LOWER BACK PAIN IN GOLFERS: A REVIEW OF THE LITERATURE

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ABSTRACT

Objective: To review the epidemiological literature on low back pain in golfers and to review the golf swing and relate the literature on the mechanics of the swing to the lower back.

Methods: A computer search was conducted of Index Medicus (1966 to 2004), MANTIS (1880 to present) and CINAHL (1982 to 2004) for literature on the following key words: low back, golf, injury. A manual search for relevant references in review papers on the subject was also conducted. The results were collated and literature fitting the criteria were collected and evaluated for suitability.

Results: The lower back is a common site of golf-related injury and has resulted in much research being conducted on the forces produced by the 'modern' swing in the low back. An analysis of the 'modern' swing when compared to the 'classic' golf swing, demonstrates lower rotational forces on the low back in the 'classic' swing. However, no studies exist to compare the different types of swing.

Conclusion: The back is an area of the body that undergoes significant movement and muscular activity during the golf swing. It is likely that the significant activity and repetitive nature of the swing are associated with the high rate of injury in golfers. Modification of the golf swing has been hypothesized to reduce the incidence of low back injury in golf. Further research needs to be conducted on the various golf swings to evaluate if different swings change low back injury rates in golfers. (J Chiropr Med 2005;4:135–143)

Key Indexing Terms: Low Back Pain; Golf; Athletic Injuries

INTRODUCTION

All types of people can participate in the sport of golf. Participants in golf can come from all age groups, both genders and skill levels. Golf is played worldwide and boasts very high participation rates, particularly in older age groups. With over 486,000 registered golfers (n=572 900), participation rates in Australia rank golf as the second most popular organized sport behind aerobics (n= 704,200), according to a recent Australian Bureau of Statistics publication.[1] In the same publication, golf is the fourth most popular non-organized sport (n=1,324.8) behind walking (n=2,598,700), swimming (n=1,911,600) and aerobics/fitness (n=1,444,900).[1] The number of registered golfers in Europe is 3,741,680 as of March 2003,[2] while in the United States, the number of golfers with a handicap is 4.5 million and the number of golfers over 18 who have played in the last 12 months is 26.2 million.[3]

Golf provides exercise and social interaction and, with its handicap system, all skill levels can play and complete with each other. The average handicap (the average number of strokes over par a golfer is for 18 holes, par being what the professional golfer would be expected to score) in Australia for the registered golf club member (with the Australian Golf Union) is 18.1 in males and 27.5 in females,[4] while in the United States it is 16.1 for men and 29.2 for women.[5] American data reveals that for men, the middle quartile (25%–75%) for golf handicaps range from 10 to 20. In females this range is 22 to 35.[6] The 18–30 years age group is the peak age group for handicap players in Australia with an average handicap of 14.4 for males and 22.5 for females.[4] There is a steady increase in handicap with increased age. The peak age for golfers is 31 years.[7]

The chiropractic profession is well known for its treatment of spinal conditions, of which low back

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pain (LBP) is the most common presentation. As such, the doctor of chiropractic needs to be aware of the impact that golf has on the low back and how the golf swing can potentially be a mechanism of injury. 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 low back injury.

METHODS

Study Selection

Studies on golf injuries were included in this review if they included data on the incidence on low back injuries, and included the mechanism of injury. Studies on the mechanics of the golf swing were included if they examined the low back and the surrounding trunk musculature. Studies in peer-reviewed publications were identified by a comprehensive search of Index Medicus (1966 to 2004), MANTIS (Manual Alternative and Natural Therapy Index System) (1880 to 2004), and CINAHL (Cumulative Index to Nursing and Allied Health Literature) (1982 to 2004). The primary search terms were: *golf*, *injury*, and *low back*. In Index Medicus there were 75 papers identified using the key words golf and injury, 42 papers for golf and back, 10 papers for golf and low back and 3 papers for golf and injury and low back. In CINAHL there were 27 papers for the key words golf and injury, 26 papers for golf and back, 9 papers for golf and low back, and 2 papers for golf and injury and low back. In MANTIS there were 19 papers for the key words golf and injury, 20 papers for golf and back, 14 papers for golf and low back and 6 papers for golf and injury and low back. After using the peer-reviewed criteria and eliminating publication in multiple databases, a list of 30 papers from the databases was established. Studies were further identified by analysis of the references of selected publications. Proceedings of the World Scientific Congress of Golf (1990,1994,1998 and 2002) were also examined for papers relevant to the search criteria. Eight papers were initially selected from these conferences. Selected papers were assessed for relevant information of low back injuries and collated into similar areas of interest.

DISCUSSION

The low back is one of the most common injury sites in golfers. The incidence of golf-related low back injury ranges from 15–34% in the amateur golfer and 22–24% in the professional ranks. Collectively the incidence of LBP in the male golfer is 25–36% and 22–27% in the female golfer.[8–16] These ranges vary for a number of reasons. Many studies have low subject numbers. The findings of these studies may not be indicative of the general population of golfers because of the low statistical power.[17]

Other studies are retrospective in nature, which may limit the conclusion drawn by the findings found due to recall bias (the responses to questions asked may not be indicative of what actually occurred due to the inability to accurately recall what had occurred in the past).[18–20] Yet, other studies demonstrate strong selection bias. That is, the subjects in the study group are not representative of the target population.[20–22] These studies include the hospital/sports injury clinic studies. This type of injury study, by definition, only analyzes more serious injuries, those injuries that require medical treatment and also only those that are more acute in nature as opposed to the overuse-type mechanism of injury that is more common in golfers.

A further limitation to many studies is the lack of a definition as to what constitutes an injury. When participants are not given clear objective guidelines, the subjective nature of the issues involved result in variations. Also, this makes it difficult to analyze the data of several studies, when each has either no definition of injury, or differing definitions of what constitutes an injury.

A methodologically sound study requires a large number of participants, a prospective design (take a point in time and analyze the subjects forwards) and a definition of what constitutes an injury. Furthermore, it may be recommended to ask the golfers themselves for data as opposed to experiencing inter-examiner variability in the case of obtaining information from practitioners. Survey style studies have a high response rate to reduce non-response bias.[23–25]

Most golf injuries can be classed as 'minor' in nature (golf absence one week or less).[8] Golf-related back injuries usually involve the lumbar musculature in the form of strains or irritation of the zygapophyseal joints and sprains to the surrounding ligamentous tissue, though 18% of chronic problems (over 1 yr) in one golf-related study occurred in the back.[8] Research has showed that golfers had a 0.59 relative risk of herniated disc to those that do not play the sport, while those that play >2 times a week have a

0.19 relative risk. Thus, there appears to be a reduced risk of disc herniation in golfers compared to the general population.[26]

Sugaya et al[27] examined LBP among right handed professional golfers (n=282). They found that of those with LBP (n=154), 51% suffered right side pain, 28% left and 21% central pain. They also found a correlation between right side back pain and the follow through phase of the golf swing. Radiographs of 16 of these professionals with LBP found that compared to age matched controls, these golfers demonstrated statistically more osteophytic formation at L3-L4 ($P<0.01$), and in total ($P<0.01$). They also found that facet changes were statistically different overall ($P<0.01$) and at L4-L5 ($P<0.01$) and L3-L4 ($P<0.05$). There unfortunately was no protocol as to how these 16 professionals were selected for radiographic investigation and there is low statistical power for the results found. Right-sided back pain predominance was also found in junior golfers.[28]

A one-year prospective study on LBP in beginner golfers (196) found that 8% reported a first time occurrence of low back and 45% reported a recurrence of back pain with only 6 subjects attributing golf to this recurrence of back pain.[29] At baseline of the study, there was a 63% cumulative incidence of back pain and 20% reported back pain in the month prior to the survey. In comparing the subjects, those that were athletes had an odds ratio of 2.1 to the non-athletes prior to the study for back pain and those that played one other sport, beside golf, had a 1.4 risk of a recurrence to back pain compared to those that only played golf.

The Golf Swing

The golf swing is a complex movement of the body 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).[30] The golf swing has changed and developed over the years, often with new equipment, such as the change from hickory shafts with a lot of bend in them to the more rigid steel shafts. During the 1960's, the time of legendary professional Jack Nicklaus, the golf swing underwent a fundamental change from what was referred to as the 'classic' swing to the 'modern' swing.[31] The reason for this change lies in the fact that the modern swing is a more powerful swing with greater distance being achieved. Additionally, this swing achieves a higher ball flight that allows the ball to stop close to where it landed (helpful in shots that were hit to the green).

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.[32] 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. Examination of video footage of the 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 forwards after hitting the ball.

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.

In a comparison, the modern swing exhibits a complete shoulder turn (almost to the point that the back points to the target) that is similar to the classic swing, but the pelvis is still relatively facing the ball.[33] A large torque occurs between the moving upper body and the stationery pelvis. Hip movement starts the downswing phase and the end of the follow through is characterized by a body position generally known as the "reverse C".[34] This position is characterized by an imaginary line drawn from the right foot to the neck and head of the player that is in the shape of a backward "C", compared to the straighter position of the back in the 'classic' swing. 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 instrumental in the generation of LBP in many professionals who utilize the modern swing. Celebrated LBP suffers in professional golf include Jack Nicklaus, Fred Couples and Greg Norman, to name a few.[35]

Due to the perception that the modern swing is causing a greater incidence of LBP, there has been a modification of the modern swing to reduce the stress to the low back. A golf swing that incorporates aspects of the modern and classic swing has been developed. This swing (what may be referred to as the hybrid swing) incorporates the large difference in rotation of the shoulders compared to the pelvis, akin to 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.

Kinesiology of the Golf Swing

Studies on the functioning of the trunk muscles have been conducted.[36,37] Kinesiology studies generally further break down the golf swing phases into the following 5 phases:

1. The back-swing - ball address to top of backswing
2. Forward swing - top of swing to club horizontal (early part of downswing)
3. Acceleration - horizontal club to impact (late part of downswing)
4. Early follow through - impact to horizontal club
5. Late follow through - horizontal to completion of swing.

These studies generally divide the downswing phase in half adding the acceleration phase, just prior to hitting the ball. They also divide the follow through phase into early and late, roughly dividing it into half.

Kinesiology studies are able to establish these phases by analyzing both muscle activity and the position of the golf club. Epidemiological studies are unable to use these phases, as it is quite difficult for a golfer to know exactly the position of the club when an injury has occurred. If it is divided up into the simplified swing, there is more likelihood that the correct swing phase has been attributed to the injury.

When reviewing studies on the muscle activity of the trunk muscles during the golf swing of professional golfers (or high-level amateurs with a handicap of 5 or less), it was found that general muscle activity for the swing is lowest during the back swing. In the right handed golfer there is an increase in muscle activity of all muscles during the forward swing (early part of downswing) with the right erector spinae, the right gluteus maximus, and left abdominal oblique demonstrating their maximum levels during this phase. During the acceleration phase (late part of downswing), both the upper and lower rectus abdominus, the left gluteus maximus, left erector spinae and the right abdominal oblique displayed their maximum activity.

The effect of the golf swing on lumbar motion has been evaluated by Hosea et al.[38] They demonstrated that the golf swing involves a number of loading patterns including lateral bending, compression (over 8 times body weight), shear forces (translation) and axial rotation. They reported that peak loading in the golf swing occurs during the forward swing and the acceleration phase of the swing. In general, amateur golfers (n=4) exhibited greater peak forces than the professional golfer (n=4).

Other research has been conducted on the differences in both muscular activity and spinal motion in LBP sufferers and asymptomatic golfers.[39–44] These studies have found that activation rates of the abdominal musculature were the same in both groups but that the lead external oblique muscle (left ob-

lique in the right-handed golfer) had a significantly delayed activation onset in the chronic LBP group.[39] They found that the golfer with chronic LBP had increased pain after a 50 minute practice session, but no significant difference was found in EMG abdominal activity, which corresponded to fatigue levels. Also, there was no significant change in ball velocity of a drive when comparing the swing before and after the practice session.[39] Another study examined the transversus abdominis muscle of golfers with and without LBP and found that those with a history of LBP (in the last 2 years, but not the 3 months prior to the study) had significantly reduced endurance ($P<0.025$) than their asymptomatic counterparts.[40]

Motion analysis of the hip and spine during the swing between amateur and professionals was examined by McTeigue et al.[41] They found that amateurs displayed significantly more left side bend at the top of the backswing and significantly less right side bend at impact than professionals. Amateurs also had a significantly longer swing time (backswing and downswing) than professionals.[41]

Further research examined spinal motion in the professional golfer with and without back pain.[42] Compared to the golfer with no back pain, those with LBP flexed their spine more at address and used more left side lateral flexion during the swing and what appeared to be supramaximal rotation in LBP golfers during the swing.[42] When comparing velocities of movement during the downswing, the study found that there was significantly less flexion velocity in those with LBP, but significantly more left side bend velocity.[42]

The influence on spinal motion of using different clubs by the same player has been studied.[43] Lindsay, Horton and Paley[43] found that in the address position, the 7 iron club produced more flexion that when using a driver. Given that the difference in length of the shaft of the two clubs was 18cm 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 (ROM)and right side bend velocity during the swing was also seen in the 7 iron.[43] A possible explanation for this is that with a 7 iron swing, the increased flexion at address and upright swing plane (the path the golf club takes during the swing), 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.

When comparing the motion of the hips to the shoulder, Burden, Grimshaw, and Wallace[44] found that most low handicapped (<10) golfers started to turn their hips back towards the ball before the shoulder had completed movement at the top of the backswing.[44] This is to achieve added torque to the club and apply the summation of speed principle to the movement.[44]

Research into the effect of swing modification has been performed.[45] 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.[45]

The effect of treatment on swing mechanics has been examined in a case study involving a professional golfer with chronic LBP.[46] The implementation of a 3-month exercise program and tuition of the swing was proposed to result in the reduction of pain and changes in muscle activity during the swing. 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.

In a protocol for the evaluation of chiropractic manipulation on lumbar muscle activity and kinematics on tasks, Lehman and McGill[47] 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.

Methodological Issues in the Literature

Hosea and co-workers reported an important study on the effect the golf swing has on the low back.[38] Despite this good start, further studies of similar methodology need to be conducted on the different types of golf swing (eg, classic, modern, hybrid, short backswing) to evaluate differences between the swings. Many professional golfers and researchers propose swing modifications, but without any analysis of this type they are fraught with dogma and limitation. Bulbulian et al reported that a shorter swing reduces muscle activation, which may lead to a reduction in low back injury rates.[45] The study made no mention of what occurs during the impact and follow through phases of the swing, aspects of the swing that are known to be associated with increased risk of injury. As such, it ignores epidemiological data that reports nearly 50% of all injuries occur at the impact of the golf club with the ball and nearly 30% occur during the follow through phase.[9] The proportion of back injury that occurs during these two phases closely follows this finding. Even though peak muscle activity occurs during these phases, and this may be associated with injury, the fact that the majority of golfers utilize the modern golf swing finish (the reverse C), raises the possibility that the low back injuries are due to poor and/or repetitive spinal loading rather than changed muscular activity.

Horton and co-workers[39] report that there was delayed muscle activation during the golf swing of the abdominal muscles of LBP sufferers and there was no change in activation after practice. This finding raises the possibility that the injury is being generated in the non-contractile elements, which are producing most of the pain (ligaments, capsules and connective tissue). The presence of delayed muscle activation leaves non-contractile elements susceptible to injury particularly of the overuse type, possibly due to a loss of support of the non-contractile structures by the contractile elements.

In a separate study, Lindsay and Horton[42] evaluated spinal motion in asymptomatic and LBP golfers to discuss the possibility that over rotation has a potential role as a cause of LBP. This study is commendable as it evaluates differences between the swings of the two groups. However, only active ROM from the neutral position was performed. There was no comment on whether pain limited the movement in the symptomatic participants. By only evaluating active ROM, they failed to take into account the passive ROM available at neutral, which may be achieved, particularly in a dynamic fashion. The golf swing is a dynamic movement, which involves momentum and the conversion of energy, from potential to kinetic, as well as force from acceleration. These factors result in the golf swing being able to achieve more ROM than a standard active ROM in a controlled movement, which is slower, a point made by the authors.

A possible explanation for the reduced active ROM seen in those with chronic LBP is that muscular tonicity in the thoracolumbar musculature can reduce this active ROM. In addition, pain avoidance behaviors that have been previously learnt and are still in use can also decrease muscle activity. A question that needs to be asked in relation to these findings includes whether the swing 'changes' seen in subjects with LBP were a cause of the pain or an effect of the pain. A prospective evaluation of asymptomatic golfers and their swing patterns needs to be conducted to determine if those who develop LBP have differences in the dynamic rotation swings compared to static, both prior to and subsequent to, the pain onset. It is possible that golfers who developed LBP would change their address posture and swing as a result of pain. As such, an evaluation of the address posture (particularly flexion) and swing (particularly in rotation, flexion and side-bend) of those golfers who subsequently develop LBP needs to be conducted to determine if there are changes as a result of pain.

A limitation that exists with many spinal motion analysis studies (including those outlined above) is that multiple levels and multiple regions are all categorized into lumbar spinal motion. Many studies analyze the 'hips' to determine spinal load and compare these movements to the shoulders.[41–44] As such, both thoracic and lumbar movement is included so specific motion cannot be determine. Many of the changes are likely to be occurring in small areas and not necessarily at the lumbosacral level. Thus, generalization of the findings from a large region to a small segment is inappropriate. Studies need to be conducted using a similar protocol as Hosea et al[38] reviewing small motion segments (L3-L4 in this case). A series of concurrent

evaluations of the upper, mid and lower lumbar regions (as well as muscle activity evaluation of the gluteal, abdominal and hamstring muscles) in the different swing patterns (modern, classic, hybrid) would be a significant addition to the literature.

From their study of transverse abdominus activity during the golf swing, Evans and Oldreiv[40] concluded that these stabilizing muscles had not regained the strength lost when the LBP occurred. Again, a question arises as to whether these changes are the cause or the effect of pain, particularly when compared to asymptomatic controls. The authors reported their study to be limited by a lack of control for level of exercise, body type and occupation. The authors further reported that the two groups were not matched in terms of age but concluded that since those in the study group were 20–45 years of age and previous studies found that those over 50 had more injuries, they concluded age to not be a factor in pain development. Justification of this assumption was not made besides the authors' subjective beliefs. The conclusions drawn by the authors rely on the work of others to supports their untested proposition. A more appropriate study would be a prospective long-term randomized control trial examining the effect of no exercise or exercise on the transversus abdominis in regards to muscle endurance and its effect on the generation of low back injuries in golfers (or vice versa).

In regard to studies of therapy intervention for golfers with LBP, Grimshaw and Burden[44] found that there was a decrease in pain during the 3-month period of an exercise program and tuition of the swing. This decrease may be due to these strategies implemented,[44] but may also be purely due to the natural history of a complaint. There is no control, which is an inherent limitation of a case report. The swing changes seen may have been the result of the reduction of pain as opposed to the coaching intervention. This is particularly true of the muscular activity findings. Eccentric contraction of a muscle, which occurs in the extensor muscles during the follow through to decelerate the swing, produces a more forceful muscle activity. Explanation of the increased activity in the follow through can be explained by the fact that subjects with LBP do not want to contract eccentrically as it is known to produce/aggravate pain. In pain free subjects, eccentric contraction more readily occurs, which results in more muscle activity. This explanation alone may render the proposed explanation mute, and explain the muscular activity changes during the swing as opposed to alteration of swing by coaching.

The paper by Parziale[48] raises different issues in regard to treatment. Parziale found that a combination of 1) medical or surgical treatment, 2) physical therapy including physical modalities and exercises for strength, flexibility and endurance, and 3) golf swing modifications produced a 98% return to sports participation in 145 subjects with golf-related injuries (44.8% were back injuries). This study examines the effects of a multi-modal treatment regime that includes many treatment therapies, and concludes that the treatment regime worked. The study was uncontrolled and therefore suffers from the issue of subjects resolving from the natural history of the injury process, where time resolves the complaint. Also, due to the nature of the multimodal treatment, the effective and ineffective elements of the multi-modal program cannot be identified.

The study conducted by Lehman and McGill[47] approaches the golf swing from a different perspective. They present the swing as a complex task rather than as a sport based movement.[47] The research puts forward a protocol on how to perform a neurophysiological analysis of the effects of the spinal manipulative therapy on a complex biomechanical movement. They cite the need to evaluate both simple and complex tasks and propose the protocol on how this can be achieved. They conclude that no conclusions can be made on the efficacy of chiropractic spinal manipulative therapy on the golf swing, but stress the need to use appropriate neurophysiological methodology in further study

Authors have proposed changes to the modern swing to reduce low back injury.[49,50] The modern golf swing was reviewed in these papers and literature was introduced to support how unfriendly the swing was to the back. A back-friendly swing was proposed, which upon examination appears similar to the classic swing with a slightly shorter backswing. Seaman and Bulbulian[49] cite a previously published study of theirs to support the proposed changes to the golf swing.

An attempt has been made to report various mechanisms designed to reduce low back injuries in golfers[51] but this paper only reports on the literature and fails to critically evaluate it. The impact of golf on the facet joints has also been discussed,[52] but

mainly its discussion examines general concepts of lumbar mechanics in injury generation by relating that the extension in the golf swing can cause irritation of the posterior elements. Finally, a case report in review form has appeared in the literature,[53] as well as a report of compression fractures in osteoporotic females during the golf swing.[54]

The search used in this review has attempted to locate all relevant documents on golf related lower back injury. Despite the detailed nature of this search, it is possible that relevant literature not sourced by this search could have resulted in the omission of relevant work. However, it is unlikely that important material was missed outside this search criteria as none of the papers mentioned any other relevant references in their reference lists that were not already located in our search.

CONCLUSIONS

In summary, the golf swing, and in particular the modern swing, has been implicated in the generation of LBP. Most research at present evaluates discreet areas of the low back, or the swing. Many of these studies propose changes to the swing. Studies of swing mechanics (joint motion and muscle activity) need to be conducted on the different swing types that occur (classic, modern, hybrid, short backswing). Importantly, long-term prospective research on golfers needs to be undertaken to evaluate who gets LBP and determine what intrinsic and extrinsic variables in the swing (joint motion and muscular activity for example) are key to those that develop LBP. In terms of injury rehabilitation, large scale, long-term prospective studies are required to evaluate what swing modifiers and/or treatment interventions result in the reduction of LBP in sufferers.

It would not be practical to report how a different swing may reduce injuries and recommend its use if the general population of golfers find that their golf game suffers as a result of its implementation. It is likely, in such a scenario, that the golfing fraternity would not adopt the changes recommended. Therefore, this review recommends that further research be conducted to evaluate the hybrid swings, to determine if hybrid swings reduce low back injury rates in golfers and if these changes alter the distance and accuracy achieved by the 'modern' golf swing.

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