing of a professional golfer with chronic LBP. Changes in all three axes of movement during the golf swing and both upper and lower right erector spinae exhibited decreased activity occurred after manipulation. As reported by the authors, this was a case report on the effect of

manipulation on the golf swing with only short-term changes measured. As such, this limits any conclusions drawn on the possible effects of chiropractic manipulation on the golf swing.

Research into the effect of swing modification has been performed.[22] The shorter back swing in amateur golfers (n=7) demonstrated only a minor reduction in the club head speed at impact and no loss of ball contact accuracy in performance measures. It was further found that there was a decrease in the muscle activity of the right oblique 750–250 ms prior to impact, with the left lumbar muscle showing decreased activity and the latissimus muscle demonstrating increased activity during the acceleration phase. The left lumbar muscles showed increased activity during the follow through phase, but there was a decrease in activation of the trunk muscles at the same time. In contrast, there was an increase in the activity of the shoulder musculature activity both just prior to, and after impact.[22]

Two studies were identified which proposed a golf specific rehabilitation program for golfers with LBP. The first study was a case report by Grimshaw and Burden.[23] The authors used trunk rotation and paraspinal muscle activity to assess the effect of a 3 month rehabilitation program. Dynamic stabilization exercises involving the Transverse Abdominus (TA) and the Multifidi (MI) of the low back were utilized. The TA was exercised with light contractions while lying supine with the knees bent. The MF was exercised in both the prone and quadruped positions through alternating forward flexion of one shoulder and extension of the opposite hip simultaneously. These exercises were done 3 to 4 times each day. Each session consisted of 10 repetitions for each exercise, holding initially for 5 seconds and gradually building up to 20 to 30 seconds. Swing modifications were also made to give the golfer a more upright posture, decrease shoulder turn during backswing, and increase hip turn during backswing. Lying and seated rotational spinal stretches were also incorporated twice per day and 3 to 4 times per week with eight to 10 repetitions holding for about 30 seconds in each stretch. At the end of the treatment period, the player had decreased EMG signal intensities throughout his swing in the paraspinal muscles and was able to resume golfing without LBP. Changes in activity included a decrease in left sided erector spinae (upper and lower) activity during the downswing, but increases in activity of both the left and right erector spinae muscles (lower thoracic, upper and lower lumbar) during the follow through.

The second study was retrospective, nonrandomized, and involved a group of 145 golfers treated through a multidisciplinary golf rehabilitation program.[24] The group characteristics were as follows: 95% were amateur golfers, 80% were male, mean age was 55.7 years, and low back injuries were present in about 45% of the study group (49% of the men and 28% of the women). The most common swing modification was change to a ‘‘classic’’ golf swing through a front heel raise and shortened backswing. Swing modification was used in 83% of the subjects, along with flexibility training and physical therapy. Specific discussion on the training methods used, length of treatment period, and percentage of those with back pain who responded to the ‘‘classic’’ swing modification were not included. The authors reported a 98% success rate in return to golf participation and the absence of new golf-related injuries within the first year after completion of the program.[24]

A modification to a more “classic” swing and a strength/conditioning program were implemented in both of the above mentioned articles. Unfortunately, it cannot be determined to what extent the modifications in swing had on the reduction of LBP. It is reasonable to conclude that the modifications in the swing reduced the forces placed upon the lumbar spine and thus, reduced the LBP. It is equally possible that LBP subjects would be able to load their lumbar spines using a “modern” swing and be free of pain, provided they increase their flexibility and conditioned their lumbar stabilization muscles to protect against increased forces.[1]

Injury prevention

The best treatment for golf related injuries happens to be a focus on prevention. A few studies were mentioned previously that focus on a stretching and strength conditioning program for the rehabilitation of golf related LBP. It seems to reason that if you perform these stretches and or exercises prior to getting injured, one might be able to withstand the extra forces placed on the lumbar spine and prevent these injuries from occurring. Christie and Hawkins[25] point out in their text that other factors have an impact on your low back, not just performing a swing with a posture other than neutral. Little thing like being in a flexed seated position in the golf cart, getting in and out of the cart, and bending over to pick up tees, balls and markers repeatedly could prove to be detrimental, especially in the older populations. These authors propose

restoration of a neutral lumbar spine through manipulation and muscle work and to strengthen the core with stabilizing exercises.[25]

There are multiple prospective, randomized studies that show the effectiveness of stabilization exercises in LBP patients. These techniques have been shown to reduce the recurrence of LBP in subjects presenting with their first episode of LBP [spine 91].[26] Once patients master these stabilization contractions, it is important to incorporate dynamic components such as extending the hip and forward flexing the contralateral shoulder simultaneously from a quadruped position. These maneuvers have been shown to increase the cross-sectional area of the paravertebral muscles significantly more than stabilization exercises alone.[27]

Furthermore, a good pre-round warm-up is very important for injury prevention. Gosheger et al.[28] published a retrospective study of 703 golfers. The purpose of the study was to perform an assessment of musculoskeletal problems that develop in golfers, and to identify other variables that are associated with an increased risk of injury. They found a statistically significant decrease in injury by about 60% in golfers who stretched and warmed up for at least 10 minutes before playing.[28] Unfortunately, only about 50% of golfers perform some type of warm-up activity according to a study of over 1,000 amateur golfers.[29] Christie and Hawkins, as well as other referenced sources, suggest an activity like jumping jacks or jogging in place to elevate body temperature, followed by a period of dynamic stretching (not just static stretches) and swinging with a club.[12,30,31,]

Conclusion

One important thing to consider when talking about golf and golf injuries is to dispel some of the false impressions about the sport. Golf is said to be a relatively benign sport that usually is not linked to injury. However, people are not aware of the tremendous forces that are placed on the back, as well as other areas of the body due to the mechanics of the golf swing. This general lack of knowledge leads individuals to play without being properly conditioned, play without properly warming up, and to play without the proper instruction. All of which have leave the individual susceptible to injury.

By studying the biomechanics of golf, it is easy to see how back pain can transpire. The golf swing, in particular the modern swing has been implicated as a generator of LBP. Many of the studies point to the fact that the modern swing produces greater torque and lateral bending in the spine. This is a hazardous combination for the low back. More studies need to be conducted on swing mechanics (joint motion and muscle activity) of the different swing types to determine if the swing is the primary pain generator. Golf is a very dynamic sport. Other aspects (posture, balance, coordination, conditioning level) also need to be looked at. Studies need to be performed to evaluate who gets back pain and the intrinsic and extrinsic variables in the swing are key to those who develop LBP.

Without these studies it would be unreasonable to suggest that a certain type of swing may reduce the incidents of LBP. It is also unreasonable to expect golfers to adopt this swing with the possibility of their game suffering. While there is one good study in the Journal of Manipulative and Physiological Therapeutics that shows reduced back muscle activation with a short backswing in golf without decrements in swing accuracy and or club head velocity, it is the only one of this kind.

While the human body is not designed to handle the forces placed upon it from a golf swing, there are measures that can be taken to prevent injury to the low back. In terms of rehabilitation and prevention, swing modification along with certain strength and conditioning exercises seems to be the best approach. Strength training (of the core), lumbar stabilization exercises, flexibility exercises (especially in rotation), assuming a more neutral posture, and warming up before rounds have all been beneficial at reducing LBP.

As healthcare providers, especially chiropractors, it is important to understand how the golf swing impacts the lumbar spine. This may have a huge impact on how treatment is rendered. These therapies and swing modifications are all reasonable recommendations to consider in a patient suffering from golf related LBP.

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