Case report: reduction of low back pain in a professional golfer

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ABSTRACT

GRIMSHAW, P. N., and A. M. BURDEN. Case report: reduction of low back pain in a professional golfer. *Med. Sci. Sports Exerc.*, Vol. 32, No. 10, pp. 1667–1673, 2000. Previous research agrees that the majority of injuries that affect male golfers are located in the lower back and that they are related to improper swing mechanics and/or the repetitive nature of the swing. This study describes the trunk motion and paraspinal muscle activity during the swing of a golfer with related low back pain (LBP) and assesses the effect of a 3-month period of muscle conditioning and coaching on these variables. Motion of the trunk was measured using three-dimensional video analysis and electromyograms (EMGs) were recorded from the same six sites of the erector spinae at the start and end of the 3-month period. At the end of the period, the golfer was able to play and practice without LBP. Coaching resulted in an increase in the range of hip turn and a decrease in the amount of shoulder turn, which occurred during the swing. In addition, a reduction in the amount of trunk flexion/lateral flexion during the downswing occurred in conjunction with less activity in the left erector spinae. These changes may serve to reduce the torsional and compressive loads acting on the thoracic and lumbar spine, which in turn may have contributed to the cessation of the LBP and would reduce the risk of reoccurrence in the future. In conclusion, further research with more subjects would now be warranted in order to test the findings of this program for the prevention of low back in golfers as piloted in this case report. **Key Words:** THREE-DIMENSIONAL KINEMATICS, ELECTROMYOGRAPHY, INJURY, REHABILITATION

The most common injuries affecting both amateur and professional male golfers are to the lower back (1,7,8). Injuries to this site, as well as to other commonly injured sites such as the wrist, elbow, and shoulder, have mainly been attributed, in both groups of golfers, to excessive repetition of the swing during play and practice (1,2,7,8). Poor swing mechanics have also been linked to the cause of these injuries in amateur golfers (1,2,8), who have been shown to develop greater torque, and shear and lateral bending forces in the lumbar spine than professional golfers (6). This additional loading, combined with swing repetition, may cause or exacerbate any preexisting lower back pathology (2). Although it is apparent from the literature (1,2,7,8) that lower back injuries in golf are related to poor swing mechanics and/or repetition of the swing, there is limited published research (9), that has addressed the exact cause of such injuries. In addition, no research has reported whether modifying the swing of an injured golfer would in fact lead to a cessation of such an injury.

The first purpose of this study was to analyze the technique of a golfer with a history of low back pain (LBP). For this purpose, three-dimensional (3-D) kinematics and activity of the paraspinal muscles were recorded during a series of swings. The second purpose was to determine the effect of modifying the swing, primarily to reduce the twist in the lumbar spine, on the paraspinal muscle activity and potentially the pain experienced by the golfer. Any changes made to the golfer's swing were again quantified using 3-D techniques.

METHODS

Subject History

One right-handed professional male golfer (age 22 yr, height 1.77 m, body mass 73 kg) with a history of LBP from participation in golf volunteered to take part in the investigation. The golfer was a recently qualified club professional, and he provided written informed consent in accordance with the American College of Sports Medicine guidelines. He had originally developed LBP in 1992, but

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the pain that prevented participation in golf occurred over the 12 months before this investigation, while he was training for golf and practicing the swing. The subject was unable to complete a round of golf or practice session without severe pain. The LBP was diagnosed by a general practitioner as deterioration of the ligaments and fibrous tissues around the lumbar spine. The diagnosis was supported by magnetic resonance imaging (MRI) scans, which indicated deterioration around the L5 region, with no specific laterality. Before this investigation, an osteopath treated the golfer by attempting to increase the range of motion in the thoracic and lumbar spine using manipulation techniques and providing a series of conditioning exercises to strengthen the muscles associated with spinal stability. These exercises were continued throughout this analysis and intervention. Appendix A outlines the conditioning program in more detail.

Although still suffering from LBP, the golfer's technique, in particular the motion of the trunk and activity in the paraspinal muscles, was examined using the methods outlined. After a preliminary analysis of the videos taken of the golfer, his swing was modified by a Professional Golf Association (PGA) qualified coach. The main intentions of the coach were to increase the range of hip turn while maintaining approximately the same alignment of the shoulders during the swing. The coaching strategy is identified in more detail in Appendix B. This, theoretically, would place less torsional load on the thoracic and lumbar spine (5,6). After this conditioning and coaching intervention stage, the golfer's technique and paraspinal muscle activity were reanalyzed, again using the methods outlined. On both testing sessions the weather was calm and warm.

Technique Analysis

The golf swing was divided into the following four points in time:

Address. The instant before the first movement of the clubhead away from the ball.

Top of backswing. The instant at which the clubhead reached its most lateral position, toward the flag, before changing direction.

Impact. The instant after which the ball had left the tee. At this point, the clubhead was in a position similar to that which it was in at the address.

End of follow-through. The instant when the clubhead came to rest behind the golfer.

From these points the backswing was defined as the time between the address and the top of backswing, the downswing as the time between the top of backswing and impact, the follow-through as the time between impact and the end of the follow through and total swing as the sum of the backswing, downswing, and follow-through.

Analysis of the golfer's swing, during both testing sessions, took place on a grass-prepared tee-box, approximately 20 m^2, which opened out onto a field approximately 350 m in length. After warming up by taking a number of practice swings, the golfer was filmed taking 20 swings with

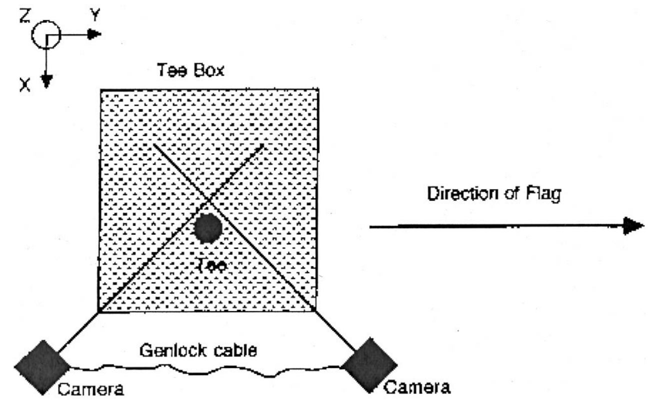

Figure 1—Plan view of the filming area, camera locations and orientation of orthogonal (x, y, and z) axes of the calibration frame, which was used in the technique analysis of the golfer.

a driver. Two genlocked video cameras, an AG-DP200 and an AG-DP800H (Panasonic, Osaka, Japan), were used to film the golfer from the front, on both his left and right sides. The cameras were both located at a distance of 14 m from the center of the tee-box and were level with their optical axes intersected at approximately 90° (see Fig. 1). The golfer performed each stroke within the 1.9 m × 1.6 m × 2.2 m (6.7 m^3) volume defined by a calibration frame, which contained 24 points of known location (Peak Performance Technologies Inc., Englewood, CO). This calibration frame was filmed before the swings, and 16 of the points were later used to reconstruct the 3-D coordinates of digitized landmarks. The filming volume was defined as 1.6 m along the x-axis, 1.9 m along the y-axis, and 2.2m along the vertical z-axis. The direction of the flag was along an imaginary line parallel to the y-axis as shown in Figure 1.

Six of the 20 swings, in which the ball traveled in the direction of the flag, were chosen for further analysis, as these were thought to represent the golfer's typical technique. In addition, they were the most appropriate swings in which impact could be observed using 50-Hz analysis. All fields (50 fields·s^{-1}) from both videos of each swing were digitized, between the address and the end of the follow-through, by the same operator. Twenty points were digitised on each video field, which defined the body as a 14-segment model plus the club. Further details of the methods that were used to digitize the videos, reconstruct the two sets of two-dimensional coordinates into real world 3-D coordinates, and smooth the 3-D coordinates are presented elsewhere (3). Because the study was primarily concerned with hip and shoulder movement, it was considered appropriate to use cameras operating at 50 Hz. This procedure has been used in a number of studies involving a similar high frequency of activity (e.g., 3,6,11).

For each of the swings, the following angles were calculated throughout the total swing:

Spinal angle (°). The angle between the line joining the midpoint of the shoulders (C7) and the midpoint of the hips to the right horizontal along the x-axis when viewed toward the sagittal plane of the golfer.

Hip angle (°). The angle in the x–y plane between a line joining the hip joint centers and a line parallel to the y-axis

TABLE 1. Summary of kinematic results for test 1 and test 2 (minus (−) sign denotes an open position toward the flag and a positive (+) sign indicates a closed position).

Position of Swing	Spinal Angles (°)		Hip Angles (°)		Shoulder Angles (°)		Hip/Shoulder Angles (°)	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
Address	63.0	65.0	−1.2	+1.7	−4.3	+4.9	2.7	2.5
Top of backswing	59.5	58.3	+9.1	+31.9	+99.9	+101.6	90.2	68.6
Impact	56.8	60.8	−22.9	−12.9	−4.9	+21.9	19.9	35.3

between the tee and the flag. Hence, if the line joining the hips was parallel to the line between the tee and the flag, the hip angle is neutral (0°). Turn of the hips from the neutral position away from the flag (a closed position) is described by positive hip angles, and turn in the opposite direction from the neutral position toward the flag (an open position) is displayed by negative hip angles.

Shoulder angle (°). The angle in the x–y plane between a line joining the glenohumeral joint centers and a line parallel to the y-axis between the tee and the flag. Neutral, positive, and negative shoulder angles are defined as for the hip angle.

Hip to shoulder separation angle (°). The angle in the x–y plane between the line joining the shoulders and the line joining the hips. This angle is expressed as a relative measure between the shoulder and hip angles.

Analysis of Paraspinal Muscle Activity

A Muscle Tester ME3000P System (Mega Electronics Ltd., Finland) was used to record bilateral electromyograms (EMGs) from paraspinal muscles in the lower thoracic and lumbar regions of the trunk (at least 3 cm away from the spinous processes). Bipolar surface electrodes were placed on the skin overlying the erector spinae at the levels of T12, L2, and L4. Before electrode attachment, the skin underlying the electrode sites was shaved and cleaned with an alcohol wipe. The electrodes were pregelled Ag/AgCl disks (diameter = 1 cm) positioned, with a center to center interelectrode distance of 2 cm, along a line approximately parallel to the direction of the underlying muscle fibers. Photographs taken of the electrode positions at the first testing session were used to aid replication of these positions during the second testing session 3 months later. The signal from each muscle was amplified by a differential preamplifier (gain $\times$ 412, common mode rejection ratio $>$ 110 dB, input referred noise $<$ 3.5 μV RMS in the measuring bandwidth of 15–500 Hz) situated at the end of a cable that attached the electrodes to a data logger unit. This unit sampled the analog EMG signal at a frequency of 1000 Hz and converted it to a digitized form, using a 12 bit A/D converter, which was later downloaded to a PC via an optic cable.

To depict the changes in EMG amplitude over each swing and between each testing session, the raw EMGs were rectified and the mean absolute value (MAV) calculated over successive time windows of 50 ms throughout the duration of each swing. The average MAV (average of all 50 ms windows within a stage) was then determined for the backswing, downswing, and follow-through phases of each golf swing. The MAV needed to be normalized in order to compare the activity between the different muscle sites and of the same muscle site across swings and over the two testing sessions. It was decided not to use the common normalization method of expressing the MAV from the golf swing as a percentage of the MAV from a maximal voluntary contraction of the same muscle. This was because individuals with LBP may under perform during such contractions, due to the anxiety of pain or further injury, and render the normalized MAV unreliable. Instead, the MAV was expressed as a percentage of the MAV from the same muscle recorded while the subject was stationary during the address. It was felt that this was a more reliable method, providing that the subject had not significantly altered his body position at the address between testing sessions.

Temporal Synchronization of Technique and Muscle Activity Analyses

Both the data logger unit and a light emitting diode (LED), placed in the field of view of one of the cameras, were connected to a specially constructed "synchronization box." When this box was activated by a transmitter held in the hand of an experimenter at the start of each swing, the data logger began collection of EMGs and the LED was simultaneously illuminated. This subsequently enabled the EMGs to be temporally related to the kinematic information from the golf swing. A buzzer also sounded when the box was activated to inform the golfer of the start of each swing.

RESULTS

All the results presented are as a mean of the six trials chosen for the analysis. A summary of kinematic information at the address, top of backswing, and impact is shown in Table 1.

Spinal Angle and Magnitude of Paraspinal Muscle Activity

By considering the spinal angle (see Fig. 2), it is clear that the golfer was standing in a similar position at the address and at impact in both testing conditions (address in test 1 = 63.0 ± 3.0° and in test 2 = 65.0 ± 3.9°, impact in test 1 = 56.8 ± 1.6° and in test 2 = 60.8 ± 1.2°). In addition, the range of movement throughout the backswing in both testing sessions is almost identical. The magnitude of activity in the paraspinal muscles was also similar between testing sessions during the backswing (see Fig. 3). However, during the downswing, the pattern of motion and muscle activity was markedly different between testing sessions. In test 1, the spinal angle slightly increased and then rapidly

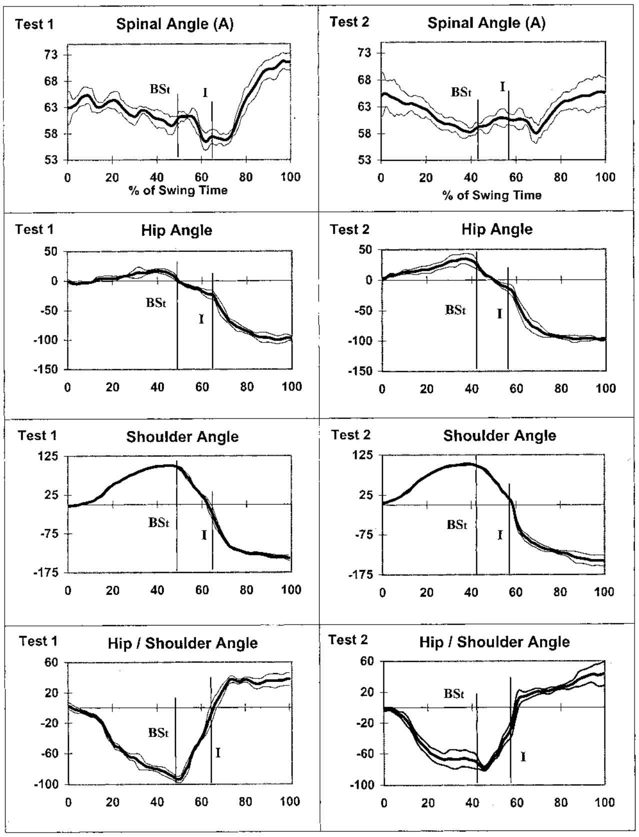

Figure 2—Angular kinematics of selected parameters for test 1 and test 2 during the golf swing (± SD of six trials shown on graphs). Units are expressed in degrees (y-axis) and % of the golf swing (x-axis).

decreased by approximately 5°, immediately before impact, which showed a combination of rapid flexion and lateral flexion to the left. Figure 3 shows that this motion was accompanied by activity in the upper and lower lumbar portions of the left erector spinae equivalent to 8.5 ± 1.6 and 3.6 ± 0.7 times the activity measured at the address. In comparison, during the downswing in test 2, the spinal angle remained almost constant throughout the same stage of the swing. This reduced motion was accompanied by less activity in both the upper (4.7 ± 1.8 times that at the address) and lower (2.4 ± 1.1 times that at the address) lumbar regions of the erector spinae during the downswing.

Hip Angle

The hip angles at the address were again very similar between testing sessions (test 1 = −1.2 ± 4.3° and test 2 = +1.7 ± 3.6°). Throughout the backswing, the hips rotated to a maximum closed angle of +16.8° during testing session 1 and a greater angle of +35.0° in testing session 2 (see Fig. 2). In both testing sessions, the hips started to turn back toward the flag to place them at +9.1° and +31.9° (± 5.1 and 10.0) at the top of the backswing in tests 1 and 2, respectively. Thus, the hips had started turning back toward the position at the address before the downswing had commenced. Turn of the hips continued at approximately the same rate throughout the downswing in both testing sessions to place them in an open position at impact (test 1 = −22.9 ± 7.2° and test 2 = −12.9 ± 6.2°). Therefore, the hips turned through a greater range of movement (44.8°) during the downswing in test 2 than in test 1 (32.0°). The magnitude and timing of hip turn resulted in the hips being more in line with the intended direction of ball flight at impact in test 2 (i.e., not leading with the hips).

Shoulder Angle

At the address, the shoulder angle was also in a similar position in both testing conditions (test 1 = −4.3 ± 1.1° and test 2 = + 4.9 ± 2.6°). During the backswing, the shoulders turned to a similar maximum position in both tests (test 1 = +100.4° and test 2 = +102.1° (± 1.5 and 3.1)). Figure 2 shows that the shoulders experienced a large range of motion of 104.7° during the downswing of test 1, which placed them in an open position at impact (−4.9°). This range of motion was reduced to only 79.7° during test 2, which resulted the shoulders remaining in a closed position at impact (+21.9°).

Hip to Shoulder Separation Angle

At the address, the hip to shoulder separation angle showed an alignment of the hips and shoulders as adopted by the golfer (test 1 = 2.7° and test 2 = 2.5° ± 4.7 and 2.7). By the top of the backswing, the hip to shoulder separation angle had reached 90.2° in test 1 and 68.6° in test 2 (± 4.2 and 10.0), indicating more hip turn in test 2, as the shoulders rotated to approximately the same position. At impact, the hip to shoulder separation angle produced values of 19.9° for test 1 and 35.3° for test 2 (±11.7 and 8.18). In test 1, both the hips and shoulders had turned past the neutral position creating an open position at impact for each. The change in the pattern of hip and shoulder turn resulted in a reduced hip to shoulder separation angle during test 2 at the specific critical points of the top of the backswing and early in the downswing (5,6). This angle reached a maximum of 93.9° early in the downswing in test 1, in comparison with 79.0° in test 2.

DISCUSSION

The 3-D kinematic analysis confirmed that the golfer's technique changed considerably between the first and second testing sessions. Coaching resulted in the hips turning through a greater range of motion during the backswing and downswing of the second testing session, as intended. The shoulders turned through approximately the same range of motion during the backswing in both tests and turned through a reduced range during the downswing in test 2. In addition, Figure 2 also shows that the hips began turning back toward the flag well before the shoulders in test 1. This sequential pattern of hip and shoulder turn, commonly referred to as "leading with the hips," was also noticed in 75% of a group of eight low-handicap golfers analyzed in a previous study (3). Leading with the hips was far less

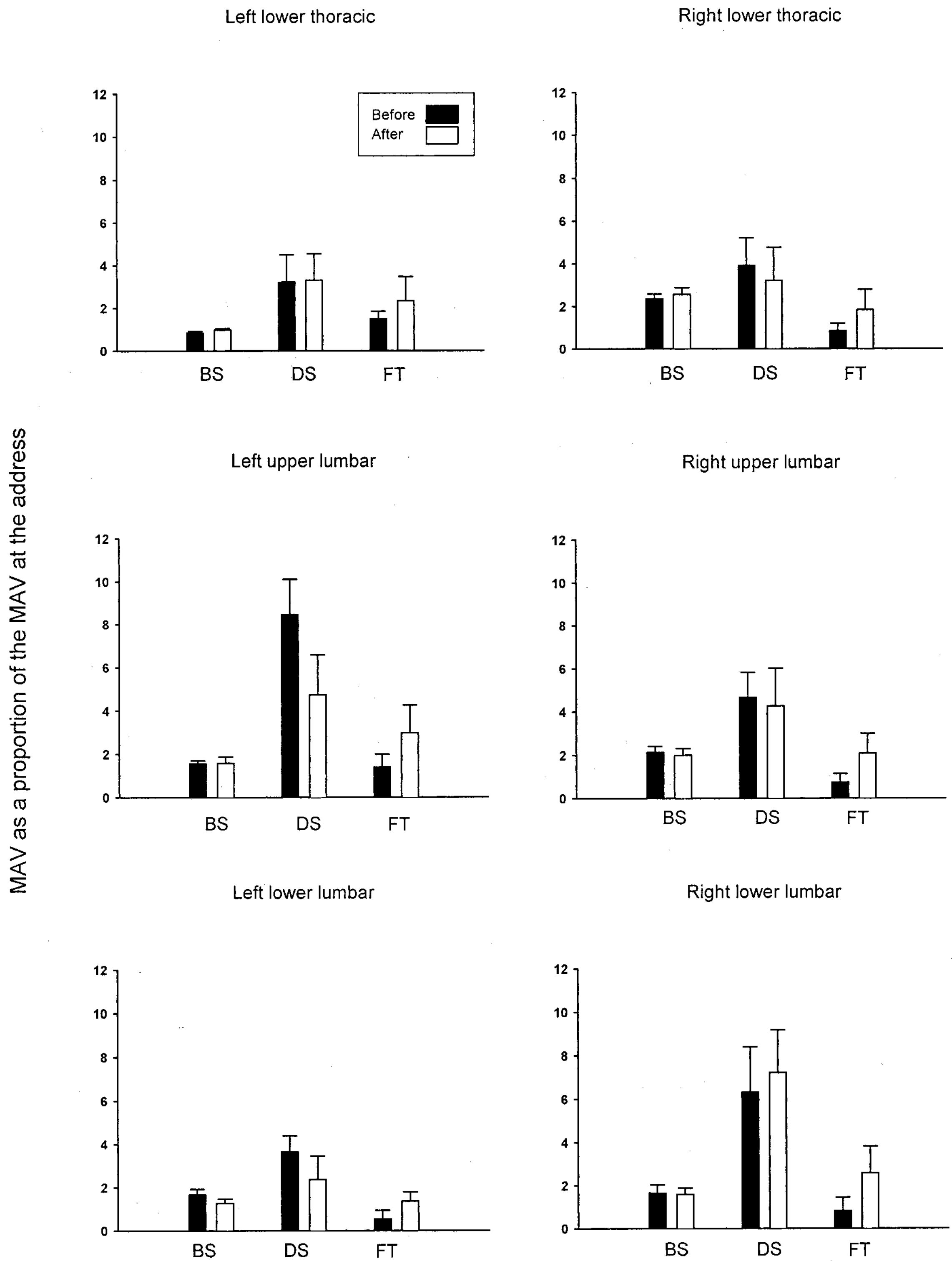

Figure 3—MAV (mean ± SD) of EMGs from the six sites of the erector spinae. Separate bars are presented for the backswing (BS), downswing (DS), and follow-through (FT) stages of the golf swing at the start (before) and end (after) of the 3-month coaching period.

evident during test 2, where both hips and shoulders began turning back toward the flag at approximately the same time, just before the start of the downswing. In conjunction with the reduction of shoulder turn relative to hip turn, this should serve to reduce the torsional load acting on the thoracic and lumbar spine, which reaches its initial peak during the transition between the backswing and the downswing (5,6).

The range of trunk motion, as measured by the spinal angle, and paraspinal muscle activity were similar during the backswing in tests 1 and 2. In agreement with previous research (10), activity in the erector spinae was greatest during the downswing, during both testing sessions. After rapidly flexing and laterally flexing during the downswing of test 1, the golfer's trunk remained in a more stationary, erect position in test 2. This was reflected by changes in paraspinal muscle activity. Activity in the left erector spinae was less during test 2 as the muscle was no longer required to produce a forceful eccentric contraction to decelerate the rapid motion of the trunk that was observed in test 1. This reduction in muscle activity may have reduced the compressive forces between the lumbar vertebrae, which reach their initial peak at the top of the backswing (5,6).

Thus, with reference to the first purpose of the investigation, the technique of the golfer, coupled with higher levels of muscle activity, indicates that he may have experienced high torsional and compressive loads in the lumbar spine up to and including the time of test 1. This would especially be the case during the end of the backswing and the start of the downswing and may have contributed to the cause of, and would certainly have exacerbated, the golfer's LBP. This is corroborated by the fact that before test 1 the golfer found it difficult to complete a round of golf due to the LBP. By contrast, in relation to the second purpose of the investigation, the golfer was experiencing virtually no LBP at the time of the second testing session. This could have been due to a combination of the conditioning exercises that the golfer undertook and the changes that the coach made to his technique. Certainly, the technique changes should have reduced the torsional and compressive loads on the lumbar spine and thereby decreased the stress acting on the facet joints and intervertebral disks in the thoracic and lumbar spine (4,8). This would also serve to reduce the chance of the golfer's swing predisposing him to LBP in the future.

CONCLUSION

The results of this investigation clearly show that the golfer's technique was markedly altered by the intervention of the coach over the 3-month period and that also during this period his LBP ceased. These technique changes should, theoretically, have served to reduce the loads acting on the lumbar region of the spine, which are thought to be responsible for LBP during the golf swing. Thus, it is conceivable that the intervention, in conjunction with the continuation of the muscle conditioning exercises, was largely responsible for the cessation of LBP experienced by the golfer and would almost certainly reduce the risk of any reoccurrence of the injury.

The work has shown that technique modification and physical conditioning are potentially critical components in the control of and reduction of sport-related pain. Further research that involves more subjects with LBP would clearly be valuable and could provide information for the prevention of lower back pain problems in golf.

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APPENDIX A—THE MUSCLE CONDITIONING PROGRAM

Objectives: To condition the muscles, which provide a degree of postural stability to the spine.

The muscles selected for conditioning are the transversus abdominus (anterior) and the multifidus (posterior). These muscles, although not para-spinal, are considered to be critical to the prevention or control of low back pain problems. It is considered important that if there is a skeletal problem in the lumbar spine, these muscles will tend to "switch off" and can fail to "switch on" again, even after the original problem has been solved. Hence, the subject needs to be conditioned to learn to selectively activate these muscles and to keep them activated all the time whether standing, lifting, sitting, or playing golf. The tendency is for the subject to substitute the relevant phasic muscles (such as erector spinae and abdominals), but these are less efficient stabilisers of the spine and they are not able to sustain a contraction for long enough to be used as postural muscles.

Transversus abdominus (anterior): light exercises, lying on the back with the knees bent. Multifidus (posterior): in the prone position with one arm and opposite leg extended; in the quadruped position and extending one arm and opposite leg, keeping spine straight; in the supine position where the back is flat and alternatively extend the arms and legs.

All exercises 10 repetitions each set and 3–4 times per day, holding initially for 5 s and building up to holding for 20–30 s.

APPENDIX B—THE COACHING INTERVENTION STRATEGY

Objectives: To reduce the lateral hip displacement (toward the flag) technique by attempting to increase hip turn during the backswing.

At the address, the golfer was standing too far away from the ball and needed to adopt a more upright position. This was combined with a slightly out of line shoulder position. The backswing appeared to have insufficient hip turn. This restricted backswing caused the golfer to assume a low, flat hand position through to impact. In addition, the down swing started too early and appeared problematic when combined with the lateral hip "slide" toward the flag.

To attempt to free the restricted backswing, the golfer was given specific exercises. In addition, the timing of the hip and shoulder turn was worked on to allow the subject to try and create more time to permit the correct positioning of the hips and the hands in relation to the relative components of the swing.

Lying Spinal Stretch (twice per day 3–4 times per week)

Lie on the ground, with legs stretched. Arms should be stretched out sideways. Raise the right leg while attempting to keep it straight. By rotating the pelvis to the right allow the leg to slowly drop to the ground. Try not to allow shoulders to be pulled off the floor. Allow the foot to touch the ground and try and hold this position for 40 s. Slowly repeat the process a number of times (8–10).

Seated Spinal Stretch (twice per day 3–4 times per week)

Sit upright with legs stretched out in front. Cross right leg over outstretched left leg. While holding the right leg with the left hand, put the right hand on the ground directly in line with the center of the back. Next, slowly rotate the thoracic area to the right as if turning the trunk in the backswing. Keep the head facing forward, as you would while swinging a club. Hold this position (20–30 s) and slowly move back to the original position. Repeat a number of times (5–10).

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