Swing Time: Podiatric Management in Golf

Applying traditional biomechanical concepts to this popular sport will help you to treat golfers more effectively.

BY KIRK M. HERRING, DPM

With its origins dating back to fifteenth century England, golf has enjoyed a long and distinguished history. Recent estimates from the National Golf Foundation suggest that golf's popularity has remained strong; while active participation has declined to 23.8 million golfers (similar to many other participation sports) an upsurge of participation of beginning golfers has increased by 2.8 million participants and in a recent survey over 40.6 million respondents indicated interest in taking up the sport. Golf demographics however are changing and what was once thought to be a sport played by mostly seniors (age 50 and over) is now seeing a resurgence of interest among younger golfers with millennials (30–39 year olds) now accounting for over 25% of all active participants. While many other participation recreational sport activities have seen a decline in participation over the past five years, golf's foundation remains strong as Americans continue to seek close-to-home recreational activities. Golf also continues to gain acceptance across many sectors of the medical community as an excellent low impact and sustainable recreational activity with minimal physical drawbacks and suitable for a wide variety of individuals and medical health conditions.

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When Injury Strikes

The repetitive nature of golfing, including the golf swing and a long day of walking and standing on the course or at the driving range, has been implicated as a primary cause for injury among golfers.[1,2] Estimates gathered over the past several decades suggest that over 80% of professional golfers will suffer two major overuse golf injuries during their professional careers, requiring an average of 9.3 weeks (male golfers) and 2.8 weeks (female golfers)

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for recovery.[2] Amateur golfers suffer from more frequent injuries, with 62% suffering from a golf-related injury each year.[1,3,4,5] Data gathered from several similar studies examining injury incidence among amateur golfers concluded that the incidence of injuries among amateurs ranged from a low of 1.19 injuries/golfer/year to 1.31 injuries/golfer/year.[1,3,4,5] When injuries are examined by anatomical location nearly a third of all golf overuse injuries are recorded in the low back and lower extremities. In a study of 393 professional golfers, over 37% of injuries were regionalized to the low back and lower extremities[2] (Figure 1). In a similar study of 198 amateur golfers, it was estimated that over 32% of injuries were regionalized to the low back and lower extremities[6] (Figure 2).

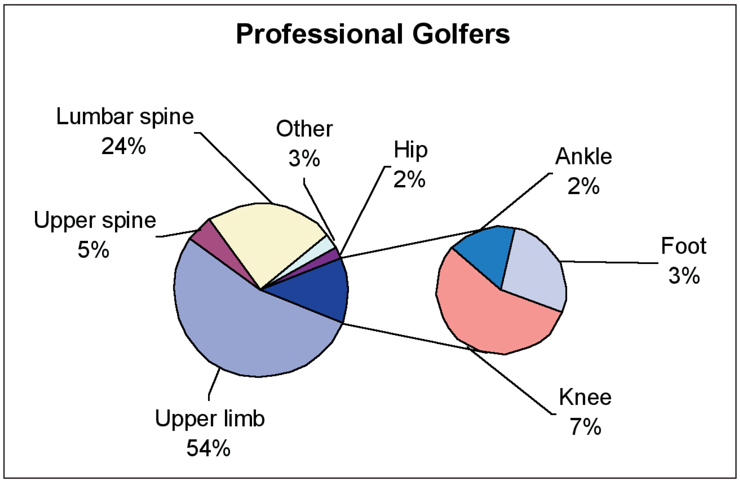

Figure 1: Distribution of injuries among professional golfers. Adapted from McCarroll, JR and TJ Gioe[4].

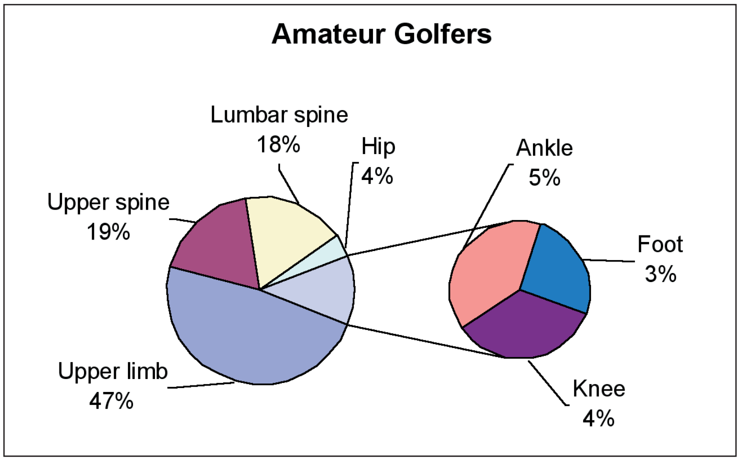

Figure 2: Distribution of injuries among amateur golfers. Adapted from McCarroll, JR and TJ Gioe[4].

It is widely accepted that golf injuries are either associated with a single traumatic and catastrophic event or a result of overuse. Numerous circumstances and events have been linked to golfing injuries (Table 1). This article will expose the podiatric physician to the basic fundamentals of lower extremity golf biomechanics and the management of golf overuse injuries.

Swing Mechanics With a Lower Extremity Emphasis

In 1687 Thomas Kincaid writes in his diary, "Stand as you do at fencing...Your arms must move but very little; all the motion must be performed with the turning of your body about." So began the analysis of the elements of golf; effective swing mechanics including setup, backswing, downswing and follow-through are dependent upon a stable base of support which promotes adaptability, strength and balance throughout all phases of the golf swing.

Aside from compensating for individual structural anomalies, environmental circumstances, and shoes, the lower extremities facilitate weight shift, sagittal and frontal plane positioning, transverse plane rotation and the dampening of shearing forces which develop at the foot-ground interface.

The lower extremities through the actions of the feet, however, also promote and support a kinematic chain reaction or coupling of hip and low back, low-gear rotation and shoulder and upper back high-gear rotation while still maintaining a stable upright position with minimal drift, sway or oscillation through all swing phases. Williams and Cavanagh[7] and Carlson[8] have provided evidence that ground reaction forces (GRF), including the direction and magnitude of shear forces, exhibit distinct differences between right and left feet during the typical golf swing. Koslow[9] examined weight shift patterns among 30-beginning golfers using an 8-iron and driver and observed that most did not execute a proper pattern of weight shift.

Computer analysis of digital video images collected over the past four years substantiates these observations and also suggests that swing patterns can be highly individualized among golfers of all experience levels. Koslow and Gatt et al.[9,10] observed that among mid and high-handicap golfers, a high degree of intra-golfer (individualized) consistency existed while a low degree of between-golfer consistency was observed when swing patterns were examined. By optimizing patterns of rotation and weight transfer during the phases of swing, the risk of overuse injuries may be reduced and a more consistent, accurate and reproducible golf swing may be developed.[7,9]

Set-up

All body segments contribute to the effective movement of the body's center of mass during a typical golf swing, none more so than the lower extremity. Every great swing has a starting point or set-up, which places the golfer in an optimal position to execute a reproducible golf swing and ball impact. This position has been described in great detail, but simply represents a comfortable ready or athletic position (Figure 3). Optimally, the subtalar joint is near neutral or slightly pronated with

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weight disproportionately shifted onto the forefoot and medial column. The golfer is now set in a relatively relaxed and stable position which requires little in the way of energy to maintain.

Backswing

The feet initiate backswing; subtle shear forces develop within both feet, which contribute to a net movement of the golfer away from the intended target[7] (Figure 4). A segmental kinematic coupling is triggered, beginning as a low-gear (hip-low back) rotation, which progresses cephalad to trigger a high-gear (shoulder-upper back) rotation, creating a smooth takeaway, which stores kinetic energy in the club for later release at ball impact.

Once rotation has been triggered, the feet serve to promote a stable base with centers of pressure maintained in the mid-part of the golf shoes throughout backswing, only shifting forward in the leading foot at the top of the backswing. Improper weight shift and the failure to maintain center of pressure near the mid-point of the golf shoe challenges the golfer's ability to "square-up" the club face at ball impact.

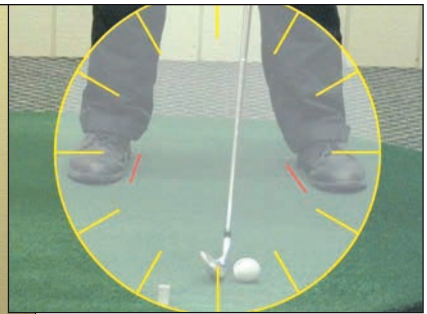

Figure 3: Typical setup position. Insert exhibits weight slightly forward onto the forefoot, establishing a relaxed athletic position requiring little in the way of effort to maintain.

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Downswing

Downswing is triggered by low-gear hip rotation which initiates club head acceleration through a descending arc of rotation; the club gains speed and momentum in preparation to transfer previously stored kinetic energy to the ball at impact (Figure 5). Contributing to swing stability and consistency, the feet serve to support low-gear hip rotation and the nearly simultaneous high-gear rotation of the shoulders and arms while standing on a variety of surfaces. At impact, weight is shifted toward the intended target, the center of pressure shifts forward, and the shearing forces peak in the leading shoe.[7]

Follow-through

Follow-through permits the golfer to safely decelerate the club head and dissipate the forces of rotation (Figure 6). Weight shift and shearing forces load the leading foot laterally, with typical loads reaching 85% of body weight.[10] The leading knee reaches a point of maximum external rotation with increased load and shear forces dissipated within the surrounding soft tissues and at the foot-ground interface. The trailing foot follows hip rotation by pivoting up onto the forefoot with weight shift directed forward as the center of pressure becomes concentrated in the forefoot.[7] The events of follow-through can create excessive laterally directed forces leading to roll out, too laterally deviated center of pressure, and lateral column overload, and can contribute to excessive external rotation of the leading leg and knee. This increases the potential for damaging hyperextension of the knee and varus strain to the ankle and foot.

TABLE 1:
Typical Circumstances Leading to Golf Injuries[1-6]

Overuse, a failure to recognize a developing problem

Technical errors and poor swing mechanics

Physical deficiencies
- Poor aerobic capacity (fatigue)
- Inadequate muscular strength
- Inadequate flexibility
- Pathomechanics associated with gait and golf swing

Lack of pre-game or practice warm-up

Lack of game or practice etiquette

Poor or improper equipment
- Old, worn out, improper shoes and/or orthoses
- Poorly fit clubs

Environmental conditions (weather, terrain, walking surfaces) •

Follow-through permits the golfer to safely decelerate the club head and dissipate the forces of rotation.

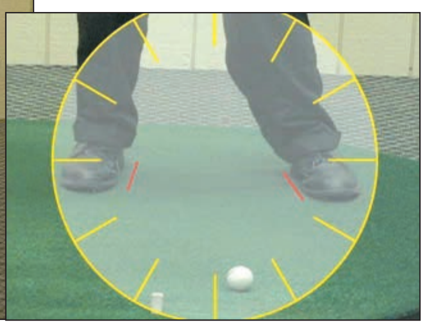

Figure 4: Typical backswing. Insert shows foot position at the top of the backswing; the weight has shifted onto the trailing foot furthest from the target.

The Anatomy of a Golf Shoe

In no other sport are so many demands placed upon a shoe. The golf shoe must be comfortable and support sustained walks over varying terrain and under a wide range of environmental conditions while also possessing the structural integrity to resist excessive oblique torque, lateral overload and excessive rotation (See Figure 7). Through a variety of proprietary designs and traction systems, golf shoes serve to stabilize the lower extremities on the supporting surface through all phases of the

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golf swing. Improper shoe design can contribute to poorer performance or even worse, injury.

When making a golf shoe recommendation, first consider models which incorporate a more athletic last or design. While the basic anatomy of a typical golf shoe is consistent with many other sporting shoes, a few components deserve special attention, including features of the upper, midsole and outsole.

The upper should possess a toebox, vamp and lacing system which comfortably suits the toes and midfoot without imposing excessive pressure on any part of the foot. The upper should also be abrasion-resistant and breathable yet resist excess moisture accumulation around the foot, which is often encountered during an early morning walk on dew-covered greens (See Figure 7).

A stable heel cup is essential for rearfoot control and should extend distally far enough to adequately support the calcaneal-cuboid joint. A moderately firm wedge-type midsole will promote adequate forefoot cushioning and augment resistance to medial or lateral instability. A slight heel raise and forefoot rocker will permit the development of an easy stride and promote a comfortable ready position without overloading the forefoot.

The midsole and outsole should be integrated with foxing in critical stress zones to resist medial and lateral stress and torque loads. Seek a continuous outsole which augments midsole stability and incorporates a cleat pattern that enhances traction on a variety of surfaces without inhibiting weight shift or rotation.

Traction Systems

Traction systems vary widely among golf shoes. While most golf shoes utilize a removable/replaceable soft spike (cleat) system, some models are spike-free. Soft spikes are incorporated into the outsole of most golf shoes to promote greater traction. Spikes come in a variety of stiffness, traction patterns and elevations (Figure 8). When considering a traction system and soft spike pattern for an injured golfer, avoid spikes which are too stiff or too tall (spike elevation) unless the injured golfer weighs over 200 pounds. When improperly matched, soft spikes can resist normal lower extremity rotation and make walking awkward. Spike-free shoes possess proprietary traction systems which rely on a variety of curvilinear ridges, raised bars and conical spikes to promote the necessary traction for a comfortable round of golf (Figure 9).

Spike-free shoes have distinct advantages for the golfer who golfs with an artificial joint. These shoes tend to promote less resistance to rotational forces and may promote easier weight transfer during swing. Spike-free shoes also release more easily

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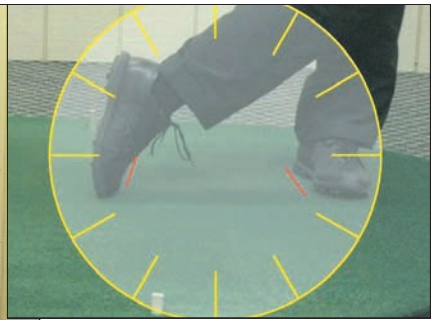

Figure 6: Typical follow-through. Insert shows weight shift onto the leading foot with the trailing foot pivoting onto the forefoot.

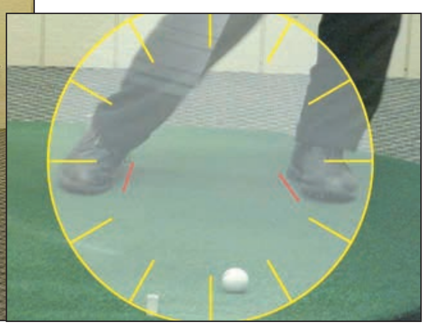

Figure 5: Typical downswing. Insert demonstrates foot position at ball impact, weight has shifted onto the leading foot nearest the target.

Figure 7: Typical golf shoe creates a stable foundation which promotes normal weight shift during swing and affords the development of a natural stride and gait pattern while protecting the foot from the elements.

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from artificial surfaces, greens, roughs and fairway surfaces during practice, walking and standing activities.

Figure 8: Soft spikes promote traction and improve grip on a variety of surfaces.

Principles of Golf Biomechanics

Avoiding "a good walk spoiled" may be easier said than accomplished. The typical golfer brings to golf a mixture of strengths, weaknesses and pathomechanic abnormalities, as well as old injuries, which through overuse may trigger golf-specific complaints. The podiatric physician may improve injury recovery and prevent subsequent re-injury by taking a few moments to carefully consider the golfer's biomechanic needs. Thus, successful treatment requires not only an accurate diagnosis, but also identification of the circumstances which aggravated or initiated the injury. In this way one is better prepared to identify contributing factors and establish a program for treatment, recovery and return to activity.

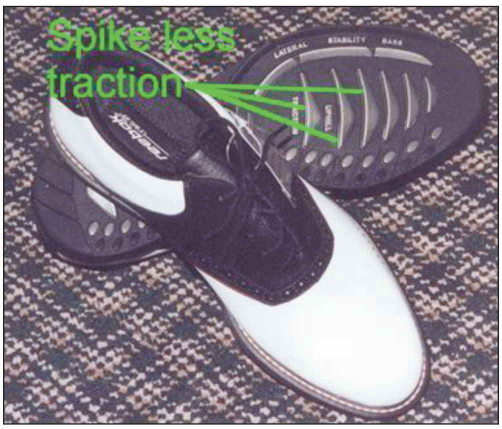

Figure 9: Spikeless traction system.

Step 1: Establishing a Balanced Swing

Jack Nicklaus once said that "the feet lead the way." The proper positioning of the feet in the golf shoe is the first step in successfully establishing a balanced and biomechanically optimized swing. Taking an accurate appraisal (biomechanic evaluation) of the lower extremity biomechanics will arm the podiatric physician with the details necessary to apply basic Root biomechanic techniques.[11]

Since the goal is to stabilize the STJ and midtarsal joint (MTJ), it is crucial to segmentally isolate upper leg, knee, lower leg, rearfoot and forefoot structural deformities and to neutralize each. When possible the evaluation of STJ characteristics such as pitch and the extent of medial or lateral displacement of the axis should be accomplished. This information can become useful, especially when the application of more advanced biomechanical control techniques are required. Kirby and Blake[12,13] offer excellent discussions relating to the theory and application of these advanced orthoses control techniques.

While orthoses should be considered to represent a powerful tool capable of neutralizing many leg and foot positional abnormalities, excessive lateral loads created by orthoses can trigger lateral instability and abnormal weight shift, especially during backswing and follow-through. Likewise, failure to achieve adequate STJ/MTJ stabilization will challenge the golfer's ability to maintain a comfortable and functional gait pattern or successfully carry out the necessary weight shift to complete a productive swing.

Orthoses Design for Golf

Unfortunately, very little data is available to help guide the podiatric practitioner when prescribing and implementing the use of orthoses among golfers. Stude and Brink[14] observed that among a group of experienced golfers, trends of balance and proprioceptive symmetry improved following a six-week conditioning period when using flexible orthoses. Herring and Davey[15] have documented significant improvements to golf performance skills when golf-specific orthoses were introduced. When prescribing orthoses intended to be used during golfing, careful attention must be paid to features which will augment a natural walk, yet aid the golfer to develop an effective pattern of weight shift (Figure 10).

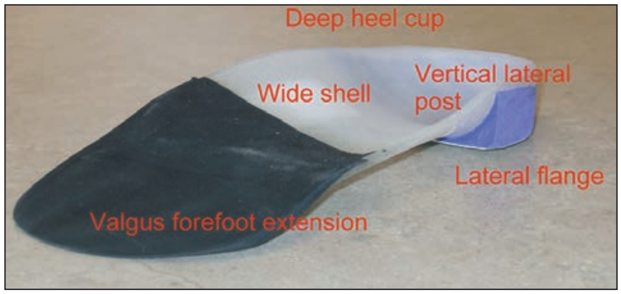

Figure 10: Typical golf orthoses.

Figure 11: Positive cast treatments include minimal plaster fill and medial heel skive.

Casting Technique

1) A neutral suspension impression cast is an excellent starting point. This casting technique is versatile, permitting the podiatric practitioner to address numerous functional circumstances intrinsically.

2) Balance the casts inverted by

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a minimum of 2°. Greater inverted cast balancing may be necessary to address structural pathology such as tibial varum. Blake inverted technique can be substituted when increased medial column support is sought. Begin with a minimum of 10°, but avoid Blake inversions of greater than 30°. Be sure to apply

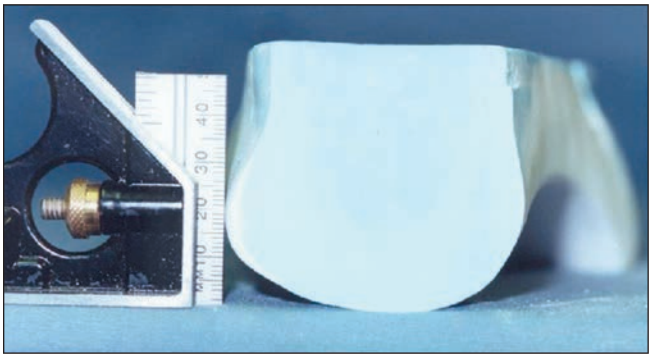

Figure 12: Adequate plaster expansion will avoid heel cup impingement.

a fascial accommodation with any Blake inversion that exceeds 10°. Avoid excessive lateral column overload when using either cast balance technique.

3) Apply a standard 2-3 mm. Kirby medial-heel skive technique to decrease the pronatory moment across the STJ axis of rotation (Figure 11). This is especially important to accomplish when the STJ axis is known to be medially deviated.

4) Apply a standard cast fill to the medial arch. Minimum arch fill is useful when greater medial column stability is sought (Figure 11).

5) Apply an adequate heel expansion to avoid posterior lateral heel cup impingement (Figure 12). Determine heel expansion based upon standing heel widths or by applying the Herring and Green formula for determining heel width where [male standing heel width] = [0.961(unloaded heel width (cm)) + 0.708cm] and [female standing heel width] = [0.929(unloaded heel width (cm)) + 0.892cm] (Figure 13).[16,17]

6) Polypropylene shells are preferred. This material offers greater compliance to deeper heel cups and lateral flanges, and is easier to adjust later. Select a shell thickness best suited to the golfer's weight to achieve a semi-rigid property of deformation under load.

7) Select a wide shell. Increase shell width by at least 5 mm. medial to the plantar bisection of the first metatarsal phalangeal joint. Wider width will improve stability throughout all swing phases and during gait. These wider or near full-width shells, however, may complicate shoe fit and require future adjustments.

8) Select a deep heel cup; a depth of 18-20 mm., which accurately contours to the heel during standing, will improve rearfoot control. Leave adequate room to account for heel soft tissue expansion, top cover materials and socks.

9) Apply an extrinsic flat no-motion (0/0) heel post of firm EVA or cork. Skive the medial side of the post, as required, to fit the heel counter of the shoe but attempt to maintain a vertical (no skive) lateral heel post border. This will help to resist excessive lateral overload during backswing and follow-through.

10) Secure a 2° valgus forefoot extension when possible. This addition will promote more effective weight shift by augmenting setup, resisting unintentional heel raise, resisting excessive external rotation and contributing to a more efficient trailing foot pivot. Do not apply this wedge to an orthosis intended to be used for the treatment of painful hallux limitus or rigidus.

11) Apply a favorite top cover and extension material to achieve the desired degree of accommodation, cushioning and shoe fit desired for the golfer.

12) Accommodations should be added when deemed appropriate. These could include distal metatarsal pads, cut-outs, heel spur pad, scaphoid pad or crest pad.

Clinical Considerations

Golfers are susceptible to numerous overuse injuries. It is unclear whether these injuries represent primary first time problems or are old dormant complaints aggravated by golfing. By applying standard podiatric medical protocols for the evaluation, diagnosis and treatment of the specific injury, the podiatric physician will be successful at resolving the injury. The effective introduction and biomechanic management of the golf athlete will serve to further expedite the golfer's return to full activities.

A Case Example of Moderate—Severe Pronation

A fifty-three year old low handicap golfer was seen complaining of medial arch fatigue and heel pain bilaterally which had recently hindered his ability to play golf. He had a ten-year history of medial arch fatigue with occasional aching pain experienced only after weekend tour-

Figure 13: Measuring heel width.

naments or after long or frequent practices. His pain had previously resolved completely with rest.

A complete history and physical examination was accomplished with his athletic history revealing chronic knee pain, which he attributed to an old football injury. A clinical diagnosis of plantar fasciitis and chronic patellofemoral pain syndrome was made and attributed to his excessive foot pronation.

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Biomechanically, he functioned with twelve degrees of tibial varum, which contributes significantly to the observed seven degrees of heel varus and the four degrees of forefoot supinatus present. The STJ and MTJ are fully pronated with subluxation of the oblique axis of his MTJ observed (Figure 14).

Orthoses management for this golfer focused around a 20° Blake inverted orthosis which also incorporated a 4 mm. medial heel skive and a shallow fascial accommodation (Figure 15). The orthoses shell was fabricated to full-width and included a medial flange. The orthosis was narrowed later to best fit his golf shoe. A deep 22 mm. heel cup and lateral flange tapering to the styloid process was incorporated in the shell. A 2° valgus forefoot extension was attached later and a no-motion extrinsic heel post was applied. A full-length 1/16" padded extension and 1/16" cushioned top cover was applied. The patient was provided with a recommendation for new golf shoes built upon an athletic last, which provides the extrinsic stability and shoe volume required by his feet and the orthoses.

Figure 14: Moderate to severe pronation.

Additionally, upon the receipt of his orthoses, arrangements were made for him to work briefly with a local golf professional to review and refine his old golf swing. A program to strengthen his quadriceps was implemented and focused upon his weak vastus medialis (VMO). Ingersoll and Knight[18] have emphasized the importance of VMO strengthening. Our strategy included daily strengthening and balance exercises, as well as encouraging the golfer to emphasize early VMO contraction during the gait cycle.

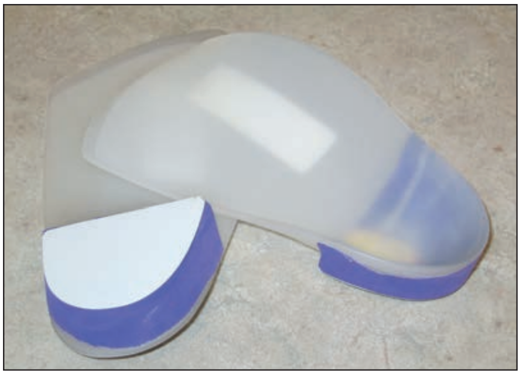

Figure 15: Orthoses shell for moderate to severe pronation.

Conclusion

The popularity of golf will continue to grow. With the ever-expanding numbers of individuals reaching retirement age, golf will become more then ever a recreational activity of choice. Podiatric medical physicians will with increasing frequency be called upon to evaluate and treat patients suffering from golf overuse injuries. Through the application of a well-planned program of podiatric care, which incorporates both basic and advanced principles of biomechanic management, the podiatric physician will be successful at returning the injured golfer to activity in a timely manner. **PM**

References

[1] McCarroll JR, Retting AC, Shelbourne KD. Injuries in the amateur golfer. Physician Sports Med 18: 122-126,1990.

[2] McCarroll JR, Gioe TJ. Professional golfers and the price they pay. Physician Sports Med 10: 54-70, 1982.

[3] Batt ME. A survey of golf injuries in amateur golfers. Br J Sports Med 26: 63-65, 1992.

[4] Batt ME. Golfing injuries: an overview. Sports Med 16(1): 64-71, 1993.

[5] Thériault G, Lachance P. Golf injuries: an overview. Sports Med 26(1): 43-57, 1998.

[6] Thériault G., E. Lacoste and M. Gaboury, et al. Golf injury characteristics: a survey from 528 golfers. Med Sci Sports Exercise 28(5): 565, 1996.

[7] Williams KR, Cavanagh PR. The mechanics of foot action during the golf swing and implications for shoe design. Med Sci Sports Exerc 15(3): 247-255, 1983.

[8] Carlson S. A kinetic analysis of the golf swing. J Sports Med Phys Fitness 7: 76-82, 1967.

[9] Koslow R. Patterns of weight shift in the swings of beginning golfers. Percept Mot Skills 79: 1296-1298, 1994.

[10] Gatt CJ, Pavol MJ, Parker RD, Grabiner, MD. Three dimensional knee joint kinetics during a golf swing. Influences of skill level and footwear. Am J Sports Med 26(2): 285-294, 1998

[11] Root, ML, Orien, WP, Weed, JH and Hughes, RJ. Biomechanical examination of the foot. Vol. 1, Clinical Biomechanics Corporation, Los Angeles, CA.

[12] Kirby, KA Subtalar joint axis location and rotational equilibrium theory of foot function. J Am Podiatr Med Assoc 91(9):465-487, 2001.

[13] Blake, RL. Inverted functional orthoses. J Am Podiatr Med Assoc 76:275, 1986.

[14] Stude DE, Brink DK. Effects of nine holes of simulated golf and orthotics intervention on balance and proprioception in experienced golfers. J. Manipulative Physiol Ther 20(9): 590-601, 1997.

[15] Herring, KM and NM Davey. Influencing golfer performance: Foot orthoses effect on ball flight characteristics a pilot study. In Influencing golfer performance: Foot orthoses effect on ball flight characteristics, MBAM 539: Decision Consulting ETJ Murff, KS Min, N Sukothanang, and YW Huang, 64p, 2003.

[16] Herring KM and RC Green. Is there room for an improved heel cup? New observations reveal differences in loaded heel width across age and gender. The Fifth International Conference on Foot Biomechanics and Orthotic Therapy, Sept., 2002.

[17] Green RC and KM Herring. Changes in heel shape upon loading and implications for orthoses and shoe design. Med Sci Sports Exercise 35(5) Supplement May, 2003.

[18] Ingersoll, CD and Knight, KL. Patellar location changes following EMG biofeedback or progressive resistive exercises. Med Sci Sports Exerc 23(10): 1122-1127, 1991.

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