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FEATURE ARTICLES

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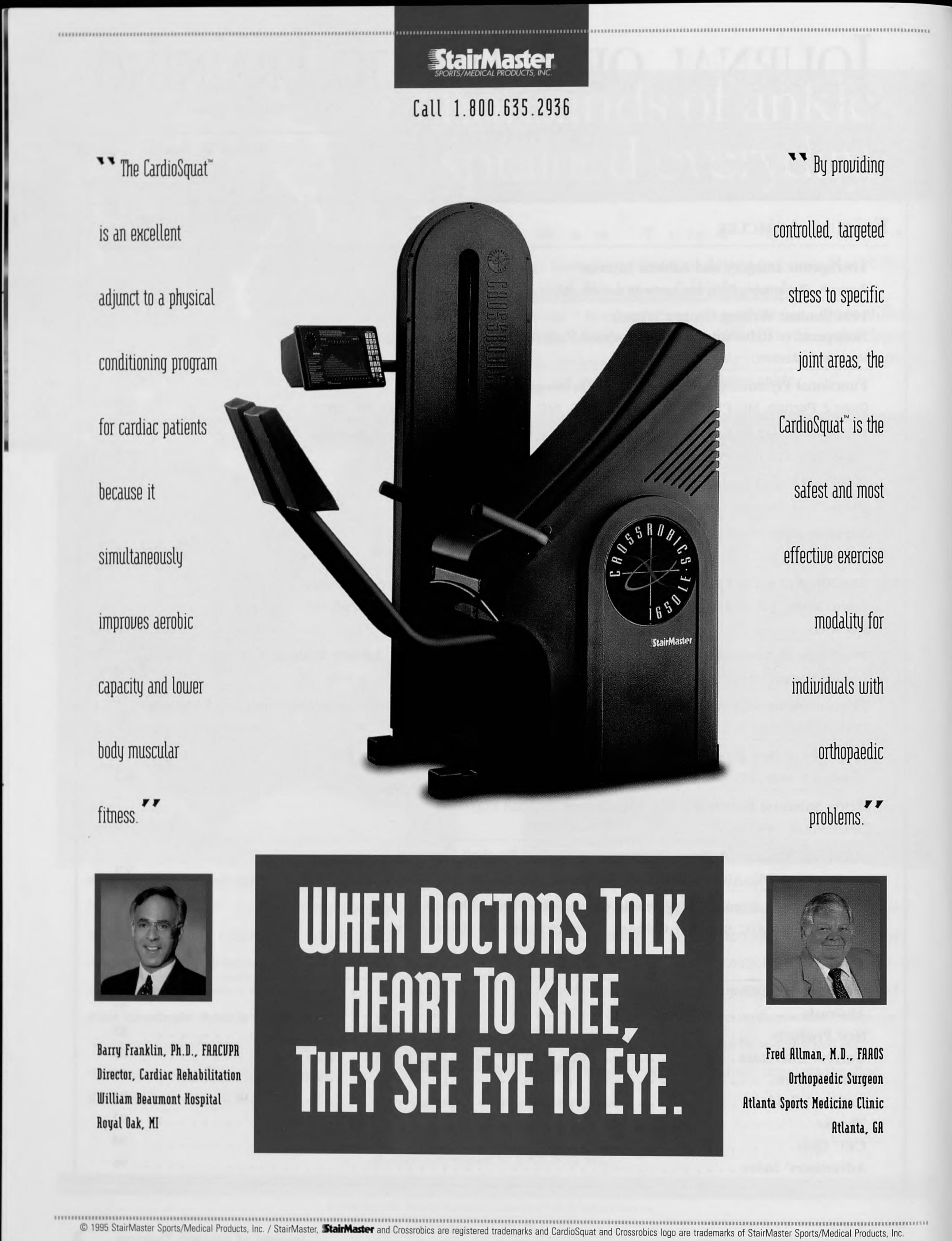
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Letters to the Editor

Communication With EMTs

Every year, sports medicine publications are full of the issue of helmet and shoulder pad removal in the event of a possible cervical spine injury. The press this topic receives is very much deserved, as the mishandling of such a situation could be devastating. Although each author may present slightly different procedures, all come to the same general conclusion—open communication must exist between the sports medicine staff and local emergency personnel to ensure proper care should such an instance arise.

In the spirit of this conclusion, our athletic training staff held an in-service concerning this issue for the administrators of our local ambulance company. We had a situation during the past football season that prompted our interest in setting up the in-service. As a result of a discussion with the staff handling our call, we were led to believe their procedure was representative of what was being taught universally. To our surprise, we found our procedure involving stabilizing the noncritical, possible cervical-spine-involved athlete with the helmet and shoulder pads on to be universally accepted.

Further investigation led us to find that only motorcycle helmet removal is practiced. Procedure manuals contain only a few sentences pertaining to football helmets. Although all the supervisors were familiar with proper football helmet procedures, the emergency personnel under them were not sufficiently familiar with the differences between motorcycle and football helmets.

As a result, the supervisors decided to place more emphasis on the issue. They have placed pertinent literature in the operations manual and an article in the upcoming newsletter. They are also planning to review the procedures with all of their staff.

Communication *is* the key. We were able to work with emergency personnel to increase their awareness of athletic injuries and our profession. In addition, we learned more about what emergency procedures they can provide in the face of a critical situation. We were even extended an invitation to do a "ride along" with an ambulance crew! Who benefits most? Our athletes! I suggest that all athletic trainers make a communication link.

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Response to Use of Electrocautery Unit

I would like to comment on a recently published article, "Using Electrocautery in Subungual Hematomas" (*JAT, 1994; 3;258*). The authors mention the use of the battery-powered unit by Medipack. In the article, they stated that they dispose of these units following each use.

I have been using the electrocautery units for over 7 years now. I agree with the authors, that they are the quickest, fastest, and probably safest device available for subungual hematomas. However, I don't believe there is any reason to dispose of the cautery units after only one use. The HIV virus, as well as the hepatitis virus, are destroyed by heat. Thus, once the cautery unit is heated, any virus on the unit is destroyed. A second way of cleaning this is simply by dipping the probe tip in LpH germicidal detergent by Calgon Vestal Laboratories for a few seconds. The entire unit could then be easily wiped off with LpH as well, if there was concern of blood being splattered on the unit itself.

I was glad to see mention of this unit in the *Journal of Athletic Training*. It is a very simple device to use and it saves a lot of time on the athletic trainer's part and anxiety on the athlete's part. Often, athletic trainers can obtain these free from emergency rooms whose personnel still insist on using them only one time.

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Author's Response

Although Mr. Kraeger's point regarding the ability of the disposable electrocautery device's high temperatures to destroy viruses is scientifically correct, decisions about the use and reuse of medical devices/equipment must be made with consideration of the manufacturer's recommendations for use and care of the equipment, as well as the Food and Drug Administration's classification of a device as reusable or disposable. We contacted Aaron Medical, the manufacturer of the Medi-Pak High Temperature Fine Tip Disposable Electrocautery Unit. Their representatives describe this unit as a one-time use, disposable device, and their product literature states this in writing. Medi-Pak does make a reusable power handle (Model number HIT 1) with a single-use disposable tip (item H101). This combination unit comprised of a reusable handle and disposable tip may provide a more economical alternative than a model where the entire unit is single-use disposable. The manufacturer reports that the reusable handles are used more commonly in overseas countries than in the United States.

We spoke with representatives of the FDA. According to their classification system, the Medi-Pak High Temperature Fine Tip Electrocautery Disposable device is a one-time use disposable device. Model number HIT 1 is classified as a reusable device and the disposable tip (Model H101) is single-use disposable. FDA classification takes into consideration a number of factors including decontamination/sterilization capability, manufacturers's recommendations, etc. According to the FDA "for a device to be 'reusable,' it must be capable of withstanding necessary cleaning and sterilization techniques and methods. The reuse of disposable devices represents a practice which could affect both the safety and effectiveness of the device." Since the manufacturer has no recommendations for reprocessing/sterilization of this entire unit, any practitioner who reuses it will, according to the FDA, "bear full responsibility for its safety and effectiveness," including any liability. It is possible for a practitioner to work through the FDA policies to reclassify devices. For individuals who want to pursue reuse of this device, inquiries could be made to the FDA's Center for Devices and Radiological Health HFZ-300.

We appreciate the opportunity to clarify this portion of our paper, and, hopefully, we have provided more rationale for our recommendations.

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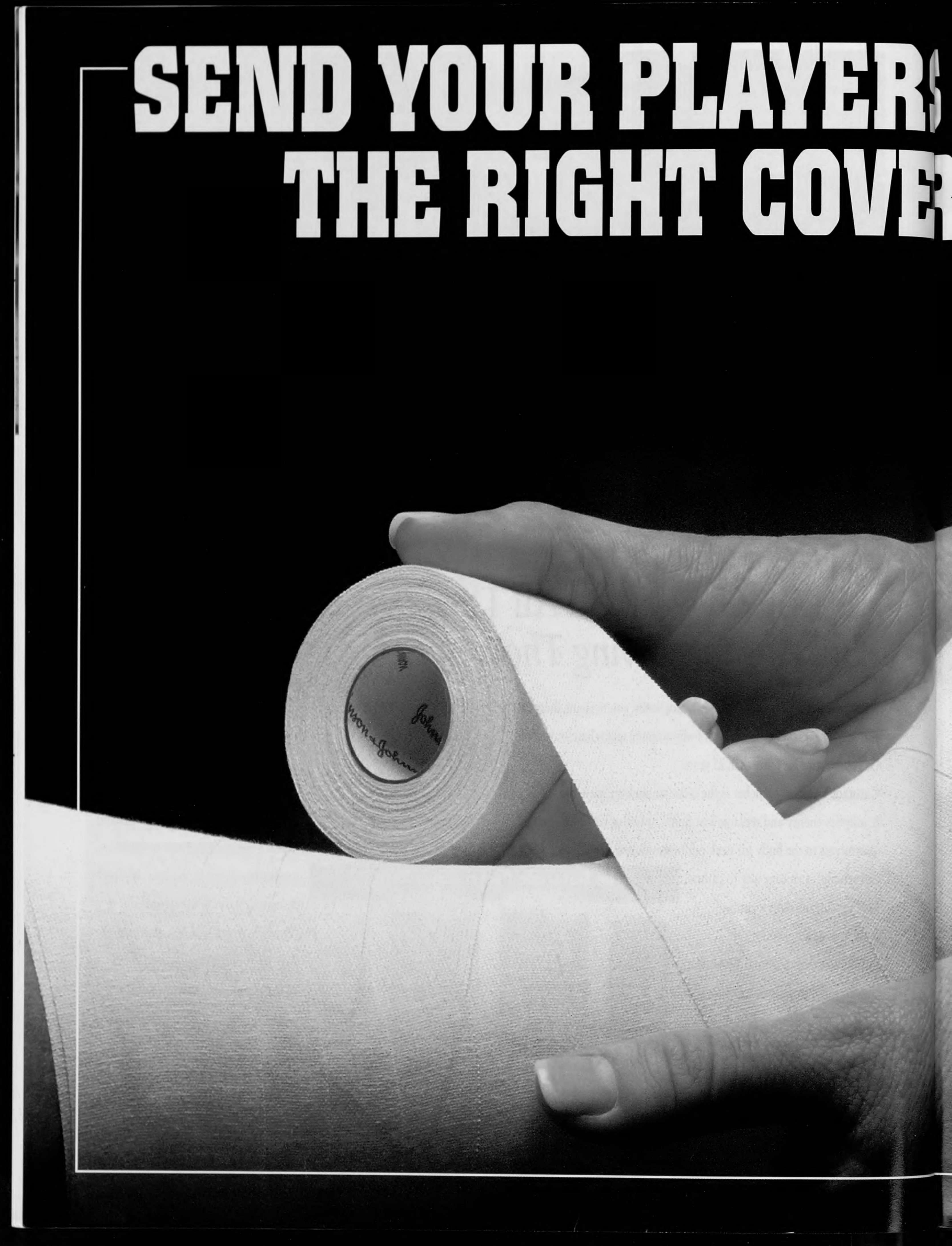
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Therapeutic Imagery and Athletic Injuries

Peggy A. Richardson, PhD
Leslie M. Latuda, BS

Abstract: *The rehabilitation process of an injured athlete can be accelerated if clinicians will use an imagery model in conjunction with existing therapeutic care. There is sufficient evidence to suggest a positive relationship between imagery and the healing process. Thus, we provide athletic trainers and practicing clinicians with basic information relating to the use of imagery in rehabilitation. Specifically, a sample imagery program is discussed incorporating the following prescribed steps: introducing imagery to the athlete, evaluating the athlete's imaging ability, assisting the athlete in developing basic imagery skills, and providing tips on the adjunctive use of imagery in a rehabilitation program.*

One of the most frustrating occurrences in an athlete's career is an injury. One solution for getting an injured athlete back into a sport as quickly as possible is combining imagery with other rehabilitation techniques. In this article, we present basic information on imagery, perspectives on mind-body integration, an athlete's perception of an injury, and suggestions for an adjunctive use of imagery in the rehabilitation program that could lead to a speedy and successful recovery from an athletic injury.

Imagery is a mental technique that allows a person to focus on a particular physical behavior or skill and to mentally practice that task or skill.[17] All athletes have the capability to expedite their own recoveries by using imagery as a psychological strategy.[12,18] When an injury occurs, athletes should not be confined to a rehabilitation program consisting of only the traditional medical or physical interventions; attention must also be given to the mind-body orientation. The use of an imagery model as an adjunct to existing therapeutic care[7,10,18] allows the athlete to cope better with internal and external pain,[2,3,16] speeds the recovery process of the injured area,[3,5,12] and keeps physical skills from deteriorating.

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Leslie M. Latuda is a Research Fellow in Kinesiology at the University of North Texas.

The Role of Imagery

Imagery is the ability to use all the senses to create or recreate an experience in the mind.[11,17] Thus, imagery is a sensory experience that occurs in the mind without environmental props.

Imagery research in sport dates back to 1930 when the technique was used to enhance physical practice and to prepare an athlete mentally for competition.[13] Only recently have researchers extended the role of imagery to the rehabilitation process. For example, Green et al[4] suggested that, for every physiological change that occurs in the body, there is a simultaneous change in the mental-emotional state. Further, both imagery and actual experiences trigger similar neurophysiological functions.[7] Applying this concept to an athletic population, Weiss and Troxel[18] suggested that athletes be taught to think constructively and not destructively when dealing with injury management. They advocated visualizing successful rehabilitation as a useful strategy for injury recovery. Since athletes already engage in imagery to improve their physical skills, the transition of using imagery to cope with injuries might be beneficial in addressing varied psychological factors related to injuries.

Mind-Body Partnership

There is a growing body of medical literature suggesting that a mind-body connection facilitates the healing process. Researchers[1,14] have reported an improved facilitation of the immune system response when activated by imagery. Others have discussed the effective use of imagery during rehabilitation from illness and injuries.[2,3,12,15,16] For example, in a discourse about mental imagery and the traumatic idea, Putnam[15] suggested that therapists who attempt to assist patients in reshaping traumatic ideas often use a variety of treatment techniques, including mental imagery. His major proposition recognized the importance of manipulations of physical and mental behavior with adjunctive mental imagery treatment.

In addition, Fiore[3] reported a high degree of success using imagery exercises with cancer patients. His research indicates positive treatment results and positive attitudes of patients who used visualization skills. Visualization reduces panic-stress images in the mind. Elimination of images that cause vasoconstriction will allow normal blood flow to resume and relax the muscles in the injured area, facilitating healing.[16]

The treatment protocol of wound care methods combined with imagery helped to reduce pain and anxiety associated with burn patients admitted to a hospital burn unit.[2] The success of the procedure was attributed to the potent effect of image on somatic function. Imagining reduced the physiological and verbal expressions of fear and pain.

Imagery is also used to assist in the healing of fractures and hip disarticulations[8] and as a tool in stress management.[6] Both counseling and imagery should be used as psychotherapies with individuals who encounter illness. Patients can confront disease, illness, or injury through imagery, recognize how it looks or feels, and eventually gain control over the illness or the injury.[3]

In the area of sport, rehearsing the skill or movement in one's mind has been shown to keep the body active and send blood to the injured area for faster healing.[7,16] Further, research conducted at the Center for Optimal Performance indicated that when athletes incorporated imagery with other physical therapies, many reported that injuries that were once chronic were no longer a problem.[12] Therefore, the literature supports, to some extent, a link between imagery and sport performance and between imagery and the healing process.

Psychological Responses to Injury

We have discussed what imagery is and the mind-body integration, but before you can be successful in this area, you must recognize how the athlete is feeling psychologically. After an injury, an athlete typically undergoes a sequence of predictable psychological reactions similar to those of a person who encounters a personal loss.[9,10] Athletes frequently respond to an injury by denying that there is physical damage, but when reality sets in, feelings of anger and depression take over. They may not understand the injury, or they may be apprehensive about their ability to attain the skill level they had before their injury. Thus, the nature of the injury needs to be explained to the athlete in lay terms that will facilitate an image of the injury in the rehabilitation process. Also, knowing what the athlete is feeling psychologically will better enable you to help the athlete cope with the injury, as well as to follow the rehabilitation protocol.

The Imagery Program

Now that you have acquired an understanding of what imagery is and why it is an important tool in the rehabilitation process, we offer four steps to assist you in establishing a rehabilitation program that includes imagery.

Introduce Imagery to the Athlete (Step 1)

Imagery works best when the athlete believes it will assist the healing process. The athlete should understand that imagery will not guarantee a full recovery, but that it has been successful when used adjunctively in the recovery process. Remember, the injured athlete is not very happy with life at this point. Simply define what imagery is and possibly give him/her a description of famous athletes in sports who have used imagery to improve sport skills and recover from injuries, such as Chris Everett, Jack Nicklaus, Bo Jackson, Greg Louganis, or Troy Aikman. Finally, you should provide a brief explanation of how imagery works so the athlete will know that mentally going through the actions while injured will benefit him/her both during and after the healing process.

Evaluate the Athlete's Imaging Ability (Step 2)

You must informally assess the athlete's ability to image (ie, ask questions or have him/her describe "how" and "what" was imaged), and you must recognize that there are differences among athletes. To be successful when using imagery, the athlete needs to have some background training on how to increase his/her ability to image. The athlete needs to be able to see, control, and vividly construct a mind-image. Injured athletes who attend practices and competitions might visualize running through the drills and workouts just as though they were physically performing them.

You now have the ingredients necessary to put together an imagery program; however, it is up to you to analyze the needs of your injured athlete. The following are some tips to get the athlete started:

- Make sure that the athlete is relaxed before imaging.
- Make sure that the athlete is in a quiet setting.
- The athlete should image himself/herself going through the movements or plays.
- The athlete should always have realistic expectations about outcomes.

Assist the Athlete in Developing Basic Imagery Skills (Step 3)

Imagery is a skill; therefore, each athlete needs to go through the three phases of vividness, controllability, and self-perception in the basic training (twice a day for 15 minutes) in order to be successful in this program. Further, the clinician should provide the following exercises and narration/instructions for the patient-athlete.

Vividness (5 minutes). Practice Exercise—"Pick a basic skill in your sport. Go over that skill in your mind. Feel the muscles at work as you go through the skill. Feel the contractions, the stretches of every muscle associated with the skill. As you practice the skill in your mind, combine all the sensations that normally occur when you perform the skill. For example, what do you most often see or hear or feel? Do not combine all the sensations at once; go through them slowly, making sure each becomes a part of your practice as you repeat the skill."

Other exercises can also be used. As the athlete masters the exercises of vividly creating these pictures in his/her mind, more complex images can then be presented in order to expand the athlete's imaging abilities.

Controllability (5 minutes). Practice Exercise—"Take the sport skill that you imaged in the last exercise. Now, imagine performing the skill with teammates or opponents. Imagine yourself successfully completing plays in relation to the movements and placement of your teammates or the opposition."

Self-perception (5 minutes). Practice Exercise—"Look back over your playing career and pick a performance in which you feel you did your best, a time when you felt you had flow and everything was working for you. Play that scene over in your mind using all your senses. Try to pick out the characteristics that made you perform so well and try to identify why they were present in the winning situation. Think about the preparations that were made for the event. Also, think about what caused the great performance."

After the athlete has a basic understanding of imagery techniques, it becomes important to link these skills to the rehabilitation process.

Provide Tips on Adjunctive Use of Imagery in Rehabilitation Programs (Step 4)

When implementing the program for an athlete, keep the information concise and simple; focus on the injury. A sample program using a knee injury with a hypothetical athlete is provided.

Injury Imagery. Have the athletic trainer or attending physician explain in lay terms exactly what the knee injury entails. Show the athlete an x-ray or picture with the muscles, ligament, and bones involved in the injury. If the athlete has an understanding of the exact place and an explanation of the injury, the imagery process will be enhanced. For example, a phrase like "the ligaments need to reattach to the bone" will be meaningful to the athlete.

After the explanation, the clinician should have the athlete go through the following exercises:

Exercise 1—"I want you to close your eyes and picture your knee. Now I want you to bring into focus the area the doctor told you was injured. Picture the x-ray and the unattached ligaments. Once you have these in focus, concentrate on one ligament at a time."

When you are sure that the athlete has an image of the injury (about 5 minutes), have the doctor explain the rehabilitation process to the athlete, including exercises to be done, conditioning, and a target date for returning to the sport. After the initial examination, the athlete needs to start on the imagery skills as soon as possible and engage in this first process for 5 minutes, 3 times a day.

Exercise 2—"Now I want you to visualize your knee. See the torn ligaments growing back onto the bone. Feel the ligaments growing and see the knee with all parts completely attached."

Skill Imagery. The athlete should attend all team meetings, practices, and games. The athlete should observe plays, strategies, and pay special attention to the situations that surround his/her position. After the practice session or meeting, the athlete needs to go through the following exercise:

"I want you to imagine yourself physically going through the plays in your mind. Take one play at a time but experience all aspects of the play. Then add to the mind-practice, going through the plays with teammates and opponents. Go through each play one at a time, just as you saw it practiced on the field."

Injury Rehabilitation Protocol. After the athlete practices *injury imagery* and *skill imagery* for one week, he/she should progress in the imagery session to the injury rehabilitation protocol.

"I want you to picture your knee where the ligaments are now mending to the bone. You have done a good job in attaching these ligaments in your mind. Now picture your knee completely healed. Mentally raise your knee a couple of inches; now bring it back down. Move it up again and let it back down slowly. I want you to feel the knee raising comfortably."

The athlete should go through this exercise for about 10 minutes 3 times a day. Slowly progress with lifting the knee with each imagery session. After approximately 1 week, alter the imagery exercise so the athlete is walking with little discomfort to the knee.

Closing Thoughts

Throughout this article, we have tried to offer some helpful hints on imagery and how it can be a productive tool in the rehabilitation of the injured athlete. There are numerous stories of athletes who have used imagery and had remarkable recoveries from injury and quick returns to their former skill levels. We hope that when you implement this imagery protocol into your rehabilitation program, you and your athlete reap great benefits. Just remember that imagery is only productive when used and practiced throughout the healing process. You are now on your way in helping your athletes to a speedy recovery.

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Nonoperative Rehabilitation of an Isolated Posterior Cruciate Ligament Rupture

Heather D. Waller

Abstract: *This case study describes the history, diagnosis, rehabilitation, and prognosis of an isolated posterior cruciate ligament (PCL) rupture seen in a collegiate soccer player. The occurrence of an isolated PCL rupture is rare in athletics. An accurate diagnosis is important and can be obtained by using techniques such as: passive tests, active tests, X rays, and magnetic resonance imaging. Rehabilitation from this injury is controversial because of the lack of documentation clearly showing the natural pathology of a PCL-deficient knee. There is research indicating that if chronic joint degeneration occurs, it will most likely be medial compartment or patellofemoral arthritis. Currently, the options are reconstructive surgery or participation in a nonoperative rehabilitation program. Because of this athlete's strength, age, and the nature of his sport, reconstructive surgery was not chosen. The rehabilitation program was progressive and modeled after the five stages of rehabilitation as described by Prentice. It emphasized strengthening the quadriceps and increasing hamstring flexibility. The athlete experienced minimal pain and inflammation after the injury. Results of rehabilitation were outstanding. The athlete was released for return to full contact 4–1/2 weeks postinjury. He demonstrated excellent performance without any abnormal knee symptoms. The ratio of quadriceps to hamstring strength was bilaterally stabilized to 87%, and the ratio of quadriceps strength of the injured knee to the healthy knee was 102% when the athlete returned to sports activities. The athlete will have to wait to see if the chronic damage that may develop will be symptomatic.*

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Isolated posterior cruciate injuries are uncommon in athletics. It is thought that these injuries go undetected more often than they are discovered. The patient's mild physical symptoms can be misleading, unlike the dramatic symptoms seen in an isolated rupture of the anterior cruciate ligament (ACL).[3] The patterns of joint instability are often confusing. A thorough initial evaluation, athlete history, knowledge of the mechanism, and execution of special tests are crucial in recognizing this injury. The rehabilitation of isolated posterior cruciate ligament (PCL) ruptures is controversial because of a lack of research showing long-term successes with nonoperative rehabilitation. Proponents of the operative repair of isolated PCL ruptures base their protocol on research that shows a high incidence of arthritic degenerative changes in the PCL-deficient knee. The problem remains that there is not enough documentation proving that reconstructive technique is more effective in retarding degenerative changes than a nonoperative rehabilitation.[18] Regardless, there are a number of patients who report successful return to daily activities resulting from consistent nonoperative rehabilitation focusing on strength maintenance.[17] Some research reports that results of joint stability tests of a nonoperative rehabilitated knee are comparable to a reconstructed knee, because, even with surgery, the joint usually is not repaired to its original static stability.[7,10]

Presentation of Case

A 21-year-old male varsity soccer player with no history of significant knee injury experienced an anterior blow to the left tibial tuberosity while performing a slide tackle during soccer preseason. The mechanism was described as being a shearing anterior blow to the superior tibia with knee hyperflexion. Immediately after the collision, he stood up to "walk it off," but, after a few steps, notified the student athletic trainer that his knee felt out of place. He was immediately evaluated.

The athlete complained of point tenderness on the tibial tuberosity and reported paresthesia in the popliteal fossa. The anterior drawer test, anterior and posterior Lachman's tests, and valgus and varus stress at 0° and at 30° were negative. The posterior drawer test was positive without an end point. The initial evaluation suggested significant damage to the PCL. The athlete was fitted with a universal knee immobilizer and crutches and then referred to an orthopedic surgeon.

The athlete saw the physician approximately 5 hours postinjury. The results of the x-rays showed what at first appeared to be an avulsion fracture of the anterior femoral attachment of the PCL. The physician performed two stability tests for the PCL. Both the active quadriceps test and the posterior sag test were positive. The patient was instructed by the physician to continue the use of the immobilizer and the crutches and to ice his knee to minimize inflammation.

A magnetic resonance imaging (MRI) examination was performed 4 days postinjury. The MRI ruled out an avulsion fracture, damage to the ACL, and damage to the medial meniscus. The MRI did show a complete rupture at the middle portion of the PCL. Additional x-rays taken at different angles confirmed the negative findings of the MRI. The athlete was allowed to begin walking without the use of crutches and the immobilizer.

The attending orthopedic physician (Dr. Michael Kody, Associated Orthopaedic Specialists, PS, Spokane, WA, personal communication, September 1993) indicated that surgery would not be the best option in this athlete's situation. The existing muscular strength of the athlete's quadriceps muscles made the athlete a candidate for nonoperative rehabilitation. The doctor predicted a successful outcome if the athlete's rehabilitation program concentrated on strengthening the quadriceps muscles and stretching the hamstring muscles. The theory was to attempt to train the quadriceps and hamstring muscles to stabilize the joint to compensate for the ruptured ligament.

Table 2.—Phase Two of Rehabilitation 9/02/93—9/15/93

Intervention	9/02	9/03	9/07	9/08	9/09	9/10	9/11	9/12	9/13	9/14	9/15
Contrast preexercise; ice postexercise*		x	x	x	x	x	x	x	x	x	x
Passive ROM	x	x	x	x	x	x	x	x	x	x	
Ham stretch	x	x	x	x	x	x	x	x	x	x	x
SLS†			x		x	x	x				
Squats§			x		x		x	x	x	x	x
Fitter¶					x		x		x	x	x
Aire-Dyne Schwinn						x	x		x		x
Strength						x	x		x		x
Workout											
Orthotron											
Orthotron (Table 5)								x		x	

* Contrast was applied beginning with heat for 5 minutes, then ice for 5 minutes, repeated three times ending with 10 minutes of ice. Contrast was applied before the exercises were done and ice was applied after the exercises.

† Straight leg raises (SLS) were done in three sets of 10 repetitions until the athlete adjusted and then increased to three sets of 20 repetitions.

§ The squat exercises were done in three sets of 10 repetitions and monitored so the athlete would avoid knee hyperextension and exceeding 15° of knee flexion. The athlete began without additional weight and added weight as necessary.

¶ The fitter exercises were done in two different ways: The skiing motion was performed for 10 minutes; the ROM was performed in three sets of 20. Both focused on strengthening the quadriceps using closed-chain kinetics.

Rehabilitation

The athlete participated in a progressive program modeled after the five-phase rehabilitation program described by Prentice.[16] Upon completion of the five phases, the athlete would be expected to have accomplished several goals. He would have full pain-free range of motion (ROM) of the knee joint and bilaterally equal strength in the quadriceps and hamstring muscles. Maintenance of the athlete's endurance would be accomplished by using isometric, isotonic, and isokinetic exercises.

Maximum protection, primary healing, functional maintenance, and controlled ROM exercises were included in phase 1 (Table 1).[16] The athlete remained crutched, immobilized, and non-weight bearing for 5 days.

Phase 2 of the rehabilitation began 6 days postinjury (Table 2). The goals were to provide moderate protection and to allow strengthening and endurance without compromising healing.[16] To provide protection, correct technique during exercises was monitored carefully. The athlete performed strengthening exercises and was advised to avoid terminal extension. The CYBEX Orthotron KT2 (Ronkonkoma, NY) strength workout consisted of performing three sets of 10 repetitions. The right quadriceps was set at 150°/sec, right hamstrings at 120°/sec, left quadriceps at 105°/sec, and left hamstrings at 105°/sec. Both legs were exercised to encourage a return to preinjury equal leg strength.

Phase 3 began 3 weeks postinjury (Table 3). The rehabilitation during this phase emphasized functional activities so that the athlete could redevelop basic skills.[16] The activities were performed at half speed.

Phase 4 began 3–1/2 weeks postinjury (Table 4), when the athlete began to work on regaining his functional skills specific to soccer. This included ball-handling skills on a natural grass surface. The program progressed according to the response of the athlete. Four weeks postinjury, the doctor released the patient, allowing him to resume full-contact practice with the team. The athlete was advised to continue to stretch the hamstrings and strengthen the quadriceps.

Phase 5 of rehabilitation began 4 weeks postinjury and focused on athlete maintenance.[16] The athlete reported general soreness and was treated for shin splints and tightness in both lower legs within one week after his return to practice. The athlete did notice a sharp pain deep in the popliteal fossa. He reported

Table 1.—Phase One of Rehabilitation 8/27/93—9/01/93

	Date				
Intervention	8/27	8/29	8/30	8/31	9/01
Rest	x	x	x	x	x
Ice	x	x	x	x	x
Compression	x	x	x	x	x
Elevation	x	x	x	x	x
Immobilized	x	x	x	x	x
Crutches	x	x	x	x	x
Doctor's diagnosis	x				x

Table 3.—Phase Three of Rehabilitation 9/16/93—9/21/93

	Date			
Intervention	**9/16**	**9/17**	**9/20**	**9/21**
Heat pre-exercise	x	x	x	x
Ice postexercise	x	x	x	x
Passive ROM	x	x		
Hamstring stretch	x	x	x	x
Squats*	x	x	x	x
Fitter†	x	x	x	x
Stairmaster	x		x	
Aire-Dyne		x		x
Schwinn				
Slideboard	x		x	
Jogging Program§	x	x	x	x
Strength workout (Orthotron)				x
Workout (Table 5)	x		x	
Sportscord¶	x	x	x	x

***† Please see Table 2.**

§ The athlete first jogged straight for 90 yds and then in figure eights with a 10-yd radius. Then he sprinted 30 yds gradually working up to 10 sprints per session.

¶ The sportscord reintroduced the athlete to lateral movements while running and following verbal commands. The athlete worked at moderate intensity for 5 to 10 minutes each session.

Table 4.—Phase Four of Rehabilitation 9/22/93—9/25/93

	Date			
Intervention	**9/22**	**9/23**	**9/24**	**9/25**
Heat pre-exercise	x	x	x	x
Ice postexercise	x	x	x	
Slideboard	x	x		
Sportschord*	x	x	x	
Jogging				
Program†	x	x	x	
Functional Workout§	x	x	x	
Interval workout¶			x	
Strength workout (Orthotron)			x	
Doctor's appointment				x

***† Please see Table 3.**

§ The functional workout consisted of the following: the zigzag pattern was followed in two different dimensions small (1 yd) and large (3 yd); the figure eights also were in dimensions of small and large. The athlete progressively began jogging with the soccer ball as he got stronger.

¶ The interval workout was the following: sprint 10 seconds, rest 20 seconds; repeated 10 times.

that it occurred twice, only while in a full sprint and, once he stopped, the pain dissipated. Two follow-up Cybex Orthotron TK2 tests were administered to ensure that the athlete was maintaining acceptable strength levels (Table 6).

At the time of his return to soccer, the athlete had increased his affected quadriceps strength to 102% of that of his unaffected knee (Table 6). When first tested, his injured knee-to-uninjured knee ratio was only 51%. Within 1 week, we saw a significant strength increase of 95%. Our athlete returned to full-contact competition, finishing with an impressive record, scoring four goals and two assists. The athlete is not expected to have any significant knee symptoms in the future. He reports that he is satisfied with the performance of his knee and continues to be asymptomatic.

Discussion

Currently, there is no widely accepted recommendation of nonoperative vs operative repair of PCL ruptures. Rubinstein and Shelbourne[17] report that treatment should be established, based on proper diagnostic techniques and the needs and characteristics of the patient. The research is consistent in recommending operative repair if there is combined ligament damage as seen in a knee dislocation.[14,15,17]

The long-term results of nonoperative repaired isolated PCL injuries have been found to have varied success. Eighty percent of the patients in Parolie's[15] study were happy with the performance of their knees. Of 25 patients, 84% had returned to their previous sport and 68% of those patients reported having the same level of preinjury performance. The patients in this study were aggressively treated with a program intensive in strengthening the hamstrings and emphasizing quadriceps strengthening. Isolated PCL ruptures often result in the development of arthritis in the medial compartment. The second most frequent site of arthritis is in the patellofemoral region.[15,18]

Research supporting a nonoperative rehabilitation of the PCL is consistent in recommending that maintaining quadriceps strength can allow a patient a full return to sports activities.[10,11,18] Lonnie Paulos, MD,[14] has established the following criteria before an athlete's return to previous activity: There should be no swelling; the patient should have 90% quadriceps strength of the unaffected leg, 80% hamstring strength of the uninjured leg, and ROM of 0° to 140°; and the patient should also have completed a jog/run program. Some of the rehabilitation techniques this program employs are: quad sets, cycling, Sportscord, Stairmaster, run/jogging, and isokinetics. This program also requires the use of a brace.[14] Paulos'[14] rehabilitation program is similar to the program in which the athlete in this case study participated.

Anatomy

The PCL is an extrasynovial ligament that derives from the development of

Table 5.—Orthotron KT2 Endurance Workout

Endurance* Set	Repetitions	Right H/Q °/sec†	Left H/Q °/sec§
1	15	210	210
1	15	150	150
1	10	150	150
1	10	210	210
1	10	300	300

*** The endurance workout was critical in maintaining bilateral endurance of the athlete's legs by manipulating the °/sec of the knee joint.**

† These data represent the °/sec setting of the Orthotron for the quadriceps and the hamstrings.

§ The left knee was the injured knee.

embryological tissues of the medial and lateral collateral ligaments.[5] The average mature PCL is reported to be 38 mm long and 13 mm wide.[1] The anterolateral and posteromedial bundles are the main structures of the PCL, named for their attachments on the femur and tibia. Both bands insert on the anterior lateral surface of the medial femoral condyle. The tibial insertion is adjacent to the lateral meniscus onto the posterior intercondylar fossa.[1,7] These bands are considered separately to discuss PCL function. The anterolateral large band is tight in flexion and relaxed in extension. The small posteromedial band is tight in extension and relaxed in flexion.[1,3]

Two meniscofemoral ligaments that work in association with the PCL are the ligament of Humphrey and the ligament of Wrisberg. The occurrence of both meniscofemoral ligaments in humans is rarely observed. In the Girgis et al[8] study, the ligament of Wrisberg was more commonly found than the ligament of Humphrey. The ligament of Humphrey inserts from the medial femoral condyle to the lateral meniscus. The ligament of Wrisberg inserts from the femoral PCL insertion to the posterolateral aspect of the lateral meniscus.[1]

Biomechanics

The PCL is known to be the primary restraint against posterior displacement of the tibia.[1,3,5,12] Bomberg[1] reports that at 90°F of knee flexion, the PCL provides 94% of the restraining force, and that there is no other single structure which provides greater than 2% of the restraining force to prevent posterior tibia displacement. When the PCL is cut, the meniscofemoral ligaments, if present, may provide a minor secondary restraint to posterior displacement of the tibia.[3]

Table 6.—Orthotron KT Test Results

Date	R Quad (psi)*	L Quad (psi)†	R Ham (psi)*	L Ham (psi)†	LQ/RQ (%)§	RH/RQ (%)¶	LH/LQ (%)¶
09/07/93	165	85	100	60	51	60	70
09/21/93	146	140	106	103	95	73	73
10/04/93	143	146	113	110	102	79	75
11/12/93	206	203	180	177	99	87	87

*** The Orthotron KT gauges read in psi. One psi equals approximately 0.62 ft-lbs. This modality was not designed for precise testing but is considered to be more accurate than manual muscle testing techniques. This data correlates to the right quadriceps (Quad) and hamstrings (Ham) muscles.**

† These data were collected for the left quadriceps (Quad) and hamstrings (Ham) muscles by the Orthotron KT discussed in (*). The left leg was the injured leg.

§ The left quadriceps (LQ) data was compared in a ratio to the right quadriceps (RQ) and expressed in percentage form. This is critical information to understand how the patient is responding to the rehabilitation program. A ratio of 100% or greater is desired.

¶ The ratio of hamstring (H) strength to quadriceps (Q) strength is important to check if the patient has a muscle imbalance in the legs.

Evaluation

There are three common mechanisms of injury resulting in PCL rupture. The first mechanism involves knee hyperflexion with an anterior blow to the anterior superior tibia. This mechanism is uncommon in athletics, but most accurately describes the shearing force the athlete experienced. This mechanism is often seen in car accidents when the anterior superior tibia hits the dashboard. Hyperflexion without trauma to the tibia by a downward force on the femur is a second mechanism. The third mechanism involves a sudden hyperextension. This mechanism will usually cause a combined ligament and meniscus injury.[6,11,12]

The PCL is thought to be injured much more frequently than it is diagnosed, because of the complexities of diagnostic procedures.[2,4] Injuries to the PCL may consist of 20% of all injuries to the ligaments of the knee.[12] Passive testing is commonly used to determine the extent of injury. PCL injuries can be either isolated or involved with combined injuries.[4] The most common combined injuries seen by Clancy[2] between 1977 and 1987 involved posterolateral structures and the PCL or the ACL and the PCL. The least common of the combined injuries observed involved the medial collateral ligament and the PCL.

Patients who suffer from isolated PCL ruptures will usually have mild-to-moderate effusion, pain with flexion, and often have abrasions or lacerations on the anterior tibia.[13] They usually report minimal pain beyond knee flexion of 90°.[2] The patient in this case study experienced pain only for the first week during passive ROM with knee flexion greater than 90°.

When the PCL is injured by a hyperextension of the knee, it is common to have an avulsion fracture at the femoral attachment of the PCL.[19] It is important for lateral and anteroposterior views to be taken to check for an avulsion.[13] Researchers have found that, with this type of injury, the PCL can be repaired, unlike a rupture at the mid substance of the ligament.[19] According to Michael Kody, MD, (personal communication, August 1993), a significant avulsion fracture would require surgical reattachment of the bone piece with a screw; a protocol for a smaller avulsion would require the athlete to remain in a brace locked at 30° of knee flexion for 6 to 8 weeks. An MRI is a critical tool to rule out any significant damage to other structures such as the ACL as well as the extent of an avulsion fracture.[17]

During evaluation of this injury, it is crucial to recognize accurately whether there is a posterior sag.[12] A posterior sag can be detected when both of the patient's legs are in 90° knee flexion and 90° hip flexion.[10] In this position, the examiner can detect a posterior sag when looking at the crest of the anterior tibia. When performing the posterior drawer test, it is important to look first for a posterior sag to assess if the tibia is in a neutral position when the test is performed. If the tibia is sagging or displaced posteriorly, then the posterior drawer test will appear to be negative.[9,12] The posterior drawer test performed at 15° of foot external rotation can indicate damage of the posterolateral structures.[13]

The Quadriceps Active Test is positive when anterior tibia displacement is observed while the patient contracts the quadriceps. The patient lies supine with 90° of knee flexion. The examiner resists at the ankles while the patient straightens both legs. The position of the tibial crest must be noted before the patient begins the movement. Test accuracy requires that the quadriceps contract while the hamstrings remain relaxed.[2,10]

In order to rule out additional injuries to the knee, other stability tests should be performed.[12] Valgus and varus tests for stability of the collateral ligaments should be performed at 0° and at 30°.[10] To apply a valgus stress, the examiner pushes against the knee and fibular head and laterally against the ankle. A positive test will show a gap at the medial joint line. A varus stress test is positive when a gap or instability occurs at the lateral joint line as the knee is pushed laterally while the ankle is pushed medially.[9] If instability is assessed with varus testing at 0° and at 30° of flexion, a combined injury involving the PCL should be suspected. The external recurvatum test and the reverse pivot shift test are additional tests to assess posterolateral rotary instability.[13]

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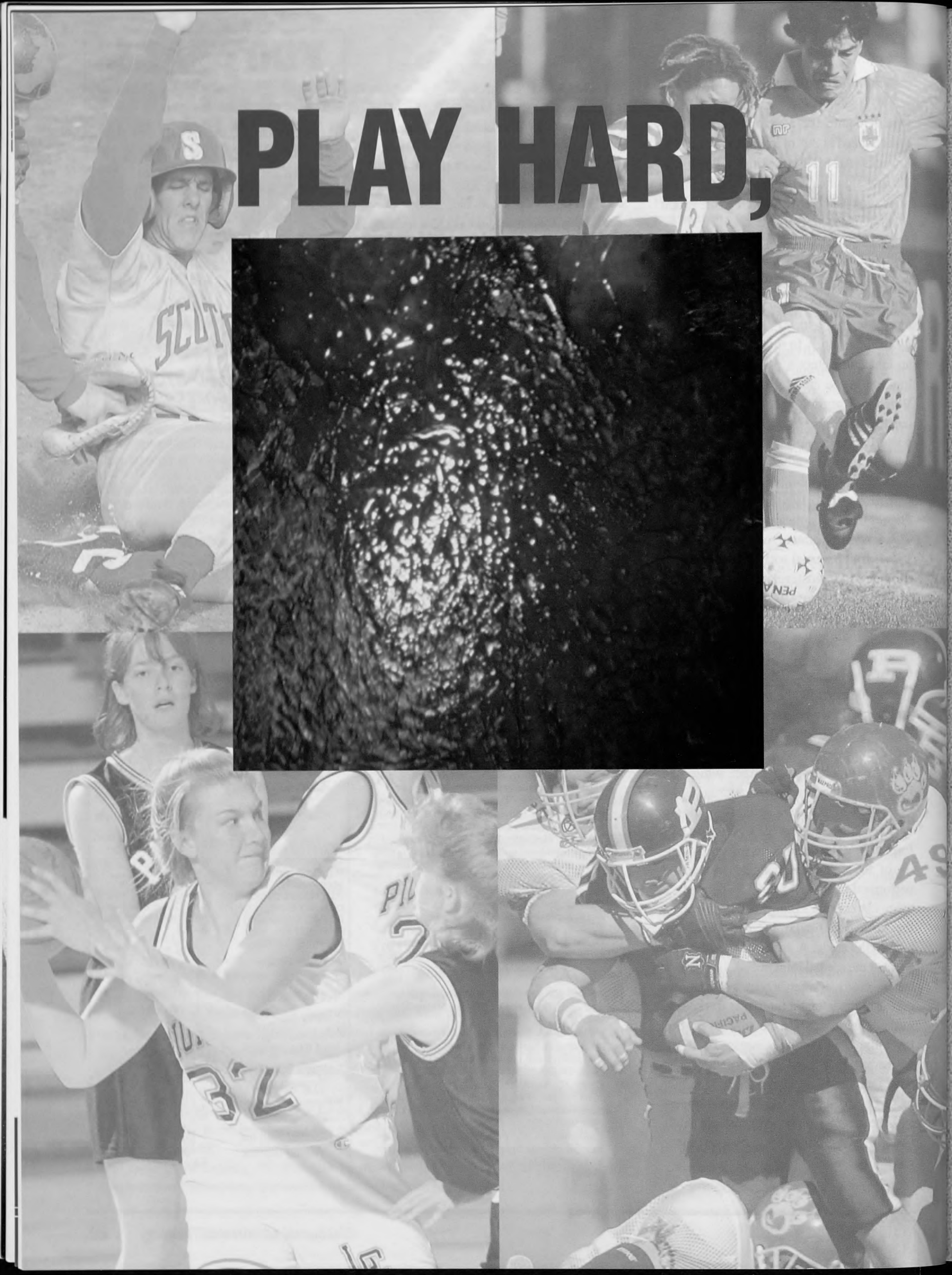
PLAY HARD,



Functional Plyometric Exercises for the Throwing Athlete

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Abstract: *In this article we provide athletic health care professionals with a variety of functional strengthening exercises to use in improving the muscular strength of the throwing athlete's shoulder. Upper extremity functional plyometric exercise in sport-specific patterns can be an important component of a throwing athlete's rehabilitation. We discuss several plyometric exercises, using the Inertial Exercise System, the Plyo-ball, and the Theraband. Proper use of these exercises can facilitate a safe and progressive rehabilitation program for the injured, throwing athlete. After the athlete has successfully completed the functional plyometric exercises, a throwing progression can be initiated.*

Recent literature adequately describes the performance of plyometric and eccentric exercises during functional rehabilitation.[1,6,16,19] Terms such as negative work, shock absorption, and deceleration are synonymous with eccentric loading. Plyometric exercise is defined as powerful muscular contractions after rapid stretching or dynamic loading of the same muscle group.[15] When using eccentric exercises to train an athlete for return to intense competition, it is important to consider the SAID principle (specific adaptation to imposed demands) and the concept of specificity.[1,6,16,19] The importance of specificity of training is evident when examining the cocking, acceleration, and deceleration phases of throwing. These phases exhibit powerful eccentric contractions of the internal and external rotators, respectively.[14,19] The purpose of this article is to provide athletic trainers and other health care professionals with a variety of functional strengthening exercises that improve the dynamic muscular strength of the throwing athlete's shoulder.

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Theoretical Basis

The cocking phase of throwing serves to increase the distance through which force may be applied to the ball.[9,14] At the end of the cocking phase, the glenohumeral joint is in a position of maximum external rotation, the scapula is retracted, the elbow flexed, and the trunk is extended. The subscapularis, pectoralis major, and latissimus dorsi all contract eccentrically to decelerate external rotation and protect the anterior and inferior structures of the glenohumeral joint.[12,14]

The acceleration phase of throwing begins with the shoulder in a position of maximum external rotation.[9,14] This phase of throwing is very explosive. At the beginning of the acceleration phase, the speed of shoulder internal rotation is 0°/s, and, at its termination, speed reaches a maximum of 7,000 to 9,000°/s. This phase of throwing is also very short, typically lasting for less than 1 second. It ends with ball release.[9]

After the ball has been delivered, the deceleration phase should allow for quick but comfortable reduction in speed of the throwing arm. During the deceleration phase, the shoulder rapidly internally rotates and horizontally adducts. The eccentric action of the posterior deltoid, supraspinatus, infraspinatus, and teres minor are most helpful in decelerating the forward momentum of the arm and protecting the posterior structures of the shoulder complex. In addition, eccentric contractions of the middle trapezius, rhomboids, pectoralis major, and latissimus dorsi also actively help to slow the throwing arm.[12,14] The activity in the scapulothoracic muscles helps decelerate the scapula, but also helps provide a stable base for the rotator cuff to act upon.

When a throwing athlete injures his/her shoulder, the initial treatment of choice is rest.[6,13] Rest allows for healing of the involved soft tissues and resolution of the inflammatory process.[6] Rehabilitation during the acute stage also includes modalities to reduce pain and an exercise program to maintain the cardiovascular status and lower extremity strength of the athlete. When the shoulder pain decreases and the injury enters the subacute stage, flexibility and pain-free range-of-motion exercise programs are initiated. The flexibility and range-of-motion exercise programs are individually designed with careful consideration for the injured structures and limitations of motion.[6]

After the athlete achieves normal pain-free motion of the shoulder, you can initiate a strengthening exercise program.[2,6,13] The goal of the strengthening program is to restore normal strength and improved muscular endurance of the rotator cuff, scapulothoracic, bicep, tricep, and pectoralis muscles. The athlete should perform most of the strengthening exercises with no weight or light dumbbells (1 to 3 lb) to isolate individual muscles.[6] Carson and Pappas[6,13] provide many exercises to improve flexibility, range of motion, and isolated muscle strength of the shoulder of the throwing athlete.

Plyometrics

We believe that health care professionals should incorporate a variety of plyometric functional exercises of the anterior and posterior musculature in a sport-specific pattern after traditional shoulder-strengthening exercises and before initiating a full throwing progression. Plyometrics are most frequently used in lower extremity strength and power exercise programs, and are defined as quick powerful movements that involve a prestretch of a muscle just before its contraction. The prestretch is the most important phase of the plyometric activity because it increases the excitability of the neurological receptors, which enhances the reactivity of the neuromuscular system.[19]

Plyometrics are also referred to as stretch-shorten exercises.[3,4,7,19] The stretch stimulates body proprioceptors such as the muscle spindle and the golgi tendon organs (GTO). The muscle spindle is a stretch receptor located within the muscle belly.[5,19] A quick stretch stimulus to the muscle spindle reflexly produces a contraction of extrafusal muscles fibers in the agonist and synergist muscles. This reflex is very rapid, occurring in .3 to .5 milliseconds.[4] The GTO are also sensitive to tension, but are located at the musculotendonious junction at both the origin and insertion of the muscle. Stimulation of the GTO produces inhibition of the agonist extrafusal muscle fibers; therefore, the GTO protect against overcontraction or overstretch of the muscle.[11] During proper performance of plyometric exercises, the excitatory effect of the muscle spindle reflex pathway overrides the inhibition provided by the GTO.[11,19]

Another principle to consider when examining physiology of plyometric exercises is the recoil of elastic tissues.[7] During the stretch phase of a muscle, the load is transferred to the elastic components and is stored as elastic energy. The elastic energy stored during the eccentric muscle contraction can enhance the following concentric contraction. The elastic elements deliver this stored energy during the concentric contraction to increase power output. Time, magnitude of stretch, and velocity of stretch affect this storage of elastic energy. To use the stored energy and to achieve maximum results with plyometric exercises, the concentric contraction must immediately follow the application of the load, and the preceding eccentric contraction (stretch) should be of short range and rapid.[3,7]

Adaptation to Stress

The healthy tendon is a metabolically active structure that demonstrates an increase in tensile strength when subjected to progressive controlled stress. This increase in tensile strength has also been observed in injured tendons.[16] To maximize the tensile strength of the tendon, use the eccentric phase of muscle contraction in the strengthening phase of rehabilitation programs, because of its ability to create greater amounts of tensile stress along the tendon.[6,10,16,17] Also, after injury collagen production within the damaged tendon increases, the collagen begins to form into fibrils which line up in a random pattern. The tensile stress created by muscle contraction along the injured tendon is important in realignment of these collagen fibrils.[8] This is the rationale for using functional plyometric exercises before an athlete returns to throwing.[17]

Inertial Exercise System™

The following exercises functionally strengthen the muscles used during the throwing motion. These exercises improve both concentric and eccentric activity of the muscles in a pattern specific to the throwing motion. The Inertial Exercise System or Impulse System (Engineering Marketing Associates, Newnan, GA), increases eccentric torque,[1] and is an excellent way to begin eccentric muscle training. The unit allows the resistance to move horizontally on rollers along a fixed platform. The Inertial Exercise System allows the performance of many exercises, but we review several exercises specific to the throwing motion that are important for the throwing athlete.

Inertial Exercise I: Internal Rotation With the Inertial Exercise System

The athlete begins this exercise in a position of maximum active shoulder external rotation at 0° of shoulder abduction and progresses to a position of 90° of abduction as tolerated (Fig 1). Many throwing athletes may have an increased amount of external rotation when compared to nonthrowing athletes, but we have found that they have little difficulty performing this exercise. The grip attachment can consist of a Velcro loop, or an implement such as a baseball. The athlete begins at maximum shoulder external rotation and internally rotates the shoulder concentrically, causing the resistance to move along the horizontal platform. When the weight carriage passes the center of the platform, the internal rotators are loaded eccentrically as they decelerate the motion of the weight carriage along the horizontal platform (Fig 2). The internal rotators continue to contract eccentrically as the shoulder externally rotates back to the starting position of maximum external rotation where the sequence is initiated again.

Inertial Exercise II: External Rotation With the Inertial Exercise System

The external rotation exercise is similar to the internal rotation exercise, except that the direction of motion is reversed. Have the athlete turn around so that he/she faces the bar, which changes the pull of the resistance from a posterior direction to an anterior direction. The athlete begins in a position of maximum internal rotation and then externally rotates the shoulder (Fig 3). The muscle actions for the external rotators are the same as for the internal rotators during the internal rotation exercise using the Inertial Exercise System.

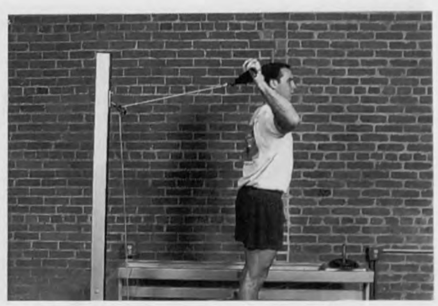

Fig 1.—Internal rotation with the Inertial Exercise System (start position).

Fig 2.—Internal rotation with the Inertial Exercise System (finish position).

Fig 3.—External rotation with the Inertial Exercise System (start position).

Inertial Exercise III: Shoulder Extension With the Inertial Exercise System

The athlete begins with the shoulder at about 45° of shoulder flexion (Fig 4). He/she then actively moves the arm into a position of full shoulder extension and scapular retraction through concentric contractions of the triceps, posterior shoulder, and scapulothoracic muscles. The movement of the weight carriage on the horizontal platform requires eccentric contraction of the posterior shoulder and scapulothoracic muscles to return to the starting position.

Plyo-Ball™ and Plyoback™ Exercises

The Plyo-Ball and Plyoback, a weighted exercise ball system, (Functionally Integrated Technologies, Watsonville, CA) is an excellent tool to incorporate into the functional shoulder program for the throwing athlete. A trainer supervises and instructs the athlete, who then gradually works alone with the aid of the Plyoback device. The weight of the balls usually ranges from 2 to 12 lb. When the circumference of the heavier balls is too large and more weight is indicated, secure a Velcro cuff weight around the wrist. Start these exercises with the elbow positioned in 90° of flexion and the shoulder in 0° of shoulder abduction. As the athlete progresses and needs to be more challenged, progress these exercises toward 90° of shoulder abduction. The following exercises strengthen and functionally train the shoulder of the throwing athlete.

Plyo-Ball Exercise I: Internal Rotation With the Plyo-Ball

Use a 2-lb Plyo-Ball with the shoulder in 10° of abduction and full external rotation and progress to a position of 90° of shoulder abduction and full external rotation (Fig 5). Throw the Plyo-Ball against the Plyoback device. Catch the ball as it returns off the Plyoback, and allow an eccentric contraction of the internal rotators to slowly decelerate the ball to the starting position (Fig 5). Use a quick concentric contraction of the internal rotators to repeat the sequence.

Plyo-Ball Exercise II: External Rotation With the Plyo-Ball

Execute this exercise in the same manner as the internal rotation exercise with the Plyo-Ball, except that the external rotators of the shoulder are now the muscle group that is eccentrically loaded. The athlete performs this exercise with a trainer's assistance or alone using the Plyoback with practice. The athlete stands facing away from the Plyoback, holding a 2-lb Plyo-Ball. The shoulder is initially placed in 0° of abduction and maximal internal rotation. The elbow is flexed to 90°. As the athlete becomes more skilled with the exercise and has no complaints of pain, he/she can progress to a position of 90° of shoulder abduction and maximum internal rotation. The athlete throws the ball backwards by rapidly externally rotating the shoulder (Fig 6). As the Plyo-Ball bounces off the Plyoback, the athlete catches the ball and eccentrically uses the external rotators of the shoulder to decelerate the ball back to the starting position (Fig 7), where the exercise is repeated.

Plyo-Ball Exercise III: Reverse Throw

The assistance of an athletic trainer is required for this exercise. Position yourself behind the half-kneeling athlete and toss him/her a Plyo-Ball (Fig 8). He/she catches it in a position of 90° of shoulder abduction with maximum external rotation, 90° of elbow flexion and scapular retraction (Fig 9). The athlete slowly decelerates the ball with an eccentric contraction of the posterior shoulder musculature into a position of shoulder adduction, shoulder internal rotation, and elbow extension (Fig 10). This exercise can reproduce the muscle action and motion of the upper extremity during the deceleration phase of throwing, but at a slower speed. The athlete then follows the same path in reverse to quickly return the ball to the trainer. As the athlete improves, accelerate the activity to reach speeds close to actual velocities observed with throwing.

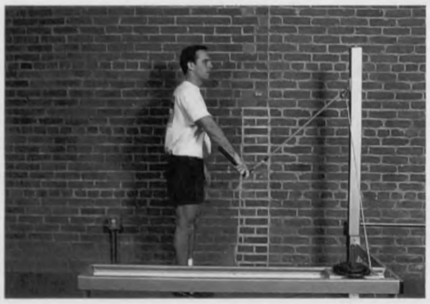

Fig 4.—Shoulder extension with the Inertial Exercise System (start position).

Fig 5.—Internal rotation with the Plyo-Ball (eccentric deceleration phase).

Fig 6.—External rotation with the Plyo-Ball (release phase).

Fig 7.—External rotation with the Plyo-Ball (eccentric deceleration phase).

Fig 8.—Reverse throw (start position).

Fig 9.—Reverse throw (catch phase).

Theraband™ Exercises

Theraband (Hygienic Corporation, Akron, OH), a resistive exercise system, provides an inexpensive and easy way to train the muscles of the shoulder concentrically and eccentrically. Theraband is a useful strengthening tool in the clinic as well as an effective component of a home exercise program. The trainer can design Theraband exercise programs to provide resistance to any phase of the throwing motion desired. Theraband exercises are by no means limited to the examples provided in this article.

Theraband Exercise I: Theraband Internal Rotation

The internal rotators of the shoulder can be strengthened in a variety of levels of shoulder abduction. Initially, the athlete will start in 0° of abduction and progress to 90° of abduction, based on reported symptoms and quality of motion (Fig 11). In the starting position, the Theraband should be tight, and positioned to resist the internal rotators of the shoulder. The athlete concentrically contracts the internal rotators of the shoulder until maximum internal rotation is achieved (Fig 12). Eccentric contraction of the internal rotators allows the athlete to return to the starting position.

Theraband Exercise II: Theraband External Rotation

The external rotators of the shoulder can also be strengthened in a variety of levels of shoulder abduction. As with the Theraband internal rotation exercise, this exercise starts in 0° of abduction and slowly progresses to 90° of abduction, based on tolerance and quality of motion. The athlete should start this exercise with the Theraband taut, and positioned to resist the external rotators of the shoulder. Concentric contraction of the external rotators of the shoulder rotate the humerus to the finish position (Fig 13), and eccentric contraction of the external rotators allows the humerus to return to the starting position.

Theraband Exercise III: Theraband Diagonals

Also, diagonal patterns of strengthening with the Theraband can be used to mimic the acceleration and deceleration phases of throwing. The Theraband can provide resistance to the anterior shoulder muscles by attaching the Theraband to a stationary object behind the athlete as he/she throws (Fig 14). This will strengthen the muscles used in the acceleration phase of throwing. The Theraband can also provide resistance to the posterior shoulder muscles by attaching the Theraband to a stationary object in front of the athlete (Fig 15). This exercise will strengthen the muscles that decelerate the arm after release of the ball. To make this exercise more sport-specific, the Theraband can be tied to a ball.

Fig 10.—Reverse throw (eccentric deceleration phase).

Fig 11.—Theraband internal rotation (start position).

Fig 12.—Theraband internal rotation (finish position).

Fig 13.—Theraband external rotation (finish position).

Discussion

The exercises we have provided should help prepare throwing athletes for competition by training the stretch-shorten cycles used during the throwing motion. These exercises should be added one at a time to properly monitor subjective feedback and objective measures (ie, swelling, strength, range of motion). As a general guideline, an athlete can begin by doing three sets of 10 to 30 repetitions and progress to five or more sets of 50 or more repetitions. The athletic trainer

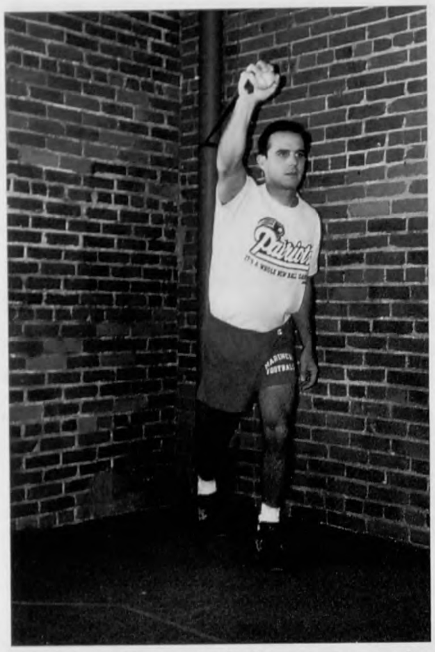

Fig 14.—Theraband diagonal exercise (acceleration).

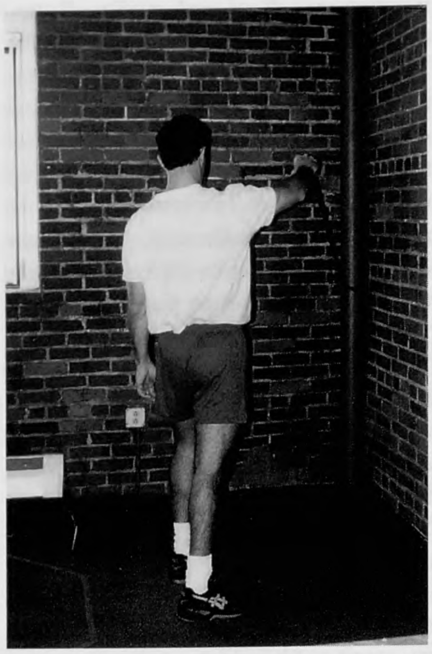

Fig 15.—Theraband diagonal exercise (deceleration).

needs to monitor the athlete closely to detect fatigue and patterns of substitution. After the athlete has successfully completed the functional plyometric exercises, a throwing progression can be initiated.

There are many different throwing progressions available, but the one we use is divided into six phases. The first phase is a warm-up phase which involves tosses at distances of 30 to 40 ft. The athlete will progress to the next phase by increasing his/her throwing distance by 30 ft to a maximum distance of 180 ft. The athlete cannot advance to the next phase of the throwing progression until he/she can complete five or more sets of 50 to 75 repetitions. Velocity of the throw is not considered important. When the athlete can throw the ball 180 ft for three to five sets of 50 to 60 repetitions without pain, the athlete can begin unrestricted throwing.[6] More recently, some authors suggest that unrestricted throwing can begin when the athlete can throw 180 ft for one set of 75 repetitions without pain.[18] Regardless of the progression used, stress proper mechanics during the throwing progression, and if the athlete experiences pain, discontinue the throwing progression until the pain resolves.[6,13,18]

It is important to remember that these exercises address open-chain rehabilitation only and that closed-chain exercises should also be performed. In addition, the entire kinetic chain, including the trunk, elbow, wrist, and lower extremities should be effectively strengthened. The functional phase of the athlete's program is the important link between well-planned rehabilitation and successful return to full competition. The SAID principle (specific adaptation to imposed demands) (SAID) dictates that the late stage of rehabilitation be specifically tailored to meet the individual's needs. The eccentric actions of the rotator cuff and accompanying musculature are critical to the function of the shoulder for the throwing athlete. Used properly, the Inertial Exercise System, Plyo-Ball, and Theraband exercises can successfully achieve sport-specific strength and function of the musculature around the shoulder.

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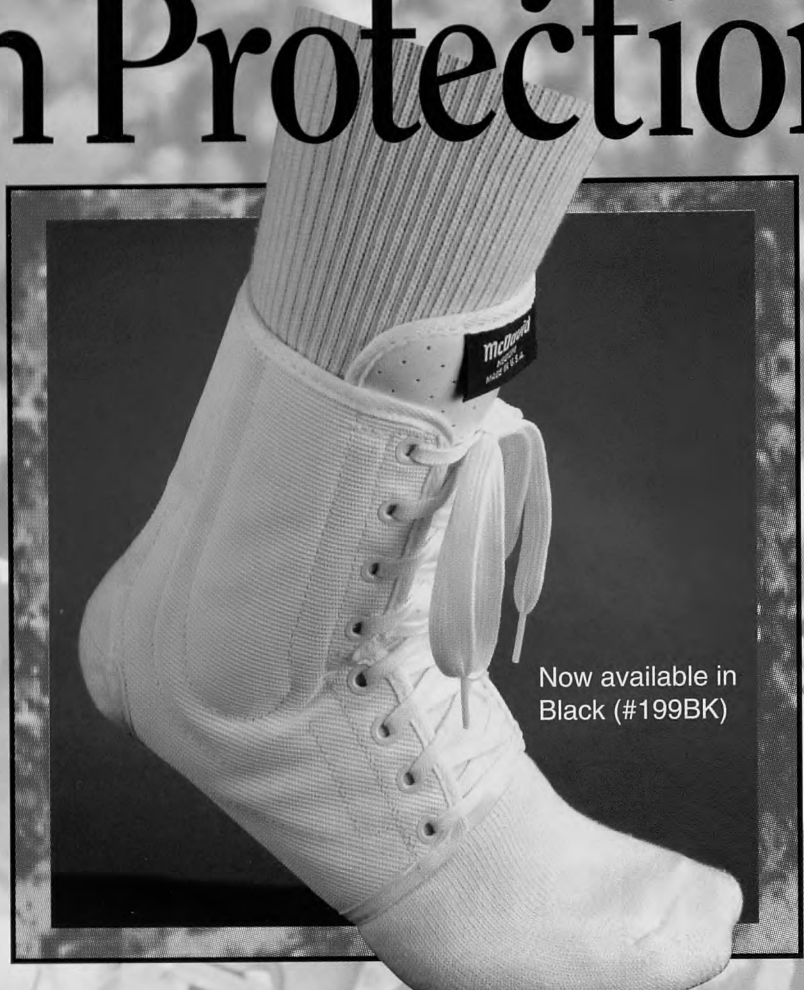
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Pathophysiology of Acute Exercise-Induced Muscular Injury: Clinical Implications

Phillip Page, MS, ATC, PT, LAT

Abstract: *Acute muscular injury is the most common injury affecting athletes and those participating in exercise. Nearly everyone has experienced soreness after unaccustomed or intense exercise. Clinically, acute strains and delayed-onset muscle soreness are very similar. The purpose of this paper is to review the predisposing factors, mechanisms of injury, structural changes, and biochemical changes associated with these injuries. Laboratory and clinical findings are discussed to help athletic trainers differentiate between the two conditions and to provide a background knowledge for evaluation, prevention, and treatment of exercise-induced muscular injury.*

The musculotendinous unit is the force-generating component of functional movement. However, it is one of the least understood links in human movement and one of the most frequently injured tissues during exercise. Athletic trainers evaluate and treat musculoskeletal injuries daily. This paper provides a review of contemporary literature on the pathophysiology of acute strains and delayed-onset muscle soreness. Predisposing factors and mechanisms of injury are presented to aid the reader in the prevention of muscular injury, while structural and biochemical changes are reviewed for the purpose of evaluation and treatment. By understanding the pathophysiology of exercise-induced muscle injury, we may be better able to prevent, evaluate, and treat these injuries.

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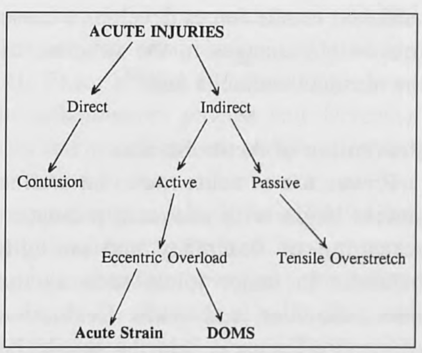
Muscle Injury Classification

Musculoskeletal injuries are very common in both athletes and nonathletes. Although both acute and chronic injuries are seen, we will limit this review to acute muscular injuries. Acute injuries result from: 1) direct trauma, causing a contusion at the point of contact, or 2) indirect trauma, causing a disruption in the myofibers without contact. Indirect injuries may be passive or active. Passive injuries result from a tensile overstretch of the muscle without contraction, whereas active injuries usually result from eccentric overload of the muscles.[28,32,46] These active injuries can be classified as acute strains or exercise-induced muscle soreness (see Figure).

Because most exercise-induced muscular injuries result from active contraction of muscles, our discussion will focus on injuries resulting from eccentric overload: acute strains and exercise-induced soreness. Exercise-induced muscular soreness or delayed-onset muscle soreness (DOMS) may be considered symptoms of injury. DOMS, however, limits performance resulting from decreased motion, decreased force production, and pain[2,14,15,26,48,51,58]; therefore, it is relevant to our discussion of acute exercise-induced muscular injury.



Types of acute muscular injury.

Both acute strains and DOMS usually occur as a result of eccentric overload and structural alteration[26,54] and result in an inflammatory reaction.[56] Although each presents similar clinical symptoms and functional limitations, they should be differentiated to determine proper treatment. For example, acute strains may require rest, whereas DOMS may respond better to stretching and activity.

Clinically, acute muscle strain injuries can be distinguished from DOMS based on the history of the injury. A strain results from a specific episode, is painful, and is easily recognized by the patient as an injury.[28] DOMS, however, usually begins 12 to 48 hours postexercise, with no specific event causing the injury[2,11,63] other than repeated eccentric muscle contraction. In both injuries, palpation, passive stretching, and active movement will cause pain.[28,56] Classification and clinical findings of acute exercise-induced muscular injury are summarized in Table 1.

Acute Strain

Acute muscular strains result from macrotrauma with immediate and direct signs and symptoms.[17,30] Most experimental studies, however, focus on acute muscular strain resulting from passive stretch in animal models. Taylor et al[61] noted that both clinical and experimental strains result from large tensile forces that cause damage to the musculotendinous structure. In a review by Garret,[28] many laboratory studies were identified that were consistent with clinical findings of muscular injury.

Predisposing Factors

Garret[28] suggested three types of muscle that are at possible risk for injury:

Two-joint Muscles. Motion at one joint can place two-joint muscles in a position of increased passive tension. The increased passive tension may lead to an overstretch injury.

Muscles Contracting Eccentrically. Functional activities in exercise require both concentric and eccentric contractions. Muscular strains are considered to result most often from eccentric contrac-

Table 1.—Clinical Manifestations of Exercise-Induced Muscular Injury

Evaluation	Acute Strain	DOMS
History	One specific episode	Unaccustomed/intense exercise
Structures involved	Musculotendinous junction	Muscle and connective tissue
Muscle contractions	Eccentric	Eccentric
Pain	Immediate, localized	Delayed, diffuse, dull ache
Palpation	Point tenderness, ± defect	Point tenderness, no defect
Swelling	±	±
Stretching	Painful	Painful
Weakness	Yes	Yes
Active movement	Painful	Painful

tions[28,32,57,66] because higher specific tensions produced in eccentric exercise lead to myofiber overload injury.[2,58,61] Eccentric contractions are common in the deceleration phase of activity.

Muscles With a Higher Percentage of Type II Fibers. These fast-twitch muscles create greater speed of contraction which may predispose a muscle to injury. Because most of the muscle action involved with running and sprinting is eccentric, muscle strains most often occur in sprinters or "speed athletes."

Arnheim[4] noted that the muscles with the highest incidence of strains in sports are the hamstrings, gastrocnemius, quadriceps, hip flexors, hip adductors, erector spinae, deltoid, and rotator cuff. In addition, he stated that a fault in the reciprocal coordination of the agonist and antagonist muscles may cause muscular strain. Knapic et al[43] reported that flexibility imbalances between agonists and antagonists may predispose athletes to injury. Interestingly, however, the flexible sides were most likely to be injured.

Previously injured muscle may also be more vulnerable to reinjury.[30] Jonhagen et al[41] reported that sprinters with recent hamstring injuries had tighter and weaker hamstrings than uninjured sprinters, although it was not known if this finding was a cause or a result of injury. Inadequate rehabilitation may not restore full strength, flexibility, and endurance to the involved tissues before return to activity. Subsequently, muscle weakness, tightness, and fatigue may predispose muscle to injury.[24,28]

Stretching and warmup before exercise have been advocated to prevent muscular injury[6,60,64] on the assumption that cold or tight muscles[23] might predispose one to muscular strain. Few experimental studies exist supporting these claims. However, inadequate warm-up exercises have been shown to be associated with muscle strains.[37] Increased tissue temperatures of 1°C[53] and 4°C[60] allowed greater elongation of the muscle before failure. Similarly, Noonan et al[50] reported that warm muscles (40°C) were less stiff than cold (25°C) muscles and required greater length to fail, offering experimental data to support warm-up as an aid in injury prevention and enhanced performance.

Mechanism of Injury

Acute muscular strains usually result from a specific event of macrotrauma.[17,30] A strain may involve the muscle itself or adjacent tissue, such as fascia or tendon.[4] The severity of the injury is in direct relation to the forces placed upon the muscle.[45] Mechanically, an acute strain may be caused by an abnormal muscular contraction,[4] a response to high specific tensions,[2] or forcible stretching of a muscle while it is active.[28] Each of these mechanisms is related to eccentric contraction, in which sufficient tensile forces develop to cause irreversible changes in the structure of the musculotendinous unit.[61]

Prevention of Acute Strains

Prevention of acute muscular strains should begin with adequate preseason screening of flexibility and strength balances in major joints such as the knee, shoulder, and ankle. Evaluation of previous muscle injuries should be performed to assess flexibility, strength, endurance, and proprioception. Preseason and in-season conditioning of muscle groups is also vital for prevention. Adequate agonist/antagonist ratios for strength and flexibility should be attained for major muscle groups, including quadriceps/hamstrings, shoulder internal rotators/external rotators, ankle dorsiflexors/plantarflexors, and abdominals/paraspinals. Muscles must be strengthened in the mode in which they are used functionally; ie, eccentric muscles should be strengthened eccentrically.

Warmup and stretching before activity are thought to prevent muscular strains. Smith[55] offers an excellent review of the literature supporting the efficacy of this practice. Active warmup such as jogging or biking should be performed before specific muscle stretching with emphasis on muscles at risk for strain, including two-joint muscles and those with high percentages of fast-twitch fibers (hamstrings, gastrocnemius, quadriceps, biceps), and muscles with high incidence of strain (hip flexors, hip adductors, erector spinae, rotator cuff). Muscles which contract eccentrically or decelerate in functional high-speed activities, such as the posterior rotator cuff in throwing athletes or the hamstrings in sprinters should be stretched for 15 to 20 seconds[6,8,62] and repeated four times.[62] Static stretching in combination with passive heating may be more effective than passive heating alone.[38]

Structural Changes

The most vulnerable site for an indirect strain injury is just distal to the musculotendinous junction or the tendon-bone junction[5,28–31,61]; therefore, knowledge of musculoskeletal surface anatomy and palpation skill is important. Pain, swelling, deformity, and point tenderness may be localized over the musculotendinous junction immediately after injury. Tendons themselves are very resilient to injury and are rarely injured acutely. Tendons will pull away from a bone, a bone will break, or a muscle will tear before tendons are injured.[4] However, in contrast to the musculotendinous junction, tendons are more susceptible to microtrauma.[30]

A muscle strain may be partial or complete, depending on the amount and degree of fiber disruption within the muscle.[28] Strains can be classified by three degrees: first degree, a minute separation of muscle fibers; second degree, partial tearing of some fibers; and third degree, a complete rupture or tendinous avulsion. While full-thickness tears do occur, partial or incomplete tears or strains are more common[30] and are clinically characterized by focal pain and swelling.[28] A palpable defect such as a bulge or gap in the muscle may be found in a complete or partial tear. Disruptions in the fibers cause biochemical changes both from direct injury to the fibers and from the inflammatory reaction.

Biochemical Changes

Serum creatine kinase (CK) and lactate dehydrogenase (LDH) enzyme levels are used to indirectly assess muscle damage following eccentric exercise.[1,2,12,14–16,26,47,48,54,58] In addition to the release of these biochemical markers, all acute strains undergo similar inflammatory reactions. Acute inflammation is the fundamental reaction designed to protect, localize, and remove injurious agents from the body in preparation for healing and repair.[4] Chemical mediators are present in acute muscular strain, as with any inflammation. These include: histamine, serotonin, bradykinin, and prostaglandin.[4] These chemicals increase the capillary membrane permeability, change blood vessel diameter, and stimulate pain receptors. Edema results from an accumulation of proteins and transudate in the interstitial space. This accumulation is a result of increased capillary membrane permeability secondary to the chemical mediators. Therefore, the characteristic swelling, heat, redness, and pain of inflammation are due to biochemical changes[4] caused by the chemical mediators. Nikolaou et al[49] noted an inflammatory reaction and edema at 1 to 2 days after a stretch-induced muscular injury. The acute phase of inflammation lasts up to 3 to 4 days after the initial injury[4] unless the tissue continues to be traumatized, as is commonly seen when injured athletes return to activity too soon or are progressed too rapidly. Proliferation of fibroblasts, increased collagen production, and degradation of mature collagen have an overall weakening effect on the tissue; therefore, efforts to stretch the tissue perpetuate the irritation and progressive limitation,[42] leading to chronic muscle strains.

As the inflammatory phase subsides, repair begins and lasts for 2 to 3 weeks. The repair phase is characterized by capillary growth and fibroblast activity to form immature collagen. This immature collagen is easily injured if overstressed; however, proper growth and alignment can be stimulated with appropriate tensile loading in the line of normal stresses.[42] The final stage of healing is maturation and remodeling of collagen, occurring from 2 to 3 weeks after onset until there is pain-free functional use of the muscle.[42] If the healing fibers are not properly stressed, the fibers adhere to surrounding tissue and form a restricting scar which is resilient to remodeling.

Treatment of Acute Strains

The key to returning any injured athlete to competition safely is to provide an optimal environment for healing and to progress the patient according to: 1) the severity of the injury, 2) the natural healing process of the body, and 3) the response of the tissue to new demands. Treatment goals for any soft-tissue injury must take the natural healing process into consideration. The overall goal is to assist the body with its natural healing process. The body must go through each stage with any soft tissue injury; therefore, the athletic trainer must not return the athlete to activity too soon. Two to three weeks of restricted activity may be a minimum to allow for collagen formation and prevent reinjury in all soft-tissue injuries.

Inflammatory Phase. Effective management of muscular strains begins at the time of injury. Care for acute injuries must be initiated as quickly as possible with rest, ice, compression, and elevation (RICE) for at least 48 hours. Cold slows the inflammatory process and decreases pain and muscle spasm; compression and elevation reduce edema. An ice bag wrapped with an elastic wrap, elevation, and crutches may be used. Rest protects the injured tissue; however, immobilization may be detrimental to healing and the uninjured tissue. As the inflammation subsides, pain-free, passive range of motion (ROM) and gentle joint mobilization should be initiated to maintain soft-tissue and joint integrity. Gentle, pain-free, submaximal isometric muscle sets may be used at multiple angles to maintain strength and keep the developing scar tissue mobile. Aggressive stretching and strengthening is contraindicated. Any increase in pain, swelling, warmth, or redness indicates a proliferation of the inflammatory phase which should be treated only with RICE. Modalities for pain and edema such as electrical stimulation and pulsed ultrasound should be used during both the inflammatory and repair phases.

Repair Phase. The inflammatory and repair phases overlap during the first week after injury. As the inflammation subsides, the athlete may attempt too much activity too soon. This prolongs the inflammatory phase and leads to chronic muscle strain. However, as collagen is laid down, it must be appropriately stressed in the normal lines of tension. This is a critical "turning point" in the treatment of muscle injuries and may be the most important stage for the trainer or therapist in any rehabilitation. Signs of inflammation (pain, swelling, redness, warmth) are used to determine whether the tissues are being overstressed with activity. The rehabilitation program must be constantly evaluated. Frequency, intensity, and duration of exercises are altered to allow for healing and to prevent inflammation for the next 1 to 2 weeks. Cold in the form of cryostretch or cryokinetics (see Ref. 44) may be beneficial initially to allow for pain-free exercise to aid in the formation of the scar tissue. Heat in the form of warm whirlpools, moist heat, or ultrasound is used to promote capillary growth and increase ROM. Contrast baths may be most beneficial during this period. Gentle, pain-free stretching and pain-free submaximal isometrics can be incorporated into contract-relax techniques to help align collagen fibers. These exercises are progressed to active ROM for the agonist. Active or resistive motion of the antagonist or contralateral extremity may also be incorporated. Finally, a cardiovascular conditioning program should be incorporated for any athlete not capable of full athletic participation.

Maturation and Remodeling Phase. As collagen matures, it requires tension in the line of normal stresses to remodel properly. Clinically, this stage presents at about 2 to 3 weeks after injury and is characterized by: 1) the absence of inflammation, 2) full, pain-free ROM, and 3) pain after tissue resistance, which is felt with passive ROM.[42] The athlete is progressed as tolerated with limited participation in his/her sport. Rehabilitation includes more vigorous stretching, closed- and open-chain strengthening, cardiovascular training, and sport-specific activities. It is vital to remember that muscles must be stressed and overloaded in the manner in which they are used functionally, following the principle of specificity. Type of contraction (eccentric vs concentric), metabolism (aerobic vs anaerobic), and functional pattern (diagonal vs cardinal plane) should be specific to the activity in which they are used. Eccentric exercise is functional in most athletic activities, develops greater tension than concentric exercise, and may be more comfortable in the early stages of rehabilitation.[7] Eccentric contraction may be performed against manual, isotonic, isokinetic, or elastic resistance. Massage, aquatic therapy, and plyometrics are beneficial to any soft-tissue treatment. Proprioceptive and endurance training are used in the advanced stages of rehabilitation. Modalities before and after activity may be beneficial as well. An elastic or neoprene wrap with a felt pad directly over the injury site provides warmth and compression. After the athlete has regained full, pain-free active ROM and over 90% strength bilaterally, full participation is allowed. Maintenance programs should be independent and individualized to avoid any dysfunctional adaptation or compensation.

Delayed-Onset Muscle Soreness

DOMS is commonly seen in patients performing new exercises or in athletes involved in weight-lifting or other eccentric activities. DOMS results from muscle damage[2,11,15,26,58] following eccentric exercise. The onset of DOMS is characterized as a dull, aching pain usually beginning 12 to 48 hours after exercise.[2,11,63] Clarkson et al[15] found that soreness peaks 2 to 3 days following eccentric exercise and subsides linearly within 10 days. In addition to pain, other symptoms include decreased motion and decreased force production.[2,14,15,26,48,51,58,65] Newham and associates,[47] however, reported a decreased force production with electrical stimulation of these muscles, indicating that the soreness itself does not inhibit force production.

Muscles adapt to a single bout of eccentric exercise. This is evidenced by less damage to the muscle after the same exercise months later.[15] The muscle is repaired without any residual dysfunction or scarring and the muscle is often able to resist even greater forces.[12,16,61]

Predisposing Factors

Armstrong[1] suggested two possible causative factors during the initial events of DOMS[2,58]: high tensions and metabolic changes.

High Tensions. High tensions produced during eccentric exercise are more apt to produce myofiber injury than isometric or concentric contractions.

Metabolic Changes. Increased temperature, decreased aerobic capacity, and decreased pH of the muscle may have a role in causing DOMS.

Mechanism of Injury

Exercise that results in the development of soreness is associated with the rapid destruction of muscle tissue.[11,26] The soreness usually results from muscle damage following repetitive eccentric exercise or after the first or second session of a new training program.[2,11,15,22,58] DOMS is also associated with muscle spasm, as evidenced by increased EMG activity.[20,21,46,52] DOMS results primarily from structural muscle damage and microtrauma and may be related to the resultant biochemical changes of the inflammatory process.

Prevention of DOMS

Few studies exist on the prevention of DOMS. Because it is known that eccentric contractions cause muscle damage, DOMS may be prevented with warmup and stretching before and after eccentric or novel exercise. Ideally, DOMS is prevented by avoiding eccentric or unaccustomed exercise. Clinically, this is not possible. Athletes in competition, weight lifters, and patients undergoing early rehabilitation commonly perform eccentric exercise. This eccentric training develops strength to resist further damage.[15] Therefore, specific eccentric training is neccesary for any sport activity to help prevent further damage or injury. Eccentric training sessions should be limited to two per week to allow adequate rest and recovery between sessions. Patients should be educated about the importance and need for eccentric exercises, as well as about the possiblity of DOMS.

Effective prevention of DOMS may begin in the acute stages of treatment before symptoms begin. Prophylactic ibuprofen administered before or immediately after heavy eccentric exercise may decrease the pain associated with DOMS.[34] Yackzan et al[65] found that subjects who received ice massage immediately after eccentric exercise had more ROM 24 hours later than those who did not receive it. Further research is needed on the prevention of DOMS, including the roles of warmup, stretching, and immediate treatment after intense eccentric exercise.

Structural Changes

Structural damage to subcellular components following eccentric exercise has been found by microscopic evaluation.[1,3,11,26,40] High specific tensions seen in eccentric contractions could mechanically disrupt the connective tissue, myofilaments, sarcomere, sarcolemma, or sarcoplasmic reticulum.[1,2,9,10] Friden et al[25,26] found alteration of Z-bands in type II fibers both immediately and 3 days after eccentric exercise.

Damage to the extracellular matrix (ECM, the interface between the myofiber and fascia) following eccentric exercise has been evaluated by Stauber and associates.[58,59] Myofiber and ECM damage result directly from eccentric contractions.[27] Stauber et al[59] reported that eccentric muscle action is related to mechanical shearing at the ECM. These structural changes then cause biochemical changes within the injured tissue.

Biochemical Changes

Damage to the sarcolemma and ECM creates an altered chemical environment

Table 2.—Treatment of DOMS

Authors	Treatment	Efficacy
Ciccone et al[13]	Trolamine salicylate phonophoresis	Effective
Denegar et al[18]	TENS	Effective
DeVries[20,21]	Static stretching	Effective
Hasson et al[33]	High speed, voluntary muscle contraction	Effective
Hasson et al[34]	Ibuprofen	Effective
Haynes & Perrin[36]	Topical counterirritant	Effective
Hill & Richardson[39]	Topical trolamine salicylate cream	Effective
Prentice[52]	Static or PNF stretching + cold or heat	Effective
McGlynn et al[46]	Stretching and biofeedback	Reduced EMG, but not pain
Prentice[52]	Heat	Not effective alone
Yaczan et al[65]	Ice massage	Not effective alone
	Continuous ultrasound	Increases pain
Denegar et al[19]	Microcurrent	Not effective, + analgesic effect
Hasson et al[35]	Dexamethasone Iontophoresis	Questionable

within the muscle. The release of proteins and ions into the plasma as a result of inflammation is similar to that found in acute strains.[1,2,59] Increases in these levels indicate damage to the sarcolemma. Elevations of CK, LDH, protein metabolites, and myoglobin have been found in plasma up to 48 hours following eccentric exercise.[2,3,14,54,58,63] These biochemical events occur within the muscle cells themselves and begin approximately 24 hours postexercise,[15] before phagocytic cells enter the injury site.[1] Time-specific clinical events (such as peak soreness at 2 to 3 days) may correspond to the time of increased enzyme levels (such as CK increase at 2 days). While Tiidus[63] reported such a correlation between soreness and enzyme levels, Clarkson et al[15] cautioned against claiming a cause-and-effect relationship based on limited research.

The structural disruption leads to the normal inflammatory response: an increase in chemical mediators such as histamine, bradykinin, prostaglandin, and serotonin,[4] causing pain and swelling. The products of the inflammatory response sensitize free nerve endings in muscle,[11,56] thus increasing soreness. Stauber et al[59] concluded that the DOMS after repeated eccentric muscle action is not because of actual myofiber damage, but more likely results from inflammation.

Treatment of DOMS

Because DOMS results from microtrauma, structural damage in DOMS is not as severe as in acute strains resulting from macrotrauma. The symptoms of DOMS resolve relatively quickly without any residual dysfunction; therefore, DOMS can be treated symptomatically. In any exercise-induced muscular injury, RICE is the ideal immediate treatment to decrease inflammation and pain. However, because DOMS begins at 24 to 48 hours after exercise and peaks at 2 to 3 days after exercise, treatment may not begin immediately after injury.

The goal of treatment of DOMS is to reduce the pain, swelling, inflammation, and muscle spasm. These goals are similar to those in the acute stage of any soft-tissue injury. Several authors have studied the efficacy of these treatments (Table 2). Static or proprioceptive neuromuscular facilitation (PNF) stretching,[20,21,52] high-speed muscular concentrics,[33] nonsteroidal anti-inflammatory drugs (NSAIDs),[34] and topical counterirritants[36,39] have been shown to be effective in reducing pain associated with DOMS. Phonophoresis[13] and transcutaneous electrical nerve stimulation (TENS)[18] may be effective, but the benefits of iontophoresis[35] and biofeedback[46] remain questionable.

Most studies report significant improvement in DOMS with combinations of exercise and modalities. DOMS can be treated symptomatically by reducing the pain, soreness, swelling, and muscle spasm. NSAIDs and topical counterirritants may decrease soreness. Static or PNF stretching in combination with cryotherapy (spray-and-stretch or ice massage) also help to decrease the symptoms of DOMS. In addition, high-speed, rapid concentric muscular contractions may provide relief. Further research is needed on the use of massage, pulsed ultrasound, and electrical stimulation (including TENS, iontophoresis, and microcurrent) in the treatment of DOMS.

Conclusion

Both acute strains and DOMS present similar clinical signs; however, they can be differentiated by history of the injury. While many studies exist on the structural changes and biochemical changes of exercise-induced muscular injury, many questions remain unanswered. The exact changes in human muscle after an acute strain have not been determined. A cause-and-effect relationship for DOMS has not been firmly established. We have reviewed the literature on these acute injuries and provided clinical findings to aid in the care of musculoskeletal injuries. Further research is needed on the causes of these injuries, as well as on effective preventive and treatment techniques to return athletes and patients back to preinjury levels.

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Head and Facial Injuries in Interscholastic Women's Lacrosse

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Abstract: *The purpose of this study was to determine the advisability of protective headgear for interscholastic women playing lacrosse by recording the occurrence of head and facial injuries. During this 3-year study, the head and facial region was the most frequently injured individual area (5.4/100 athletes) of all body structures. The three areas of the head and face that were injured the most were: the head (36%), the eye (23%), and the nose (18%). Being struck by an opponent's stick or the ball were the two most common mechanisms of injury, with contusions (63%), lacerations (14%), and concussions (10%) being the most frequent injuries. Athletes were most often in the act of catching the ball or being stick-checked when the injury occurred to the head and facial area. Twice as many head and facial injuries occurred during game play than practice, with on-goal and midfield play being the most hazardous situations. Over the 3-year study, 75% of the athletes who sustained a head or facial injury were incapacitated for 0 to 1 day. Due to the lack of severity of injuries, we concluded that helmets were not necessary for interscholastic women.*

Women's lacrosse is still played similarly to the original Indian version, using no formal boundaries and no protective headgear.

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Women are not allowed to roughly or recklessly check/tackle another player's crosse or have body-to-body contact.[11] In order to safeguard the players, there is an imaginary bubble around the head in which no stick may enter.[11] With these restrictions on physical contact in the women's game, no protective equipment is currently required, except for a mouthpiece. Despite the seeming lack of contact in women's lacrosse, head and facial injuries do occur.[3–10,14] This raises the question of whether helmets and eye protection should be required.

To date, research on injuries to high school female lacrosse players has been limited and sporadic. Mayer et al[6] and Lapidus et al[5] described case studies of women receiving injuries to the fingers and facial area. The research of Whiteside et al[14] on fractures and refractures in intercollegiate athletics mentioned fractures to women lacrosse players but did not describe the mechanism of injury. Gillette[2] looked at a broad spectrum of female intercollegiate athletic injuries, including lacrosse injuries; however, she did not report the type or severity of injuries or state how long the athletes were incapacitated.

Other studies by Koerner[4] and S. E. Scott (unpublished data, 1990) sampled only one area of the country and had small representation. These two studies registered only head and facial injuries and made no comparisons between the occurrence of head and facial injuries relative to other sites. We believe that, without the comparative data, one cannot state whether or not head and facial injuries are truly common in women's lacrosse. As a result, there is little evidence to support or refute the use of the helmet or other protective head devices at this level.

The purpose of this study was to investigate, on a national level, head and facial injuries occurring to female, interscholastic lacrosse players. The incidence of head and facial injuries relative to other body parts allowed conclusions to be drawn about the need for protective headgear.

Methods

In the spring of 1990, we contacted 400 high schools in the 19 states that offered women's lacrosse on the varsity and/or junior varsity level as a competitive sport. To create the largest sampling size possible, the list was compiled from the United States Women's Lacrosse Association (USWLA) and state coaching directories. We mailed survey packets to the head varsity coach of each identified school. The packets included a cover letter stating the purpose of our 3-year study, a school information sheet to gather information about that school's lacrosse program, instruction sheets for each coach, and injury report forms. If applicable, the coach was instructed to acquire the assistance of the school athletic trainer. To ensure recording accuracy by the coach and or athletic trainer, we provided a definition of terms and conditions.

Reports were returned monthly indicating the number of games, practices, and participants. This enabled us to calculate the number of injuries per 100 athletes and injuries per 1000 exposures. We gathered information at the end of each month on the athletes injured during a varsity or junior varsity game or practice. If data were not received by the end of the month, we sent a letter and initiated a follow-up phone call to the coach or athletic trainer. Any school that was delinquent in reporting after the follow-up was subsequently dropped from the study.

Before distribution of the study, several athletic trainers and lacrosse coaches reviewed the survey instrument for reliability. The instrument was a modified version of the National Collegiate Athletic Association's (NCAA) Individual Injury Form-Lacrosse, with specific changes for the interscholastic level. The

Table 1.—Comparison of Injuries

Location	Injuries/100 Athletes
Head and Face	5.4
Head	2.0
Eye	1.3
Nose	1.0
Cheek	0.5
Mouth	0.4
Jaw	0.18
Teeth	0.06
Ear	0.05
Tongue	0.00
Upper Extremity	2.3
Finger	0.54
Thumb	0.52
Shoulder	0.29
Other	1.0
Lower Extremity	14.0
Ankle	3.5
Knee	1.9
Upper Leg	1.7
Lower Leg	1.4
Other	5.5
Body	0.49
Lower Back	0.22
Stomach	0.12
Ribs	0.11
Other	0.04

injury report form generated the following information regarding head and facial injuries: 1) who was injured, 2) the occurrence of head and facial injuries relative to the rest of the body, 3) the mechanism of injury, 4) when the injuries occurred, and 5) the severity of the injuries based on time lost.

An injury was defined as damage to any part of the body resulting in any time lost from participation. Any player who sustained an injury during a game or practice and returned, even the same day, was recorded for this study. Participation was defined as being able to fully participate in all aspects of the game or practice. For example, an athlete who was able to jog, but could only participate in some of the drills, was not considered to have returned.

Calculations were performed to find significant differences within each question. Answers to questions that had a normal distribution of data were analyzed using an Analysis of Variance (ANOVA) with a Bonferroni post hoc test for specific differences. For the data that were not normally distributed, a Kruskal-Wallis one-way ANOVA with a Dunn's post hoc test for specific difference was used ($p < .05$).

Results

Eighty-five (21%) of contacted schools responded. At the conclusion of the first year, 16 (19%) of initial respondents failed to return injury/practice/game data. The remaining schools (n = 69) submitted all required information sheets. Although the number of participating schools dropped in the second year, the remaining 63 schools representing 15 states and 75% of the original coaches/athletic trainers were involved for the entire 3 years. Forty-three (69%) of the reporters were coaches and the remainder (31%) were athletic trainers.

There was a total of 1383 injuries reported by the 7263 participants, producing an injury rate of 19/100 athletes (3.9/1000 athletic exposures) over the 3-year study. The injuries occurred during 3006 varsity games, 2472 junior varsity games, and 13 117 total practices from both levels.

Fifty-six percent of the total injuries involved the lower extremity, 29% the head and face, 12% the upper extremity, and 2% the trunk (Table1). The combined head and facial area was the most commonly injured individual body part (5.4/100 athletes), followed by the ankle (3.5/100), and the knee (1.9/100). For the purpose of this study, we defined the head as that area above the neck other than the eyes, ears, or face. We defined the eye as the eye orbit, eyebrow, eyelid, and all other structures of the eye proper. There were 398 head and facial injuries over the 3 years, with an exposure rate of 1.1/1000 athletic exposures. The three areas of the head and face that were injured most frequently were: the head itself (2.0/100 athletes), the eye (1.3/100), and the nose (1.0/100), with no significant difference among these. The most common injuries occurring to the head and facial area were: contusions (3.4/100), lacerations (.7/100), and concussions (.5/100), with no significance found.

No grade level had a significantly greater head and facial injury rate; the juniors' rate was 1.7 per 100 athletes; seniors', 1.5; and sophomores', 1.3. Athletes with no playing experience and those with greater than 5 years experience were injured significantly less often than those with 2 to 4 years playing experience. Varsity athletes (3.9/100) sustained significantly more head and facial injuries than junior varsity (1.4/100); ($F(2,4) = 98.406, p = .0004$). There was a significant difference between those athletes who received head and facial injuries during the game (3.5/100) and those who were injured during practice (1.8/100); ($F(1,2) = 293.95, p = .003$). Injuries to the head and facial area were the highest during the second half of a game (2.1/100), followed by the first half of the game (1.3/100), and the second half of practice (.96/100). Offensive players were injured more frequently than defensive players (Table 2).

Being hit by the stick (3.1/100) was the major mechanism of injury for head and facial injuries, followed by the ball (1.9/100), and collision with a competitor (.38/100); ($F(3,6) = 101.53, p = .0001$). The athlete was most often catching a ball (1.3/100) or being stick-checked (1.2/100) when the injury occurred. The two most dangerous situations were on-goal play (2.1/100) and midfield play (1.7/100). Most injuries sustained were minor with only 0 to 1 day lost (4.1/100) being statistically higher than 1 to 2 days lost (.6/100); ($F(2,12) = .026, p < .05$).

Table 2.—Percentage of Total Head and Facial Injuries by Position

Position	#	%
Goalie	5	1.3
Point	19	4.8
Coverpoint	26	6.5
Third Man	28	7.0
Left Def Wing	26	6.5
Right Def Wing	21	5.2
Total Defense	125	31.3
Center	35	8.8
Rt Attack Wing	48	12.0
Lt Attack Wing	30	7.5
Third Home	29	7.3
Second Home	26	6.5
First Home	21	5.2
Total Offense	189	47.3
Non-Positional Drills	84	21.0

Discussion

The most commonly injured areas of the head and face (head = 36%, eye = 23%, and nose = 18%) closely corresponded to Koerner's[4] study, in which she showed the head to be the most commonly injured (32%), followed by the eye (23%), and nose (23%). Contusions amounted to 60% of the injuries to the head, followed by concussions at 26%, and lacerations at 11%. Eye injuries were primarily of two types: contusions (76% of the injuries), and lacerations to the eyebrow (18%). One reported injury to the eye produced nerve damage that affected the athlete's eyelid. A ball struck her in the head and triggered a chronic problem that she had had with the eye. Injuries to the nose were mostly contusions (48%) and fractures (29%).

The injury rate to the head and facial area of 1.1 per 1000 athletic exposures in this study is greater than that which can be projected from Koerner's[4] 1980 study (.76/1000) for the high school player. The head and face injury rate of 5.4/100 athletes was the highest incidence of injury, followed by the ankle (3.5/100), and knee (1.9/100).

As in Koerner's[4] study, a blow by the stick was reported in our study as the most common mechanism of injury for head and facial injuries. Fifty-six percent of the injuries were caused by the stick and 35% were caused by contact with the ball. Contusions (3.4/100), lacerations (.7/100), and concussions (.5/100) were the most common injuries to the head and face. These types of injuries are consistent with the common mechanisms of injuries. Varsity athletes (3.9/100) were injured twice as often as were junior varsity players (1.4/100). These findings are similar to those for other sports and to Koerner's findings.[4,5,13] Offensive players received more injuries (47%) than did the defensive players (31%), with nonpositional drills accounting for the rest (21%). The right attack wing sustained the highest number of head and facial injuries (12.3%) followed by the center (8.8%) (Table 2). These results differ from Koerner's[4] results, which showed that the point had the most injuries to the head and facial area at 12.5% followed by the right attack wing at 11.1%.

As athletic health care providers and instructors of the game, athletic trainers, physicians, and lacrosse coaches must be aware of the impact of rule changes on the game. Injurious situations must be identified and steps taken to safeguard the participants. According to a conversation with the USWLA's Peel Hawthorne (October 1993), the USWLA changed the rule in 1983 that prohibited defensive personnel in the shooting space when an offensive player is about to shoot. The second rule change occurred in 1985 and stated that no defensive person could be in the 8-meter arc for more than 3 seconds.[12] Koerner[4] suggested that the point was most often injured because she was often the last person left to defend against a shot on goal and was injured on the follow-through from a shot.[4] A point player would occasionally position herself as a second goalie during the game and would be in the shooting space. With the rule changes, this situation can no longer occur, and the point player has been injured less often. In our study, the point received only 4.9% of the injuries. The right attack wings and centers may be injured most often because they are usually the best athletes on the field and will most often be handling the ball.

Although the numbers are very small, with .04 athletes injured per game and .01 per practice, the head and facial injury rate is twice as high in a game (3.6/100 athletes) as in practice (1.8/100). Because practices exceeded games by a 2.5:1 ratio (13 117:5478), a higher head and facial injury rate in games is more significant. Results of the study showed that more injuries occurred during the second half of the game than in the first half (2.1/100 vs 1.3/100). As the game progresses, the athlete could become fatigued and lose the ability to safely control the stick.

The length of time that an athlete is out of participation is a common parameter used to describe the severity of an injury. Being unable to fully participate for 0 to 7 days is frequently used as an indicator for a minor injury.[1] In this study, being unable to fully participate for 0 to 1 day represented significantly the highest percentage of all injuries at 75%, while 1 to 2 days lost was 11%. In Koerner's[4] study, 85% of the athletes who sustained an injury returned within 0 to 1 day. No catastrophic or fatal injuries occurred involving the head and facial area in our study over the 3-year period.

Catching the ball and being stick-checked were the most common activities engaged in when a head injury occurred. Most of the catching injuries in a game occurred during midfield play (27%), and on-goal play (13%). Typically, during midfield play, the athletes are widely dispersed and passes can be longer than a closer spaced on-goal play. A long pass may cause a head or facial injury due to poor judgement of the incoming ball by the athlete or because of the tight meshed pocket of the women's stick, which might enable the ball to bounce out of the pocket and hit the player in the face. In Koerner's[4] study, being stick-checked (49%) and catching (21%) injuries were the two most common activities on all three levels of play (interscholastic, collegiate, and national).

On-goal play (39%) and midfield play (31%) accounted for the majority of head injuries. Similarly, Koerner[4] found that 45% of the injuries occurred during the on-goal play, whereas midfield play accounted for 28% of the head and facial injuries. During on-goal play, more athletes are confined to a smaller area and this precipitates the occurrence of injuries.

Conclusions

Women's lacrosse depends upon its rules and style of play to help ensure safety. In order to safeguard the players, there is an imaginary bubble around the head in which no stick may enter. In this 3-year study, the injury rate for the head and facial area was the highest of all parts of the body, with 5.4/100 athletes sustaining a recorded injury. However, due to the lack of severity of injuries, with 86% of athletes who sustained an injury to the head and facial area returning to full involvement within 2 days, we conclude that additional protective equipment such as helmets is unnecessary in the present form of the women's game.

Although there were no catastrophic injuries to the eye, serious eye injuries have occurred.[3,5] Eye protectors are not

required, but are presently accepted by USWLA's guidelines and because of the potentially permanent impact of eye injuries, we recommend their universal implementation.

Although the evidence does not support the need for helmets, athletic trainers and lacrosse coaches must nevertheless concern themselves with those field activities and mechanisms of injury that can result in head and facial injuries. Catching a ball, especially during midfield play situations, and lack of stick control were two of the main causes of head and facial injuries. Those charged with instruction and safety must develop drills that will enable players to control the stick on defense as well as develop their ability to control the ball in midfield and on-goal play.

At present, few women's lacrosse teams require the use of helmets. Further investigation is currently underway by the authors to record the occurrence of injuries over a 3-year period in those programs that require helmets.

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Suprascapular Neuropathy in a Collegiate Pitcher

Andrew N. Smith, MS, ATC

Abstract: *A healthy, 20-year-old, highly competitive collegiate baseball pitcher developed vague pain and soreness in the dominant posterior shoulder with live pitching. The symptoms intensified, and, after a particularly poor starting performance, the athlete presented for physical examination. Examination revealed visible atrophy of the infraspinatus muscle and decreased strength in external rotation and abduction. Magnetic Resonance Imaging was inconclusive. Electromyographic examination revealed decreased suprascapular nerve conduction to the infraspinatus muscle. Our diagnosis was entrapment neuropathy from traction on the suprascapular nerve at the spinoglenoid notch, causing delayed conduction to the infraspinatus muscle. We took a conservative approach of shoulder rehabilitation and activity modification, which resulted in the athlete returning to a highly competitive level without further problems, despite the remaining atrophy and muscle weakness. Examination of injuries to the shoulder complex, especially in athletes involved in repetitive overhead motions, should take suprascapular neuropathy into consideration.*

Chronic injuries to the throwing shoulder in baseball players are common at all levels of the game. These injuries can result from extreme shearing forces acting upon the rotator cuff muscles as they stabilize and decelerate the joint, while the larger external muscles produce arm speed and motion. Neuropathies to the shoulder are rare and are often difficult to diagnose because of the subtle and slowly progressing signs and symptoms related to these injuries, but they need to be considered in the differential diagnosis of shoulder injuries. Ringel et al[12] state that muscle atrophy and pain may be secondary to suprascapular neuropathy. This neuropathy in the throwing athlete can be a debilitating and activity-limiting injury. It is often underrecognized and in many cases may be treated conservatively[2] through rehabilitation, activity modification, and rest. This case report is interesting, due to the patient's ability to excel upon return to a high level of competition despite remaining external rotation weakness and infraspinatus atrophy.

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Case Report

A 20-year-old white male, third-year collegiate baseball starting pitcher, presented with vague pain and soreness in the posterior aspect of his left throwing shoulder. Unusual weakness and poorer-than-usual pitch control, velocity, and overall performance were his chief complaints. After an uncharacteristically poor pitching performance, he presented for physical examination. Detailed history revealed no specific trauma to the neck or shoulder, but he had been treated for rotator cuff tendinitis with rest, ice after pitching, stretching, ultrasound, and nonsteroidal anti-inflammatory drugs (NSAIDs) approximately 1 month earlier. His condition, in his opinion, had not completely dissipated but had not worsened. Physical examination revealed nonspecific soreness over the superior-lateral portion of the scapula with a large, visible, and palpable gap covering the entire infraspinatus fossa. Bilateral muscle testing revealed fair shoulder abduction and external rotation in adduction and 90° of abduction according to Hoppenfeld's[7] muscle gradations. Other shoulder range-of-motion and muscle testing were normal. Scapular Winging, Reflex, and Drop Arm tests[7] were unremarkable.

Magnetic Resonance Imaging (MRI) was ordered by our orthopedic consultant, followed by electromyography (EMG) testing. The MRI was unremarkable, ruling out trauma (including tendinitis), ganglionic cyst, or other foreign body irritation of the suprascapular nerve. The EMG testing revealed decreased nerve conduction to the infraspinatus muscle with normal supraspinatus and surrounding muscle innervation. The diagnosis was suprascapular entrapment neuropathy, causing infraspinatus muscle atrophy resulting from irritation from traction on the nerve at the spinoglenoid notch. The athlete was prescribed NSAIDs and it was recommended that he discontinue midweek pitching, but be allowed to pitch one game in each of the remaining 3 weekends. A previously implemented shoulder rehabilitation program was altered to emphasize the posterior musculature which externally rotate the arm and act as decelerators in overhead throwing.

After the season, the athlete performed these exercises one or two times daily, completing approximately 25 repetitions with 2- or 3-lb dumbbells. In his final collegiate season, he continued the rehabilitation protocol and was able to pitch at a highly competitive level without complication, culminating with the opportunity to compete at the international level. He was able to excel at this level despite the presence of (although improved) strength deficits in external rotation and remaining infraspinatus atrophy.

Discussion

Suprascapular neuropathy is a well-documented,[3–6,8,9,11–15] yet rare and often misdiagnosed, injury to the shoulder complex in athletes. The lesion is generally attributed to entrapment of the nerve at the suprascapular notch, which may be caused by abnormal configuration of the notch or neuroplasia.[4,5] The neuropathy is associated with marked atrophy of the supraspinatus and infraspinatus muscles, with vague, localized pain and loss of strength in abduction and external rotation with abnormal scapulohumeral mechanics.[4,8,9] Atrophy of the supraspinatus muscle, with its trapezius muscle covering, is not as easily detectable as in the infraspinatus. The nerve may also be compressed at the spinoglenoid notch with concomitant denervation and atrophy of only the infraspinatus muscle.[9]

The most common cause of the injury is direct trauma, such as contusion or scapular fracture, but ganglionic cysts, penetrating injury, inflammation, or prolonged muscular exercise alone may also contribute to the injury.[1,6,8,11–13] Prolonged backpack use has even been reported as a cause.[9] Certain extremes of the scapular motion can render the nerve taut, kinking it over the edge of the foramen, causing a "sling effect."[6,11] This mechanism helps explain how inflammation of the nerve combined with certain forceful muscular contractions can cause injury.[14] This effect can be amplified in athletics with the added stress placed on the shoulder complex when a ball or racket is involved. Maximum abduction and external rotation in overhead activities, with the simultaneous eccentric contraction of the infraspinatus acting as a decelerator on the movement of the scapula, increases the distance between the points of origin and termination of the nerve. In baseball pitching, the extreme angular velocities and torque generated during cocking, acceleration, and release may subject the suprascapular nerve and artery to rapid stretching, which may cause axonotmesis even if there is no complete entrapment of the nerve.[12] It seems that this rapid and repetitive stretching may kink or "sling" the nerve at either the suprascapular or spinoglenoid notches, causing decrease innervation distal to the respective anatomic landmark.[1,8,11,12]

Anatomy

The suprascapular nerve (Fig 1) is a mixed sensory and motor nerve[1] which derives from the upper trunk of the brachial plexus formed by the roots of C5 and C6 at Erb's Point. The nerve passes inferiorly, usually behind the brachial plexus and parallel to the omohyoid muscle beneath the trapezius.[11,13] The nerve descends down to the superior border of the scapula, passing the notch below the transverse scapular (or suprascapular) ligament where the suprascapular artery and vein course above.[3] It passes

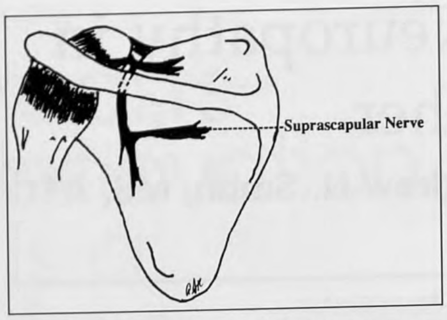

Fig 1.—The course of the suprascapular nerve along the posterior scapula.

through the suprascapular notch where it is relatively fixed to the floor of the fossa and enters the suprascapular fossa.[16] The suprascapular notch may assume a deep and narrow or shallow and wide shape.[11] Motor fibers of the nerve branch to the supraspinatus muscle with articular filaments running to the glenohumeral and acromioclavicular joints. Sensory and sympathetic fibers innervate two thirds of the shoulder capsule.[5,6,11,13] The nerve completes its course as it curves around the lateral border of the spine of the scapula, the spinoglenoid notch, and enters the infraspinatus fossa, where it typically breaks off into two motor branches which supply the infraspinatus muscle.

Diagnosis

The chief complaint of patients with suprascapular neuropathy is deep and diffuse pain, most often localized to the posterior and lateral aspects of the shoulder, but also may be localized into the arm, neck, and upper anterior chest wall.[11] Appreciation of pain of the posterior shoulder and scapula appears to be caused by compression of the afferent fibers of the nerve.[1] Occasionally, the patient may complain of burning, aching, or crushing pain with certain scapular motions.[11]

A detailed history is an important part of diagnosis. History should include questioning regarding 1) past or recent trauma; 2) when pain or soreness began; when it occurs after or during activity, night pain; 3) severity and location of pain, referred pain; and 4) feeling and sense of weakness and with which activities symptoms occur.

Physical examination may reveal suprascapular notch tenderness upon palpation and weakness with manual muscle testing in shoulder abduction,

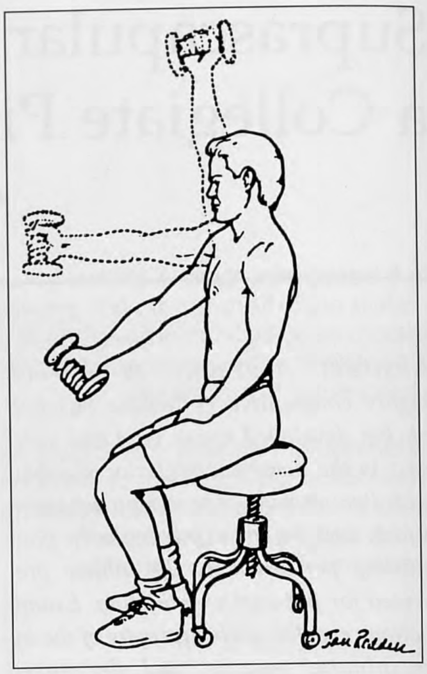

Fig 2.—Shoulder flexion.

scaption (shoulder abduction from 0° to 90° at 45° of horizontal flexion) with arm internally rotated, and external rotation in adduction and abduction when compared bilaterally. Visible and palpable atrophy of the infraspinatus and supraspinatus may also be present. A diagnosis of suprascapular neuropathy is made by exclusion and is based on abnormal EMG findings.[3,4,8,11,12]

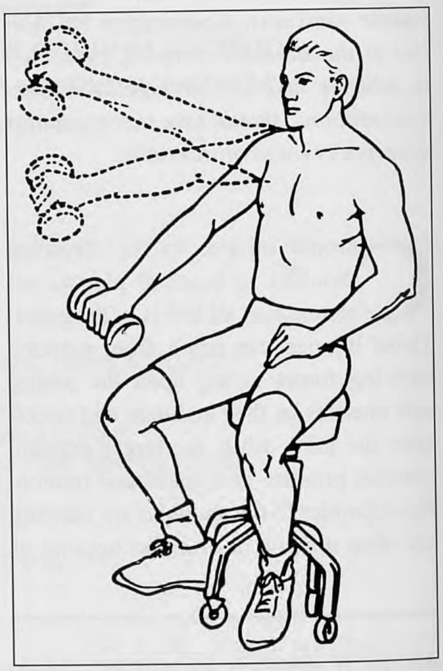

Fig 3.—Scaption with shoulder internally rotated (thumb down).

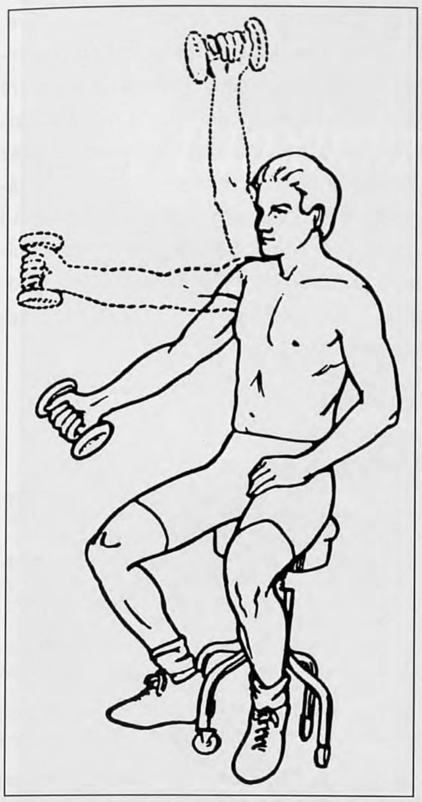

Fig 4.—Scaption with shoulder externally rotated (thumb up).

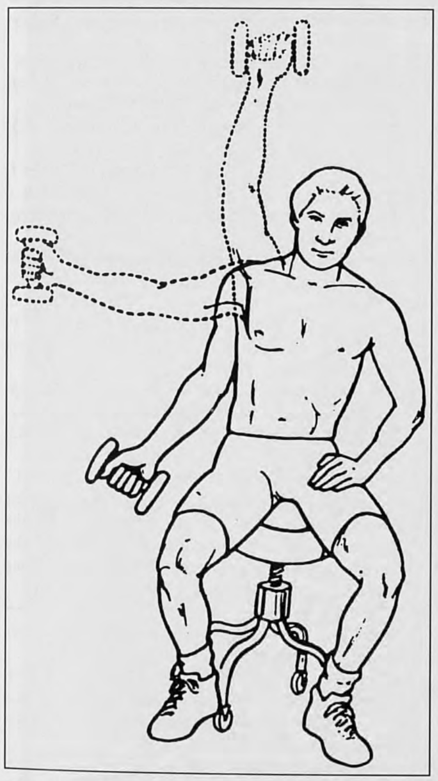

Fig 5.—Abduction with shoulder externally rotated (thumb up); also completed in internal rotation (thumb down), not pictured.

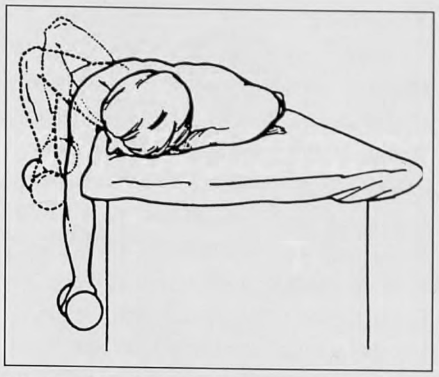

Fig 6.—Prone rowing.

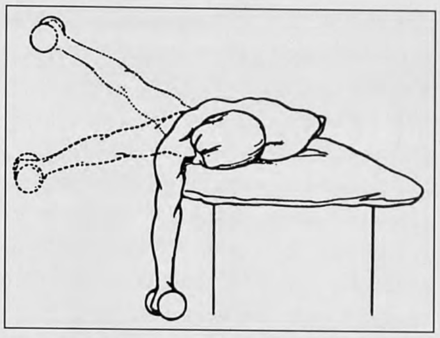

Fig 7.—Horizontal extension with shoulder internally rotated (thumb down).

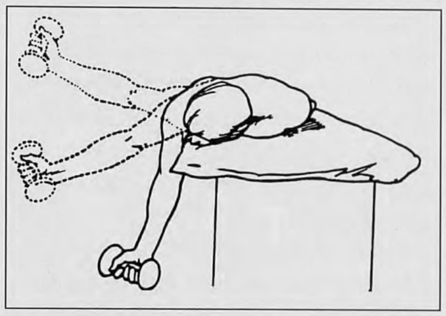

Fig 8.—Horizontal extension with shoulder externally rotated (thumb up).

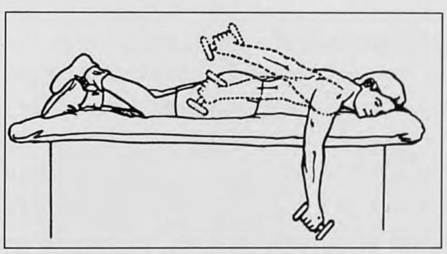

Fig 9.—Prone shoulder extension.

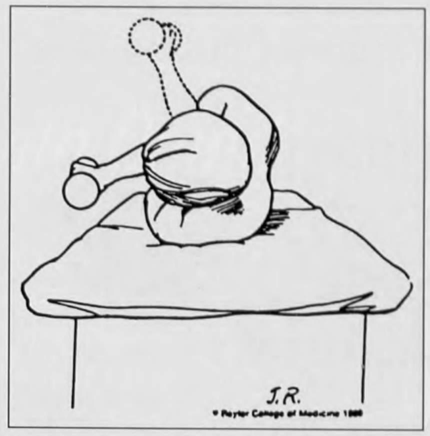

Fig 10.—External rotation with shoulder adducted.

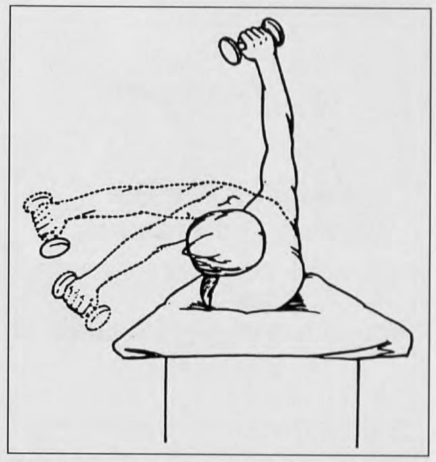

Fig 11.—Deceleration,eccentric horizontal extension.

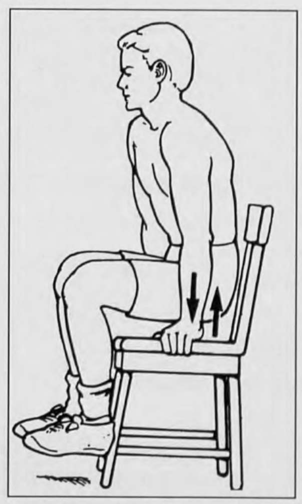

Fig 12.—Seated press-up.

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Treatment

Treatment of suprascapular neuropathy in an athlete consists of conservative rehabilitation and activity modification. Rehabilitation protocols should consist of daily isotonic shoulder exercises emphasizing slow, controlled movements producing an eccentric or decelerating type of muscle contraction.[16] Shoulder flexion (Fig 2), scaption with shoulder internal and external rotation (Figs 3 and 4), abduction with shoulder internal and external rotation (Fig 5), prone rowing (Fig 6), horizontal extension with shoulder internal and external rotation and elbow extended (Figs 7 and 8), prone shoulder extension (Fig 9), external rotation in adduction (Fig 10), deceleration (eccentric horizontal extension) (Fig 11) and seated press-ups (Fig 12) are the exercises to be emphasized.[10,17] Each exercise should use a 2- or 3-lb dumbbell and gradually increase repetitions. Further rehabilitation should consist of simulating the athlete's specific activity (deceleration in baseball), overall shoulder strengthening, and cardiovascular maintenance.

Treatment may also consist of electrical muscle stimulation, cervical traction or collar, and injection. Activity modification is important in attempting to dissipate the cause of inflammation. Surgical release of the suprascapular ligament, with optional enlargement of the scapular notch, is often recommended to those patients with positive EMG findings, including delayed nerve conduction,[11] who have attempted the conservative approach. Treatment choices must take into account the future activity plans of the patient as well as the severity of muscle weakness and daily activity modification.

Conclusion

Suprascapular neuropathy can be a debilitating and aggravating injury, especially in a high-level athlete. Definitive-diagnosis can only be made through EMG testing. Suprascapular neuropathy should be considered and included in the differential diagnosis of ill-defined shoulder pain, especially in athletes involved in activities requiring repetitive, extreme shoulder motions. Shoulder rehabilitation and activity modification are the initial treatments of choice for this ailment. This case report presents a case in which the athlete was able to rehabilitate the throwing shoulder and strengthen the surrounding musculature enough to substitute for the atrophied infraspinatus and return to a previous high level of activity.

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The Effect of a Toe Cap and Bias on Perceived Pain During Cold Water Immersion

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P. Scott Olmstead, BS, ATC
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Abstract: *Cold water immersion is an integral part of acute injury care. Despite tremendous success, the treatment causes discomfort, which may result in noncompliance. Two variables, including use of a neoprene toe cap and prior knowledge of the perceived sensations of pain gained through a therapeutic modalities class, were examined for their effects on the perception of cold. Thirty-four subjects were recruited and underwent two 21-minute cold water immersion treatments (14°C). During this time, each subject completed a McGill Pain Questionnaire every 3 minutes. The results from the questionnaire were analyzed using a Stepwise Discriminant Analysis Function with factored categories undergoing multivariate analysis. Factors distinguishing between the perceptions of cold for both variables were identified. The toe cap does reduce pain sensation during cold immersion. Taking a therapeutic modalities class resulted in a higher perception of the sensory component of pain. Those who had not taken such a class tended to score higher in responses to the affective pain component and the categories that represented a combination of pain components. By providing athletes with a greater understanding of perceived pain associated with cold treatments, compliance with treatments should be greater.*

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Cold water immersion is an integral part of athletic injury care.[1,4,6] This modality is successful in reducing pain,[1,4] allows early motion,[4] and reduces inflammation.[1,4] Despite the effectiveness of cold therapy, it is uncomfortable.

What sensations occur during cold applications? The sensations of "pain, numbness, or throbbing,"[7] "numb, stinging, and freezing,"[3] "cold, burning, aching, and analgesia"[1,2,6,8] have all been reported. The toes have been the area of most reported discomfort.[1,2,6]

Attempts have been made to reduce the unpleasant sensations associated with cold. Nimchick and Knight[7] reported that perceived pain was reduced when subjects wore a toe cap. They also reported a less superficial temperature drop in those body parts covered by the toe cap.[7]

In addition to the use of the toe cap, we believe that prior knowledge of treatment sensations may alter perceptions of cold/pain. The purpose of this study was to determine whether the use of a toe cap and/or prior expectations of cold sensation affected the pain associated with cold water immersion. This was accomplished by comparing responses on the McGill Pain Questionnaire (MPQ) as follows: 1) to cold water immersion while wearing or not wearing a toe cap, and 2) from subjects who had taken a therapeutic modalities class and from those who had not.

Methods

Thirty-four volunteers (19 men and 15 women) were selected from the student body of Southern Connecticut State University. Nineteen of the students (10 men and 9 women) had taken a therapeutic modalities class, and 15 had not. This provided a sample of individuals who had previous expectations of perceived pain involving cold water immersion. All subjects signed an informed consent document in compliance with university policy. We excluded potential subjects from the study if they had a history of cold-induced problems such as Raynaud's Syndrome. We also excluded subjects who were hypersensitive to cold, neoprene glue, and/or nylon. Subjects were allowed to withdraw at any time without prejudice or penalty.

We used a version of the MPQ modified by Ingersoll and Mangus[4] to measure cold-induced pain (Table 1). We scored the questionnaire by coding each category and response after the subject completed it. This was done to permit statistical analysis of the data. For example, in the first response category (Table 1), there were six possible choices, numbered 1 through 6. If "pulsing" was selected, it was given a score of 3. Zero represented no response. Instructions were standardized and given by one of us. During testing, at least one male and one female researcher was present in the room. This was done to prevent subject/tester interaction based on gender.

A standard metal whirlpool was filled with 14 ± 1°C water.[6] The agitator was not used. We established this temperature by adding ice to the water before testing each subject. We did not maintain water temperature during the testing procedure, in order to simulate a therapy session. We used a PRO 14 Digit Cover

Table 1.—The McGill Pain Questionnaire*

1.	Flickering Quivering Pulsing Throbbing Beating Pounding
2.	Jumping Flashing Shooting
3.	Prickling Boring Drilling Stabbing
4.	Sharp Cutting Lacerating
‡§5.	Pinching Pressing Gnawing Cramping Crushing
6.	Tugging Pulling Wrenching
§‡7.	Hot Burning Scalding Searing
§‡8.	Tingling Itchy Smarting Stinging
9.	Dull Sore Hurting Aching Heavy
10.	Tender Taunt Rasping
§11.	Tiring Exhausting
12.	Sickening Suffocating
13.	Fearful Frightful Terrifying
‡14.	Punishing Grueling Cruel Vicious Killing
15.	Wretched Blinding
16.	Annoying Troublesome Miserable Intense Unbearable
§17.	Spreading Radiating Penetrating Piercing
§‡18.	Tight Numb Drawing Squeezing Tearing
§‡19.	Cool Cold Freezing
20.	Nagging Nauseating Agonizing Dreadful Torturing

* Categories 1 to 10 represent sensory components of pain, categories 11 to 15 represent affective components of pain, category 16 represents intensity of pain, and categories 17 to 20 represent a combination of the above components.
‡ Selected by Stepwise Discriminant for Toe Cap Condition.
§ Selected by Stepwise Discriminant for Modality Class Condition.

(Pro Orthopedic Devices, Inc, Tucson, AZ) according to manufacturer's instructions. The toe cap was turned inside out, the sewn end placed up against the toes and the toe cap drawn up and around the foot. The rubber surface was next to the skin.

We tested each subject with and without the Pro 14 Digit Cover. The order of testing was randomized by means of a coin flip. Each odd-numbered subject was assigned a testing order by a coin flip, the next subject being placed into the opposite group. As a result, half of the subjects wore the toe cap in the morning and half in the afternoon. Each subject completed a morning and an afternoon session separated by a minimum of 2 hours. Each subject submerged the right ankle 9 inches into the water in an attempt to standardize the depth of immersion.

All subjects began responding to the questionnaire after 30 seconds of immersion. Each subject completed the questionnaire every 3 minutes during the 21-minute treatment session. This provided eight response sheets for each subject during that particular immersion period. Afterwards the subjects were allowed to dry off and leave until they returned for their second session. During the second session, they underwent the same procedure except for the toe cap condition. They were requested not to divulge what they felt to other subjects, in order to prevent bias. For the purpose of analysis, the responses for each of the eight completed score sheets were added together for each subject. This provided a total of eight responses for each of the 20 categories of the MPQ.

A stepwise discriminant function was applied to identify which of the 20 categories of the MPQ best differentiated among the two variables. Although several of the categories of the MPQ may be applied to the sensations associated with cold water immersion, it can be expected that certain MPQ categories are not applicable. The stepwise discriminant function is best able to determine which of the categories are most appropriate in differentiating among the two variable conditions (toe cap versus no toe cap, and therapeutic modality class students versus no therapeutic modalities class). In determining the most appropriate categories, we were able to reduce the 20 categories to a total of 9 categories for the two variables.

Finally, we performed a multivariate analysis of variation (MANOVA) on those categories identified by the stepwise discriminant function. This further reduced the number of MPQ categories, as those which did not show significant differences were not considered in the final analysis. The means and standard deviations were then reported for those categories that showed significant differences in order to compare the responses among the conditions.

Results

During analysis for the toe cap versus no toe cap conditions, the stepwise discriminant function factored out categories 5, 7, 8, 14, 17, 18, and 19. All but categories 5 and 17 were significantly lower for the toe cap condition (Fig 1, Table 2). The selected categories represent the sensory pain component (categories 7, 8) and the affective component (category 14).

Stepwise discriminant function factored out categories 4, 5, 7, 8, 11, 18, and 19 as significant during the analysis of the therapeutic modality class students versus those students who had not taken a modalities class. Multivariate analysis on the factored questions yielded significant differences for categories 4, 5, and 11 (Table 3). The means varied according to the category (Fig 2).

While not wearing a toe cap, the subjects were more likely to have a greater sensation of ''heat'' and a more ''punishing'' experience and report that the treatment was ''itchy'' and ''smarting.'' These last sensations were replaced by a milder ''tingling'' if the toe cap was applied. Categories 18 and 19 represent combinations of pain components and were found to be significant. The toe cap

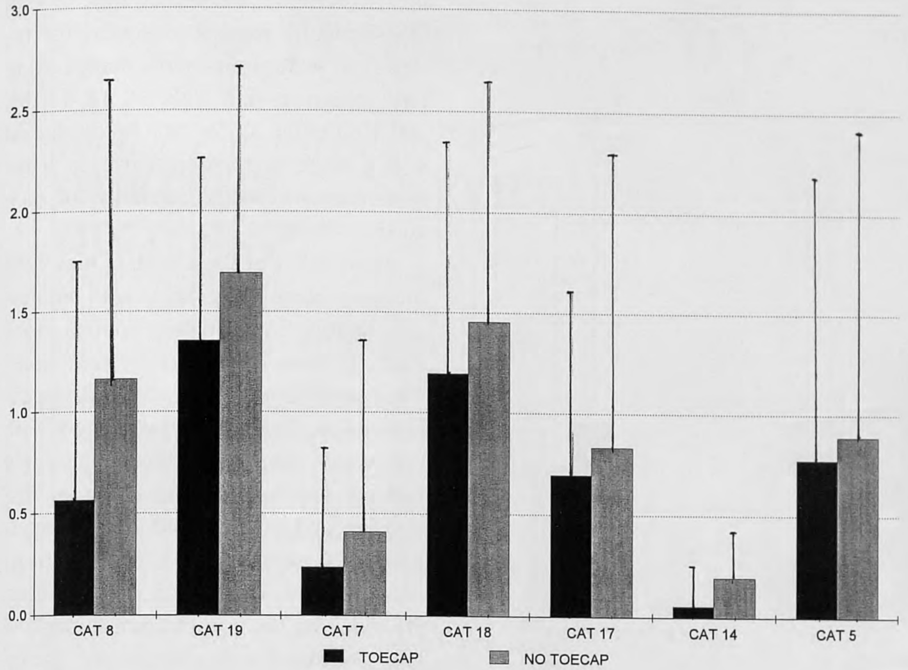

Fig 1.—Means of categories for the Toe Cap (TC) versus No Toe Cap (NTC) conditions in order of selection by the stepwise discriminant function (categories described in Table 1; *y* axis represents means of coding scale for selected category).

Table 2.—MANOVA Table for Categories Factored Out by the Stepwise Discriminant Function for the Toe Cap Versus No Toe Cap Condition in Order of Selection

Dependent Variable	Sum of Squares	Mean Square	F Value	*p*
Category 8	48.8	48.8	26.8	.0001
Category 19	15.5	15.5	15.6	.0001
Category 7	4.1	4.1	7.0	.009
Category 18	9.0	9.0	6.4	.01
Category 17	2.5	2.5	1.5	.23
Category 14	2.7	2.7	10.1	.002
Category 5	1.8	1.8	0.9	.35

df = 1

Table 3.—MANOVA Table for Categories Factored Out by the Stepwise Discriminant Function for the Modality Versus No Modality Class Condition in Order of Selection

Dependent Variable	Sum of Squares	Mean Square	F Value	*p*
Category 4	2.6	2.6	9.1	.003
Category 19	1.2	1.2	1.2	.28
Category 5	16.4	16.4	8.2	.004
Category 18	.3	.3	0.2	.65
Category 7	.04	.04	0.1	.8
Category 11	.5	.5	4.8	.038
Category 8	6.7	6.7	3.5	.06

df = 1

group experienced a less "cold" sensation and tended to feel more of a "tightness" than "numbness" compared to the no toe cap condition. The means for each question were lower for the toe cap condition.

Discussion

One's perception of pain is difficult to express. Most people have their own definition of pain and even researchers find it hard to delineate. The McGill Pain Questionnaire was broken down into types of pain. The first 10 categories involve the sensory components of pain including pressure, thermal, and spatial. The affective components of pain, evaluated with categories 11 through 15, represent anxiety and/or autonomic properties of pain. Category 16 represents an overall score of the intensity felt during pain, and categories 17 through 20 consist of terms representative of a combination of pain components.[5]

The results of our study support the work of Tovell,[9] and Nimchick and Knight,[7] who previously noted that a neoprene toe cap is effective in abating pain elicited during cold water immersion of 1°C. Prior knowledge of the sensations expected with cold immersion by those subjects who had taken a therapeutic modality class played an important role in the responses to the MPQ. These subjects may be expected to have a bias on the sensations experienced during cold therapy. In class, students are taught the four sensations that an athlete will experience with cold water immersion including pain, warming, aching or numbing, and then numbness.

During the analysis of prior knowledge on perceived pain, the stepwise discriminant function factored out seven categories, three of which (4, 5, and 11) were significantly different between the groups. It seems that subjects' knowledge of the pending treatment results in more discomfort in the sensory component of pain, as indicated by the reported higher feelings of "sharpness" and "pinching" compared to those subjects who did not possess this information. This was further supported by higher means for the students taking a modalities class. The categories examining the sensory component of pain (categories 7 and 8) were not statistically significant but were factored out by the stepwise discriminant function. Category 11, representing the affective component of pain, elicited higher mean scores for the no therapeutic modalities class subject group, resulting in a more "tiring" ex-

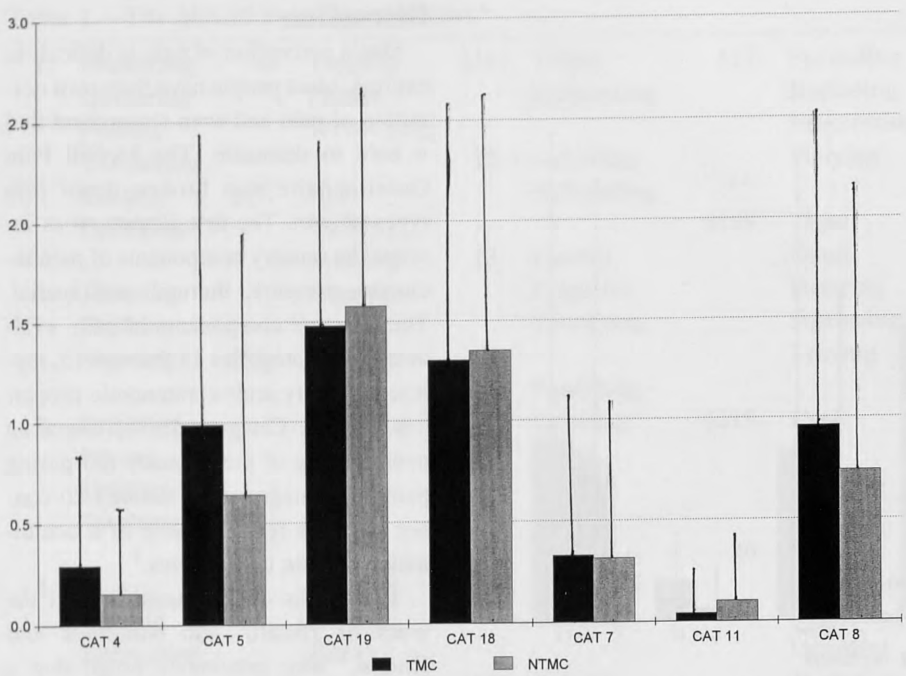

Fig 2.—Means of categories comparing those students who have taken a modalities class (TMC) and those who have not (NTMC), in order of selection by the stepwise discriminant function (categories described in Table 1; *y* axis represents means of coding scale for selected category).

perience. This indicates that those individuals experiencing cold water immersion for the first time exhibit greater apprehension and have more fear of the unknown.

Our results indicate that there are factors that can alter pain sensations during cold water immersion. We believe that the toe cap is effective in reducing much of the sensation and pain associated with cold treatment. Therefore, the use of this simple device may result in improved treatment compliance. It does seem that knowledge of expected sensations from cold application increases the sensation of pain felt during treatment, but appears to reduce some affective responses to pain. We believe that more research is necessary to determine which is more important regarding cold water immersion for the first-time patient. A possible research direction may be to determine whether it is better to keep treatment information to a minimum but to risk increased affective pain; or to disclose the information and risk increased sensation of pain, but thereby reduce the affective or anxiety component.

Another consideration is the use of the McGill Pain Questionnaire itself. Due to the limited number of categories identified by the stepwise discriminant function, it appears that several categories of the MPQ do not apply during cold water immersion and may be unnecessary. Perhaps a modified McGill Pain Questionnaire using selected categories from the main instrument can be designed for cold studies. Of the 20 present categories, only 5, 7, 8, 18, and 19 were factored out by the stepwise discriminant function for both variables (Table 1). In addition, categories 4, 11, 14, and 17 were factored out in only one of the variables. Categories 1, 2, 3, 6, 9, 10, 12, 13, 15, and 16 were not factored out via the stepwise discriminant function for either of the two variables. Despite a difference in water temperature, Ingersoll and Mangus[3] identified most of the same categories, although category 3 was selected in their study at a single time interval (6 minutes). Therefore, a modified McGill Pain Questionnaire may be designed for future cold water immersion studies using only categories 4, 5, 7, 8, 11, 14, 17, 18, and 19. Further study must be conducted with a much larger subject size, to determine the validity and reliability of such an instrument.

Application of these results may help increase compliance with cold immersion therapy by providing options to reduce the associated negative sensations. The neoprene rubber toe cap does appear to reduce discomfort associated with cold water immersion. Informing injured athletes does have an impact on the discomfort and tends to reduce the apprehension associated with a first-time treatment, but also increases pain sensations. By reducing the negative sensations and pain associated with cold therapy, the injured athlete may be more likely to complete prescribed treatments. As a result, the athlete may return to full health and be able to play sooner.

Acknowledgments

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Prediction of Academic Achievement in an NATA-Approved Graduate Athletic Training Education Program

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Abstract: *The purpose of this investigation was to determine which information used in the applicant selection process would best predict the final grade point average of students in a National Athletic Trainers Association (NATA) graduate athletic training education program. The criterion variable used was the graduate grade-point average (GPAg) calculated at the completion of the program of study. The predictor variables included: 1) Graduate Record Examination-Quantitative (GRE-Q) scores; and 2) Graduate Record Examination-Verbal (GRE-V) scores, 3) preadmission grade point average (GPAp), 4) total athletic training hours (hours), and 5) curriculum or internship undergraduate athletic training education (program). Data from 55 graduate athletic training students during a 5-year period were evaluated. Stepwise multiple regression analysis indicated that GPAp was a significant predictor of GPAg, accounting for 34% of the variance. GRE-Q, GRE-V, hours, and program did not significantly contribute individually or in combination to the prediction of GPAg. The results of this investigation suggest that, of the variables examined, GPAp is the best predictor of academic success in an NATA-approved graduate athletic training education program.*

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Graduate education, once considered an exception in athletic training, now is becoming the rule for success for the entry-level athletic trainer. Although there are many avenues through which an athletic trainer may pursue graduate education, only 13 NATA-approved graduate athletic training education programs currently exist. There are also non-approved graduate athletic training-related programs that provide excellent graduate education for athletic trainers.

For each seat available in these graduate programs, program directors often receive five or more times the number of applicants. To select from those qualified candidates, program directors must determine how to predict the potential success of applicants. Although most universities and colleges have specific criteria for admission, a program director often is faced with the final determination of qualified individuals with very similar credentials and abilities from an applicant pool.

The selection of admission criteria that best predict academic success is an important precursor to the applicant selection process. Several investigators have examined the effectiveness of admission criteria to predict the academic performance of allied health students.[1,2,4,8,9] Some of the predictors studied were: preprofessional grade point average (GPA), science GPA, standardized test scores, written composition scores, recommendations, and interview scores.

The basic goal of athletic training education is to produce competent, entry-level practitioners. To attain this goal, students must first successfully complete academic requirements. Previous academic achievement has been shown to be a good predictor of academic success in graduate business students,[10] allied health students,[9] and physical therapy students.[1,2,8] However, there are no published reports of prediction of academic success in athletic training education.

Our investigation attempted to determine which specific criteria used in the applicant selection processes would best predict the final grade point average of students in an NATA-approved graduate athletic training education program.

Methods

Subjects were 55 students (32 men and 23 women) enrolled in the graduate athletic training program at the University of Virginia during a 5-year period between 1986 and 1990. Ninety-one percent of all students included in this group were NATA-certified or eligible for certification at the time of admission. The remaining students were deficient in the number of clock hours of clinical experience. Complete data on each of the 55 students were collected from application files and final academic transcripts.

We examined five predictor variables representing criteria used in the applicant selection process: students' scores on the quantitative portion of the Graduate Record Examination (GRE-Q), scores on the verbal portion of the Graduate Record Examination (GRE-V), the preadmission grade point average (GPAp) based on course work completed before admission into the graduate program, total hours of preadmission clinical experience (hours), and the students' method of undergraduate athletic training education (curriculum or internship). The categorical program variable was coded to represent group membership (0 for internship and 1 for curriculum).

The dependent or criterion measure was the final graduate grade point average (GPAg) calculated for 36 to 38 semester credit hours of graduate study. We analyzed the data using a stepwise multiple regression analysis. The SPSS[7] stepwise multiple regression program was used to determine significant predictors of GPAg. Criterion for entry of a variable into the equation was PIN .05 and tolerance of .0001.

Results

All students in the study had (mean ± SD) GPAg of 3.4 ± .31, GPAp of 3.3 ± .3, GRE-V of 452 ± 69, GRE-Q of 525 ± 90, and 1332 ± 804 clinical hours. Twenty-eight students were graduates of an undergraduate athletic training curriculum program, and 27 students graduated from an undergraduate internship program.

The GPAp was a significant ($p < .001$) predictor of GPAg, accounting for 34% of the variance. GRE-Q, GRE-V, clinical experience hours, and the type of undergraduate athletic training education did not significantly ($p > .05$) contribute individually or in combination to the prediction of GPAg. A summary of regression coefficients are presented in the Table.

Discussion

Of the variables examined, GPAp is the best predictor of academic success in an NATA-approved graduate athletic training education program. This is consistent with the results of investigations in other allied health professions assessing prediction of academic achievement.[1,2,8,9]

GRE-Q and GRE-V did not contribute significantly to prediction of GPAg in our study. Day[4] reported that GRE-Q and GRE-V were not significant predictors individually or in combination with other variables in predicting final grade point averages of physical therapy students. Millimet and Flume[6] discovered that there existed a linear relationship between GPA and GRE scores in the acceptance rates of students into graduate programs in psychology. They indicated that as GPA and GRE scores increased, so did the rate of acceptance into graduate programs.

GRE-Analytical (GRE-A) scores were not included in our study. Day[4] suggested that the GRE-A provides a measure of analytical ability to highlight the problem-solving ability of a student. Day used GRE scores as predictors of academic success in graduate physical therapy programs. She reported that the GRE-A component and the preadmission GPA contributed significantly to the variance in predicting final GPAs in physical therapy programs. Goldberg and Alliger[5] noted that there was a positive correlation between GRE-A scores and the success of psychology students in graduate education measured with multiple criteria. They also discovered that the GRE-Q scores had some predictive abilities of future quantitative grades (positive correlations of .2 to .6).

The total number of clinical experience hours and the type of undergraduate athletic training education (curriculum vs internship) was found not to contribute to the prediction of academic success (as determined by GPAg). From this finding, however, it should not be assumed that these criteria may or may not impact the qualitative assessments of a student's clinical abilities and success in the clinical components of a student's education. Further studies, both quantitative and qualitative, are necessary to determine the success of graduate athletic training students in the clinical components of their graduate education.

The results of this investigation support the use of GPAp as an indicator of potential academic success. There are several limitations inherent in the use of GPA to predict academic success. Chaisson[3] noted that "each format for selecting out the most suitable candidates, even though designed by people with intelligence and well-intentioned motives, carries with it inevitable margins of error." She noted that, in medical schools, GPA was used as a threshold rather than an absolute determinant of selection, because GPAs were different from school to school and may have been influenced by variables, such as with whom specific courses were taken, where, and when.[3]

A second limitation is the confined variability in the range of GPAs of the applicant pool. In our investigation, the range of GPAp was 2.5 to 3.8. The narrow range may not allow adequate discrimination between applicants.[4,5] Although the use of GPAp may have some limitations, we believe that this measure provides useful information and serves an integral component of the applicant selection process.

The primary outcome of the applicant selection process is to determine those applicants who will successfully complete the academic requirements of the program. However, the long-term goal is successful clinical performance. A selection committee should attempt to select candidates who have the potential to attain both academic and clinical success. Further research is necessary to evaluate the impact of additional predictor variables on both academic and clinical performance. Data obtained from interviews, recommendations, and other sources may be included in subsequent endeavors. Continued research is required to develop and evaluate criterion variables related to clinical proficiency.

Stepwise Multiple Regression Analysis Summary of Predictors of Final GPA in Athletic Training Students

Predictor Variables	n	R^2	R^2 Change	p
GREp	55	.34	.34	.001
GRE-Q	55	.38	.04	.06
Hours	55	.38	.00	.62
Program	55	.38	.00	.83
GRE-V	55	.38	.00	.92

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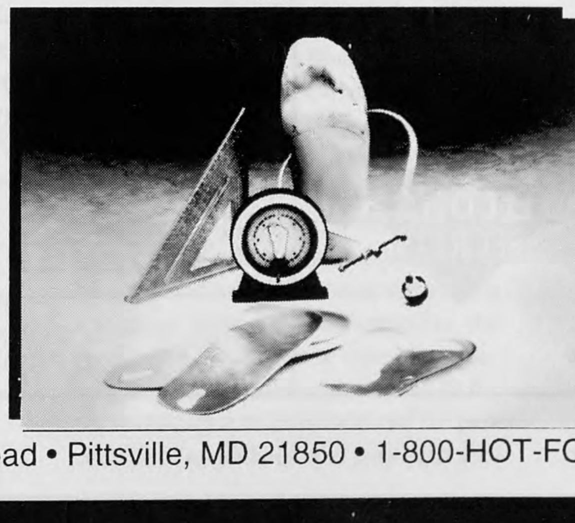

Performance on the Athletic Training Certification Examination Based on Candidates' Routes to Eligibility

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Abstract: *The National Athletic Trainers' Association Board of Certification initiated a task force whose purpose is to evaluate the criteria that determine eligibility for the athletic training certification examination. Candidates may qualify to take the examination through one of two routes: an academic-based curriculum program or the practical education, work-experience-based internship route. The certification examination is comprised of three sections: a written examination, a written simulation, and a practical examination. We retrospectively examined certification examination scores during a 2-year period to determine whether a significant difference existed between the two groups of candidates. Test results for first-time candidates sitting for one of the nine examinations administered during 1992 and 1993 were extracted from the data base maintained by Columbia Assessment Services, Inc (Raleigh, NC) and grouped according to the candidates' route to eligibility. Curriculum candidates had significantly greater scores than did internship candidates on each of the three parts of the examination. Although the test analysis yields strong statistical power in interpreting these results, examination outcomes may also be influenced by the structure and content of the academic program followed, the quality of the clinical experience, the heterogeneity of each of the routes, and the psychosocial rigors of the examination process.*

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Athletic training is one of the few professions that provides dual pathways to the certification of its professionals. Potential candidates may meet the requirements to sit for the certification examination through either the: a) academic-based curriculum route, or b) internship route, a practical education-work experience approach to eligibility (Table 1).[5] Regardless of the route taken to meet the eligibility requirements established by the National Athletic Trainers' Association Board of Certification, Inc (NATABOC), all candidates must pass a common examination to receive their credentials as athletic trainers.

The outcomes of the certification examination have long been the subject of both formal and informal debate, a debate that has subsisted almost entirely on anecdotal information. Annually, the NATABOC publishes a report that details the number of candidates who sit for the certification examination and the percentage of candidates who pass each section.[6] To date, no report has presented the actual scores obtained on the certification examination nor has the relative performance of curriculum candidates and internship candidates been examined. The purpose of this paper is to present the aggregate scores and determine whether a significant difference in these scores exists between the two groups of first-time candidates on each of the three sections of the certification examination (written, written simulation, and practical sections).

Methods

We obtained our data through certification examination records maintained by the NATABOC's testing agency, Columbia Assessment Services, Inc (Raleigh, NC). We grouped the scores of all first-time candidates sitting for the examination during 1992 and 1993 based on the individual's route to certification eligibility, using only the candidate's identification number to assure anonymity. Because of changes implemented in the registration process in 1993, we were able to identify those internship candidates who had prior formal education in another accredited allied medical field (eg, physical therapy, occupational therapy, or nursing).

Nine examinations were administered during this period, with each section demonstrating high validity and reliability. A tenth administration of the examination earmarked for candidates retaking the written or written simulation sections was excluded from our analysis. The written examination produced an average Kuder-Richardson reliability coefficient of .84, the written simulation .80, and the practical examination .89.[2]

We obtained the average score for each of the three sections of the examination, with the written section being further delineated by the six performance domains identified by the NATABOC Role Delineation Study of Entry-Level Athletic Trainers (Role Delineation).[7] The data were analyzed using a t-test with pooled variances to accommodate for the differences in sample size, and p values of less than .05 were identified as being significant.

Table 1.—Eligibility Requirements to Sit for the Certification Examination by Route

Requirements	Route to Certification: Curriculum*	Internship†
Academic	Human anatomy	Human anatomy
	Human physiology	Human physiology
	Exercise physiology	Exercise physiology
	Kinesiology/biomechanics	Kinesiology/biomechanics
	Health (personal or community)	Health (nutrition, drug use, etc.)
	First aid/CPR card	First aid/CPR card
	Prevention of athletic injuries	Basic athletic training
	Evaluation of athletic injuries	Advanced athletic training
	Therapeutic modalities	
	Therapeutic exercise	
	Administration of athletic training	
	Nutrition	
	Psychology	
	Instructional methods	
Clinical	800 clock hours of supervised work	1500 clock hours of supervised work
	200 hours must be with high-risk sports	375 hours must be with high-risk sports
	Hours may not be obtained in allied settings	500 hours may be obtained in allied settings
	400 hours must be obtained at the host institution	

* Requirements are based on course content.
† Requirements are based on course title.

Results

During the calendar years 1992 and 1993, we identified 3675 (43.5%) of the 8451 candidates who sat for the certification examination as athletic trainers who were first-time candidates. Of this group, 1443 (39.3%) met the eligibility requirements through an approved undergraduate or graduate curriculum program and 2232 (60.7%) through the internship route. For those candidates completing a curriculum program, 125 (8.7%) met the eligibility requirements through graduate programs and 1318 (91.3%) were from undergraduate programs. The passing rates for first-time candidates are presented in Table 2.

Analysis of test scores indicated that curriculum candidates outscored internship candidates at a statistically significant level on each section of the examination and on each performance domain within the written section (Table 3). Domain-based statistics could not be conducted for the remaining two sections of the examination because individual responses often encompass more than one domain.

Table 4 compares the scores obtained by curriculum candidates and those internship candidates sitting for the examination during 1993. Eliminated from the scores for the internship candidates were the scores of 89 (7.8%) individuals who indicated that they possessed other formal education in another allied heath care profession. When these data are compared to those presented in Table 3, a slight decrease in the scores obtained by internship candidates is noted for both the written and written simulation sections; an increased score is noted for the practical section. However, these score changes result in an obvious decrease in the passing rate for each examination section (see Table 2).

Low to moderate correlations were found among the grouped scores for each section of the examination. The written section had a .48 correlation to the written simulation and a .45 correlation with the practical section; the correlation between the written simulation and practical sections was .30. This finding reinforces the presumption that each section of the examination measures a unique type of knowledge.

Discussion

Although curriculum candidates performed at a significantly higher level than did internship candidates, it is necessary to consider all of the variables that may affect a candidate's score. Among these influences are the structure of the candidates' academic and clinical learning experiences and the psychological pressures of the examination process.

Inherent differences exist between the minimum academic requirements of the curriculum and internship routes to certification. Furthermore, a dichotomy exists within each route. The National Athletic Trainers' Association Professional Education Committee (NATAPEC) is responsible for approving curriculum programs at both the undergraduate and graduate level. (The approval of athletic training education programs is shifting from Professional Education Committee approval to accreditation through the

Table 2.—Percentage of First Time Candidates Passing Each Section of the Certification Examination Based on the Route to Eligibility

Examination Section	Route to Certification: Curriculum (n = 1443)	Internship (n = 2232)	All Candidates (n = 3675)
Written	757 (52.5%)	919 (41.2%)	1745 (47.5%)
Written simulation	924 (64.0%)	1211 (54.3%)	2135 (58.1%)
Practical	974 (67.5%)	1280 (57.3%)	2234 (60.8%)
Passing all three sections	462 (32.0%)	538 (24.1%)	1000 (27.2%)

Table 3.—Average Scores Obtained on Each Section of the Certification Examination by Route to Certification

Examination Section	Route to Certification: Curriculum	Internship	t
Written Simulation	519.2	497.3	6.88*†
Practical	35.0	33.6	7.11*†
Written	105.2	100.7	9.09*†
Written Section by Domain			
Prevention	18.4	17.9	5.22*†
Recognition and Evaluation	20.7	19.4	8.13*†
Management	21.1	20.2	7.28*†
Rehabilitation	17.7	16.6	8.90*†
Organization/Administration	13.4	13.0	4.85*†
Education and Counseling	13.5	13.0	6.17*†

*$p < .05$
†$p < .0001$

Joint Review Committee Athletic Training. Because all candidates sitting for the examination through the curriculum route in this study did so under the NATAPEC guidelines, this transition did not influence the results.) A review of the annual reports that approved programs must submit to the NATABOC revealed a broad range of curriculum models, with some programs being stand-alone majors, but the majority encompassing a dual academic major (eg, athletic training/physical education or athletic training/health education). These programs were housed in such units as Departments of Physical Education, Health Education, Nursing, Physical Therapy, or Athletics.

The composition of the internship route was even more diverse because no agency monitors the construct or implementation of this program type. Candidates may satisfy the certification eligibility requirements by meeting the minimum academic and clinical requirements or may have completed an academic athletic training major that exceeds the standards established by the NATAPEC but has not sought approval as such. Another influence within the internship route are candidates who possess previous background and/or licensure in a related allied health major (eg, physical therapy). This type of candidate may prove to inflate the overall scores of the internship group.

Significantly influencing the curriculum and internship routes are the differences by which academic course work is mandated for each. The NATAPEC requires approved curriculum programs to show proof that each of the 14 content areas listed in Table 1 are addressed during the students' education. Additionally, during each 5-year re-evaluation process, approved programs must indicate where and how each of the educational competencies addressed in the *Competencies in Athletic Training* is fulfilled during the students' educational experience.[9] This is in contrast to the academic requirements placed on internship candidates who are required to show proof of completion of seven courses, plus certification in cardiopulmonary resuscitation and first aid. Although five of these courses are content-specific, the objectives to be met in the "Basic" and "Advanced" athletic training courses are undefined.

The eligibility criteria place a quantitative measure on the clinical hour requirements for both routes, but it may be argued that it is the quality of these experiences that most influences certification examination outcomes. It has been documented that the number of hours accumulated by a student athletic trainer has little influence on examination performance.[3] Qualitative influences may be found in the student athletic trainer's job description, the experience of the supervising athletic trainer, the amount of actual "on-field" teaching, and the coordination between classroom education and clinical learning that occurs.

Other than the difference in the number of clock hours that must be obtained by curriculum and internship candidates, another, perhaps larger, discrepancy is found in where these hours may be obtained. Candidates progressing through the internship route are permitted to accrue 500 hours in "nontraditional" (ie, physical therapy/sports medicine clinics) settings under the supervision of a certified athletic trainer. Conversely, curriculum candidates are prohibited from accruing hours in these settings to meet the certification requirements.[10] Although the effect(s) of experiential hours obtained in nontraditional locations on the certification examination performance is yet to be determined, this prohibition is ironic because physical therapy and sports medicine clinics are the largest employers of students graduating from curriculum programs.[8]

The last issue is particular to the practical examination, yet affects curriculum and internship candidates alike. A so-called "human barrier" exists between the candidates and evaluators of practical examination performance.[1,4] The human barrier manifests itself in the form of the candidate's anxiety about performing before an unknown audience, the inability to "undo" a response, and a communication factor where the candidate must explain and demonstrate a task, requiring

Table 4.—Scores and Passing Percentages for Curriculum Candidates and Internship Candidates Not Having Other Formal Allied Health Education

Examination Section	Curriculum Candidates (n = 724) Score	Passing %	AT Internship Candidates* (n = 1057) Score	Passing %
Written simulation	519.6	64.5%	488.9	35.5%
Practical examination	36.9	68.1%	33.8	34.0%
Written examination	105.1	52.7%	100.6	32.8%

* These data exclude individuals who have been formally educated in another allied health field.

that the examiners listen to, observe, and interpret the response.

Conclusion

Although a simple research question was used for this study, many complex questions arise from its results. The next step in this process is to determine how the various influences either positively or negatively affect examination outcomes. These areas requiring prospective study include:

1. The effect that various academic models and departmental structures have on the candidate's examination scores.
2. Further analysis of the internship route that accounts for: a) candidates who possess education in other allied health areas, b) candidates graduating with nonapproved educational majors, and c) candidates meeting the minimal definition of an internship.
3. An analysis of the content of the basic and advanced athletic training courses required for internship candidates.
4. The relationship between the number of years and number of clock hours spent gaining clinical experience, the site of the experience (high school, college, clinical, or professional), and examination scores.
5. The percentage of clinical hours spent with high-risk sports and examination scores.

Attempts to produce research in the area of certification should focus on identifying and correcting those variables that hinder candidates' scores. The practice of producing and publishing predictive statistics should be avoided because of their dubious and self-fulfilling nature.

Acknowledgment

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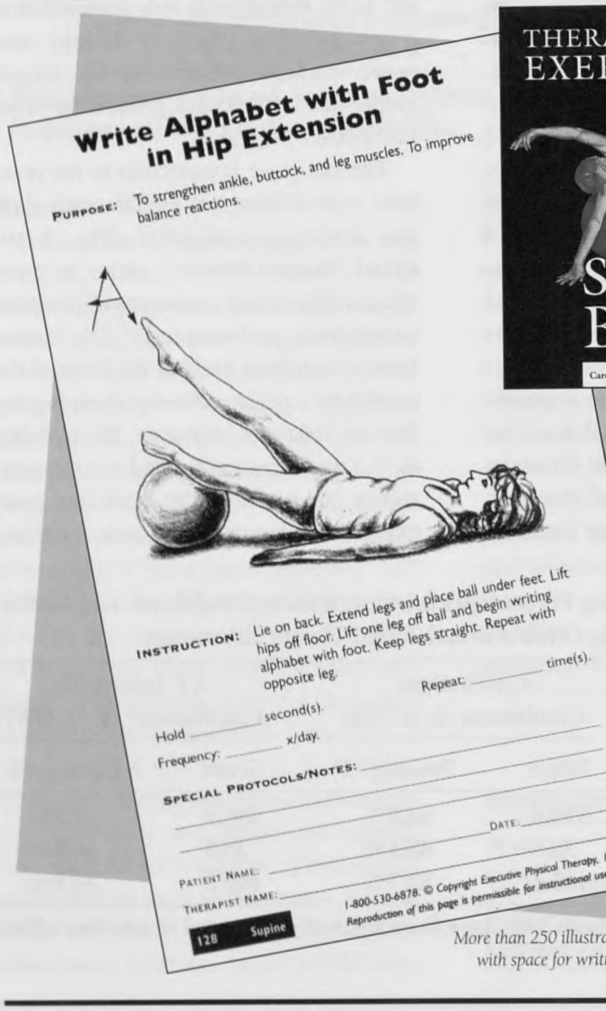

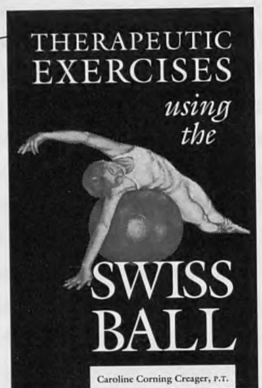

A Survey of New Jersey High School Football Officials Regarding Spearing Rules

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Abstract: *Football officials play an important role in the prevention of catastrophic head and neck injuries. Officials alone can use the spearing penalty as a deterrent to players during football games. The purpose of this study was to determine the officials' perspectives on the spearing rules and their level of enforcement. In a stratified random sample, 100 high school officials from New Jersey were surveyed. The officials returned 100% of the questionnaires. Each official worked an average of 27 games during 1992. Forty-seven percent of the officials did not call any spearing penalties. A New Jersey official called an estimated one spearing penalty in 20 games. The officials were most likely to call a spearing penalty on a late hit and least likely to call one on a ball carrier. The officials' opinions varied greatly regarding the spearing rules. The level of enforcement found in this study was extremely low. The possibility exists that officials are either overlooking or not recognizing a significant number of spears. Individual athletic trainers, state athletic training associations, and the National Athletic Trainers' Association should take steps to improve the enforcement level of the spearing penalty.*

Reduction in the incidence of catastrophic head and neck injuries in football[18–21] has been attributed to several factors, including the implementation of the spearing rules in 1976,[1,2,7,9,10,14,19–21] coaching methods that have taught safer contact techniques,[1,9,10,14,19,20] and better medical care.[9,10] An intriguing question relates to exactly why the spearing rule has been effective. The most obvious explanation is that the rule has caused a reduction in the incidence of spearing. Spearing rules could have caused this reduction in two ways: 1) influencing coaches to teach safe contact techniques, and 2) influencing officials to penalize incidents of spearing during games.

Authors[4–6,13] have begun to take a closer look at the level of enforcement of spearing rules. Officials alone can use the spearing penalty as a deterrent to players during football games. They therefore have a crucial role in the prevention of severe head and neck injuries.[4–6,9,13,14] The purpose of this study was to determine high school officials' perspectives on spearing rules and their level of enforcement.

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Methods

I selected a stratified random sample of 100 high school football officials from the four regional chapters in New Jersey. The selected sample represented 12% of the total active officials. I chose the officials from the New Jersey State Interscholastic Athletics Association's 1992 Directory of Officials.[12]

I designed 25 questions (24 close-ended) for the questionnaire. The majority of the questions were based on the Likert scale.[16] I mailed a questionnaire, an optional comment page, and a postage-paid return envelope to the home address of each official. I coded each questionnaire and all respondents remained anonymous. As many as five follow-up letters were mailed, each of which included the same material as the original mailing, with the addition of a new cover letter.

Results

Response rate was 100%; 95% of the questionnaires were completed. Five officials did not answer the questions because they were not active in New Jersey during 1992. One official did not respond to the final seven questions; for those questions, 94 responses were used. Fifty-three percent of the officials also used the optional comment page to provide additional information and explanations.

Games and Spearing Penalties

Three officials (3.2%) did not respond to the number of games officiated or the number of spearing penalties called. The 92 respondents officiated a total of 2,474 games in 1992, including high school, college, and Pop Warner. Each official worked an average of 27 games. The officials estimated that they had called 125 spearing penalties in the 2,474 games, an estimated one spearing penalty in 20 games during 1992. Forty-one (44.6%) of the officials did not call any spearing penalties during the 1992 football season (Table 1).

One of the officials who called eight penalties indicated that he called six as late hits and only two of the calls were actual spearing penalties. Another official commented that, overall, there are not a lot of spearing penalties called. Several felt that the penalty is easier to call now because it no longer carries an automatic ejection. Another said that many officials shy away from the ejection penalties. One official asserted that there was no spearing to call.

Seventy-nine (83.2%) of the officials believed a ball carrier could spear. Many commented that when a ball carrier lowers his head to gain that extra yard, offi-

Table 1.—Football Officials' Estimates of the Number of Spearing Penalties They Called During 1992

Penalties Called	Officials
0	41 (45%)
1–2	39 (42%)
3–6	9 (10%)
7–10	3 (3%)
11+	0
Total	92 (100%)

Each official worked an average of 27 games.

cials should consider it spearing. One official believed that a spear occurred only when the ball carrier attempted to punish the tackler, while another thought ball carrier spearing is possible, but very unlikely. One official said ball carrier spearing is not a penalty by rule; another commented, "By rule, it is a penalty." One of the 16 (16.8%) officials who thought ball carriers could not spear, clarified his answer: "By definition, a ball carrier can spear, but, speaking practically and in terms of enforcement, I answered no."

Officials were also least likely to call a spearing penalty on a ball carrier than on other players (Table 2). Most commented that they had never seen a spearing penalty called on a ball carrier or called one themselves. Only one official indicated that he had called a spearing penalty on a ball carrier, although not in 1992. Several believed coaches would not easily accept this call or it would be very difficult to "sell." Two officials said it would have to be extremely obvious that the ball carrier was intending to injure the tackler to call this penalty. One official stated he probably would not be asked back to officiate next season if he made this call. Another said, "In some instances, officials can be severely chastised because such a call is strange, although it may be technically correct." A third official commented, "Until we educate coaches about ball carrier spearing, it would be a difficult call." He also thought it would require courage and commitment on the part of all officials to enforce the penalty consistently.

Two officials commented that coaches teach ball carriers to put their heads down before contact in order to protect themselves. One further believed that to instruct ball carriers to do anything to the contrary might expose them to injury.

Forty-seven (48.5%) officials were likely or very likely to call a spearing penalty on a blocker (Table 2). Again, several officials commented that this would be a tough call to make. One thought it would have to be extremely obvious to be "sold." Another official commented that if he made this call, coaches and fans would "run him out of town." A third official indicated that officials rarely, if ever, call the spearing penalty in a blocking situation.

Several other officials brought up the "free blocking zone." Comments ranged from "spearing in this zone is a gray area" to "not calling a penalty in this area because momentum is not at peak levels." One official felt that, within the framework of blocking, spearing was next to impossible. Numerous officials also indicated that regardless of who spears, officials should call the penalty.

Officials were most likely to call spearing penalties on late hits and tacklers (Table 2). Regarding the late hit situation, two officials said it was the most critical time for officials to call the penalty and when they call it most. Another official said he would have no problem calling a spear in this situation since he would have to believe it was a punishing tactic.

Given a situation in which an official thought an athlete accidentally speared, 49 (51.5%) were still likely or very likely to call the penalty (Table 3). There were 46 officials (48.5%) who were less likely to call the spearing penalty in this situation. Several officials indicated that, instead of calling the penalty, they would tell the athlete to keep his head out of the contact or warn the athlete of the potential for severe injury. Other officials commented that accidental spearing is still a penalty. Several officials thought the ball carrier's actions or change of direction could force or lead a tackler to spear. They indicated they would not consider this a penalty. One official stated, "In my eyes, spearing is the use of the head alone, with the hands at the side, in an attempt to punish another player."

Thirty-two (34%) of the officials believed there was little or no spearing going on in football (Table 4). There were 42 officials (44.7%) who disagreed with this statement and 20 (21.3%) were undecided. Several officials said coaches have done a great job in reducing the use of the helmet as a weapon. There were also several officials who thought that coaches were doing a poor job. Some officials felt that coaches taught and condoned tackling with the head. They said comments used by coaches such as "drive your head through the man" or "stick your hat in his numbers" have to be taken out of football. One official believed coaches teach tackling in preseason but not throughout the year. He thought it should be mandatory to cover it every week. Numerous other officials commented that intentional spearing has decreased over the years but it still happens. Another official indicated that, as the level of play increases, so does the amount of spearing.

The survey revealed that officials were slightly more likely to enforce the butt-blocking rule than the face-tackling rule (Table 3). Fifty-eight (61.1%) were at least likely to enforce the butt-blocking rule compared to 55 (58.5%) for the face-tackling rule. One official thought face tackling was rare. Numerous others stated they had never seen the penalty called. Other officials thought face tackling was difficult to enforce, because it could be the result of evasive maneuvers by the ball carrier. Another official thought the nature of the game makes face tackling an extremely difficult call.

Interpretation of the Rules

Sixty-five officials (68.4%) thought the rules were easy to interpret, while 30 (31.6%) thought they were not (Table 4). Numerous officials felt the rules were "hazy" regarding intent (if an athlete speared accidentally). Similarly, one official indicated that the "no call" on accidental or incidental spearing should be better defined.

Fifty-eight officials (61.7%) believed that, overall, the spearing rules were written in a way that allows easy en-

Table 2.—How Likely Officials Were to Call a Spearing Penalty on Late Hits, Tacklers, Blockers and Ball Carriers

Player	Very Likely	Likely	Somewhat Likely	Unlikely	Very Unlikely
Late Hit	81 (85%)	10 (11%)	3 (3%)	1 (1%)	0
Tackler	38 (40%)	38 (40%)	11 (12%)	7 (7%)	1 (1%)
Blocker	20 (21%)	27 (28%)	19 (20%)	25 (26%)	4 (4%)
Ball Carriers	7 (7%)	22 (23%)	18 (19%)	31 (33%)	17 (18%)

Table 3.—How Likely Officials Were to Call the Face-Tackling Penalty, Butt-Blocking Penalty, and a Penalty on an Accidental Spear

	Very Likely	Likely	Somewhat Likely	Unlikely	Very Unlikely
Face-Tackle	22 (23%)	33 (35%)	21 (22%)	16 (17%)	2 (2%)
Butt-Blocking	19 (20%)	39 (41%)	23 (24%)	12 (13%)	2 (2%)
Accidental Spear	12 (13%)	37 (39%)	22 (23%)	19 (20%)	5 (5%)

forcement (Table 4). Twenty (21.3%) believed the rules were difficult to enforce and 16 (17%) reported that they were undecided. One official indicated that the rule as written is fine, but coaches should help enforcement by accepting the penalty more readily. Another official indicated that the rule is clear, but that the enforcement is inconsistent. He thought spearing was an area where "preventive officiating" (warning players without calling a penalty) has gone too far; "... officials should just call the penalty." Other officials thought the penalty involved a great deal of judgment. Regarding judgment, an official stated, "For some officials to understand illegal head-first contact, you would have to draw many pictures of spearing, face tackling, and butt blocking."

Relating to judgment, I asked the officials if trying to decide on an athlete's intent or determining whether a spear was purposeful made the rule difficult to enforce. Thirty-nine officials (41.5%) thought deciding on intent made the rule difficult to enforce, whereas 48 officials (51.1%) did not agree. Seven (7.4%) indicated they were undecided (Table 4). The majority of comments related to whether the ball carrier's actions caused the accidental or unintentional spear by the tackler. Several other officials indicated that intent should not be a factor in calling the penalty.

Regarding head-first contact, 48 officials (50.5%) believed that "all" head-first contact was illegal. In contrast, 37 officials (39%) did not agree and 10 (10.5%) were undecided (Table 4). One official indicated that when he and other officials observe head-first contact and judge it accidental, they warn the player to keep his head out of contact. Several other officials commented that head-first contact can be legal if it is caused by the movements (change of direction) of the ball carrier. Another official believed that all officials do not interpret head-first contact as a penalty, but they should recognize it as such. One official believed that, in order for it to be illegal, it had to be intentional by the player. To the contrary, another official thought that no "accidental" head-first contact was possible.

I asked the officials if the severity of the spearing penalty (15 yards, ejection optional) made them very selective in enforcing the penalty. Sixty (63.3%) did not believe it mattered, while 31 (32.6%) believed it was an influencing factor (Table 4). Only 22 officials (23.4%) thought they would be more likely to enforce the spearing penalty if it were less severe. These two questions elicited the most comments. One official thought that many officials disguise these penalties as late hit calls because of the ejection. Another official said that ejection is tough because the athlete is also out for the next game. Other comments included: "15 yards and ejection are so severe, it lessens the effectiveness of the penalty"; "too many officials feel spearing is a part of the game, and are very selective in calling the penalty." One official commented, "High school teams cannot come back quickly from a 15-yard penalty. This is the first reason officials don't call the penalty. The second reason is officials don't truly understand a spear and its potential effect on the spearer." Other officials thought the penalty should be severe because of the injury potential.

Regarding changing the severity of the penalty, many officials thought the yardage of the penalty should not be a factor in throwing the flag. One official believed the penalty should be an automatic ejection. Many other officials suggested modifications in the penalty relating to intentional and unintentional spearing (similar to the face mask penalty in college). Generally, these suggestions included 5 yards for accidental spearing, 10 yards for intentional spearing, and 15 yards and ejection for purposeful spearing with the intent to injure.

I asked the officials to identify the most accurate definition of spearing. Fifty-three (56.4%) said an athlete had to "intentionally" use the crown of his helmet for a spear to occur (Table 5). Forty-one (43.6%) of the officials defined spearing as occurring when a player only "initiates" contact with the crown of his helmet.

Dangers of Spearing

I asked the officials if spearing was the primary injury mechanism of severe cervical spine injuries. Seventy-two (75.5%) of the officials reported that it was; 20 (21.3%) were undecided; and 3

Table 4.—Officials Responses Regarding Statements About Spearing

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
All head-first contact is illegal. (n = 95)	20 (21%)	28 (30%)	10 (11%)	32 (34%)	5 (5%)
Spearing rules allow easy enforcement. (n = 94)	9 (10%)	49 (52%)	16 (17%)	18 (19%)	2 (2%)
Spearing is primary cause of severe spinal injuries. (n = 95)	25 (26%)	47 (50%)	20 (21%)	3 (3%)	0
Little or no spearing in football. (n = 94)	3 (3%)	29 (31%)	20 (21%)	37 (39%)	5 (5%)
Injuries can occur regardless of intent to use the head. (n = 94)	34 (36%)	57 (61%)	3 (3%)	0	0
Deciding on intent makes penalty difficult to call. (n = 94)	7 (7%)	32 (34%)	7 (7%)	42 (45%)	6 (6%)
Penalty severity makes you selective in calling it. (n = 95)	8 (8%)	23 (24%)	4 (4%)	45 (47%)	15 (16%)

Table 5.—Officials Choice of the Most Accurate Definition of Spearing

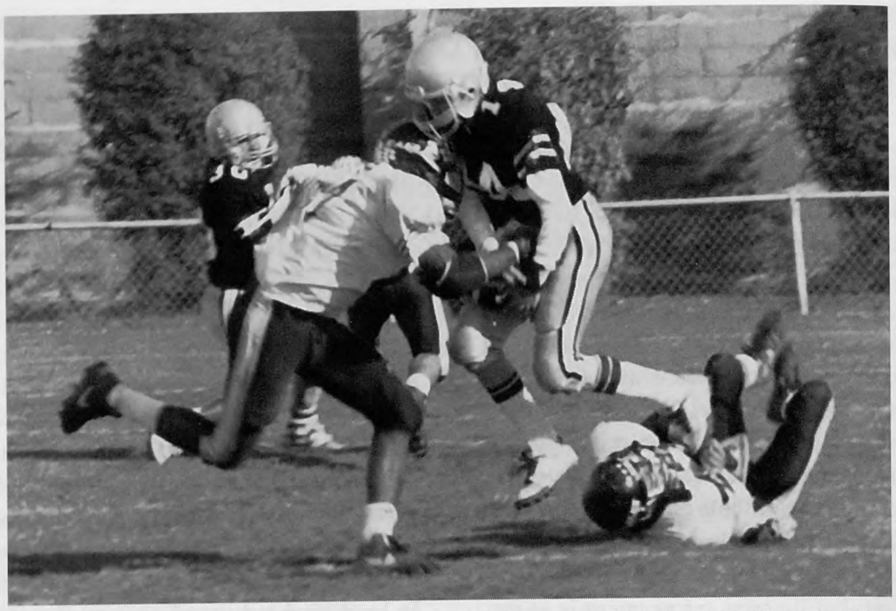
Any Player Who:	Officials
Initiates contact with the crown of his helmet	41 (44%)
Intentionally initiates contact with the crown of his helmet	32 (34%)
Intentionally attempts to harm an opponent with the crown of his helmet	21 (22%)
Total	94 (100%)

(3.2%) did not think so (Table 4). Ninety-one (96.8%) of the officials thought that head and neck injuries could occur regardless of the athlete's intent to use his head. The remaining three (3.2%) were undecided (Table 4).

The questionnaire also asked the officials whom the spearing rule was designed to protect. The majority of the officials commented that it was designed to protect both players, but 53 (55.8%) thought its primary purpose was to protect the athlete who spears, and 33 (34.7%) thought it was designed to protect the athlete who gets speared. Ten (10.5%) of the officials did not answer the question correctly. One official believed the rule was written to protect the player who gets speared, but was more dangerous to the player who spears.

Discussion

The high school *Official Football Rules*[11] defines the rules pertaining to head-first contact as follows. *Spearing* is the intentional use of the helmet in an attempt to punish an opponent. *Face tackling* is driving the face mask, frontal area, or top of the helmet directly into the runner (Figure). *Butt blocking* is a technique involving a blow driven directly into an opponent with the face mask, frontal area, or top of the helmet as the primary point of contact either in close line play or in the open field. These penalties are considered an illegal personal contact and carry a 15-yard penalty. If the foul is flagrant, an official can eject the player. The rules also define an illegal personal contact as occurring when a player intentionally uses his helmet to butt or ram an opponent.



Initiating contact with the face mask or frontal aspect of the helmet (face-tackling) is a 15-yard penalty.

I was surprised at the definition of spearing in the high school rule book; it does not mention initiating contact with the crown or top of the helmet and limits itself to an intentional attempt to punish. I was also surprised at the completeness of the face-tackling and butt-blocking rules. These rules state that initiating contact with any part of the helmet (by a blocker or tackler) is illegal. These actions also do not have to be intentional to be a penalty. Both of these latter rules, however, exclude the ball carrier. This may be a factor in an official's reluctance to recognize ball carrier spearing.

Officials' opinions varied widely regarding spearing rules. For uniform and appropriate enforcement to occur, officials should agree on the definition of spearing and its practical use. The answers of the officials surveyed split almost in half in defining spearing relating to the athlete's intent to use the crown of his helmet. A large portion of the officials also did not feel that they easily interpreted the rules and were unsure whether the rules allowed for easy enforcement. This may indicate that officials have devised their own connotations as to what constitutes spearing during football games.

A major area of concern for officials related to athletes who initiate contact unintentionally with their helmets. Over 40% of the officials thought that deciding on intent made the rule difficult to enforce. What an official would do in this situation differed by individual. Some indicated they would call the penalty; others said it was not a penalty; still others indicated they would only warn the player (preventive officiating) of possible injury. The situation most often mentioned related to the tackler whose head-first contact is the result of a ball carrier's movements. A similar situation could be envisioned for a blocker with a defender trying to evade his block. Both of these situations could possibly result in accidental head-first, head-up contact for a player using correct technique. But, in my opinion, the concept that this could cause a player to lower his head and initiate contact with the crown of his helmet is erroneous.

This brings up a major question: "Is all head-first contact illegal in high school football?" Among the four rules relating to head-first contact the answer is "yes," regardless of the athlete's intention or part of the helmet used. The exception is for the ball carrier; his head-first contact must be intentional. This was a difficult issue that may create a dilemma for the officials. Regardless of intent, the penalty is still 15 yards. Is an athlete who accidentally initiates contact with his face mask (head up) the equivalent of the athlete who intentionally initiates contact with the crown of his helmet? Is the athlete who accidentally drops his head just before contact the same as the athlete who uses the crown of his helmet to punish an opponent?

The severity of the penalty may be an influencing factor in not calling the penalty, in particular, on the athlete who accidentally initiates contact with his helmet. The officials were clear in expressing that they would call the penalty if the contact was intentional. Their opinions varied greatly regarding throwing the flag on unintentional head-first contact. On the surface, 15 yards may seem appropriate for such a potentially dangerous technique. However, the possibility exists that officials may not call the penalty unless it is a blatant occurrence. This may have been even more of a possibility up until the mid-80s when the penalty carried an automatic ejection. In turn, this is detrimental in deterring athletes from initiating contact with their helmets. Not all spears that cause serious head and neck injuries are blatant.

Another factor in calling the spearing penalty is determining whom the official is trying to protect. The primary purpose of the spearing rule is to protect the athlete who spears.[4,5] The research[9,10,17,20,21,23] that caused this rule change in 1976 dealt with spearing athletes who suffered fractured cervical vertebrae. Although the rule should protect both players, the player with the most risk of serious injury is the athlete who spears. The officials surveyed indicated that many of them feel they are primarily attempting to protect the athlete who gets speared. In my opinion, the wording of the spearing rule focuses on the athlete getting speared.

Calling the penalty as a late hit represents a situation in which the official is focusing on protecting the athlete being speared.[6] This was the situation in which officials were most likely to call a penalty on spearing. It also appeared that the officials preferred the late hit call over the spearing call. Officials may disguise the spearing call as a late hit for several reasons. Coaches may be more likely to accept this call over a spearing call, especially if an official calls it on a player other than a tackler. When the spearing penalty carried an automatic ejection, a late hit call allowed the player to remain in the game. Currently, it still removes the possibility of ejecting the player. A problem with using the late hit call is that it does not give the penalized player the proper feedback. The athlete may not realize the official penalized him for hitting with the top of his helmet. One of the goals of the spearing rule has to be to decrease the incidence of spearing. For this to occur, officials must use the spearing penalty as a deterrent to the players and be clear that the penalty is for spearing.

Level of Enforcement

The level of enforcement of the spearing penalty was extremely low. Nearly one-half of the officials did not call a spearing penalty in any game they officiated in 1992. These numbers are consistent with the penalty enforcement reported in an earlier study of a high school football season where officials called no spearing penalties,[6] even though analysis of game film indicated 27.6 spears per ball game (18.6 ± 3.0 ball carrier spears and 9.0 ± 2.3 defensive spears per game). A significant number of officials indicated they were at least somewhat likely to call a spearing penalty on all positional players; however, they apparently did not call the penalties. In practice, the spearing penalty seems to be a difficult call for officials to make.

One reason for this level of enforcement may be that there is very little spearing going on in football. One-third of the officials indicated this was the case in their opinion. However, nearly one-half the officials believed spearing does occur fairly frequently. This opinion directly contrasts the level of enforcement shown in this study. The 27.6 spears per game in my previous study excluded blocker spearing and some types of tackler spearing (a potentially large number of additional spears).[6] If these numbers are representative of other high schools, there are a significant number of spears that officials are overlooking or not recognizing. This may indicate a difference between the "medical" definition of a spear and what officials recognize as a spear.

When officials did call a spearing penalty, it was most likely on a late hit. However, players are most at risk of catastrophic injury or death when tackling or being tackled.[8–10,18–21] Although tackler spearing was next in likelihood of enforcement, there was a large drop from the late hit call. Spearing by blockers and ball carriers did not seem to be a priority for officials. From the comments made by officials, it seems that they very rarely call spearing penalties on blockers or ball carriers. The fact that these penalties are not common seems to be important. Many officials believe this plays a significant role in how readily coaches and fans will accept a call. Although numerous officials indicated that these factors should not be a factor in calling a penalty, I believe that they do play an important role.

Ball-carrier spearing appeared to be a unique concept to officials. Their responses varied greatly. A glaring disparity was that although 83% of the officials believed a ball carrier could spear, only 29% were likely to call the penalty. This indicates that the possibility exists that an official will not call a spearing penalty on a ball carrier even though he speared. Ball carriers speared once in every five plays in a 1989 study.[6] Again, if these numbers are representative of other high schools, a large gap exists between incidence and enforcement.

I believe a similar problem exists with both the butt-blocking and face-tackling rules. The comments made by officials regarding these penalties seem to indicate they are "figurehead" rules. Although a large portion of officials answered they would call this penalty, in practice, it is extremely underenforced. The officials were of split opinion on whether all head-first contact was illegal. However, the butt-blocking and face-tackling rules clearly state that all head-first contact is a rule violation. Again, this may indicate that officials have individualized the definition and application of these rules.

Over two-thirds of the officials stated they understood spearing's role as a mechanism of serious injury, and 97% thought a head or neck injury could occur regardless of the athlete's intent to use his head. In contrast, only one-half of the officials were at least likely to call a penalty on an athlete who they thought accidentally speared. The officials were either unwilling to properly apply this injury information to penalty enforcement or they believed the rules prevented them from doing so.

Stricter officiating can further reduce the incidence of serious head and neck injuries.[9,14] Numerous authors have indicated that enforcing existing rules will help prevent catastrophic head and neck injuries.[3–6,9,10,18,19,21] Coaches also play an extremely important role in the prevention of spearing, by practicing and teaching correct contact techniques.[22] I believe that these factors relate highly, with the former potentially impacting the latter.

One official commented to the contrary: "Officials can call blatant spearing, but the avoidance of penalties cannot be a motivating factor for coaches to teach proper technique. . . . I doubt rule changes would have much impact on spearing or spearing penalties." One of the greatest effects of the spearing penalty is its potential impact on coaches. The only feedback coaches have on spearing are catastrophic injuries and spearing penalties. Both are important factors relating to coaches and correct technique. However, in reality, the majority of football coaches will only deal with the threat of a catastrophic head or neck injury related to spearing. Stricter officiating and frequent spearing penalties would force coaches to confront the effects of spearing weekly.

Recommendations

On the basis of the information found in this study, I believe the spearing rules should change and the definition of spearing should expand. Simply stated, it should include any player (ball carrier, blocker, tackler) who initiates contact with the top or crown of his helmet. The penalty should include intentional and unintentional spearing but address them differently. An unintentional spear should be a 5-yard penalty. This would represent the athlete who has his head up before contact but unintentionally lowers his head at the last instant before impact. An intentional spear should be a 10-yard penalty. An intentional spear with the intent to injure another player should be a 15-yard penalty with the option of ejection.

Initiating contact with the shoulder while keeping the neck in extension minimizes the risk for the player of serious head and neck injury.[4–7,9] However, football is a high-speed collision sport and the possibility exists that an athlete may accidentally initiate head-up contact as the result of other players' movements. I do not think that the athlete who is attempting to use proper technique should be penalized. This would require adaptation of the face-tackling and butt-blocking rules. These rules should be combined into a single one. The penalty should address ball carriers, blockers, and tacklers and only penalize intentional face-mask or frontal-helmet contact.

Regardless of potential rule changes, the current enforcement level requires action by individual athletic trainers and our organizations. State athletic training associations should seek out their high school officiating associations with the goal of better enforcement of existing rules banning head-first contact. Offering educational sessions on mechanisms of injury and the types of (often unimpressive) hits that cause catastrophic injuries may make officials more aware of what we are trying to penalize. The video, *Prevent Paralysis Don't Hit With Your Head,*[17] is an excellent vehicle to express these points to officials. The National Athletic Trainers' Association should make a position statement against the low level of enforcement of the spearing rules and methods for improving this aspect of football.

Schneider[15] reported a similar situation with the face-mask penalty. The rule had been established for years but had gone unenforced. He addressed the football rules' committee regarding the potential for injury with grabbing the face mask. A member of the committee pointed out that the rule existed and apparently had not been properly used. This, in turn, led to appropriate enforcement of the penalty the following season.[15] Enforcement of the spearing penalty on a level with the face-mask penalty would be a large improvement.

The level of enforcement of the spearing rules found in this study suggests officials' impact on decreasing the incidence of spearing has been minimal if previous years were similar to 1992. If the incidence of spearing has decreased since the inception of the spearing rules in 1976, this study implies that coaches may have played the most significant role in that reduction.

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Acute Subdural Hematoma in a High School Football Player

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Abstract: *A 16-year-old football player developed a headache following a collision during a game. When his headache persisted for 1 week, he underwent a computerized tomographic (CT) scan to determine the cause. Findings were normal and a concussion was diagnosed. Seventeen days after the injury, the athlete reported disappearance of his symptoms. Provocative testing failed to recreate symptoms. The athlete continued to deny any symptoms and was cleared for unlimited participation 30 days after the initial injury. In the next game, the athlete collided with an opposing player, ran to the sidelines, and deteriorated on the sidelines after complaining of dizziness. Local Emergency Medical Squad personnel intubated him and transported him to a local hospital emergency room. Attending neurosurgeons diagnosed a right subdural hematoma by CT scan. A burr hole craniotomy evacuated the lesion. The operative report noted a second area of chronic membrane formation consistent with past head trauma. This lesion had escaped detection on two CT scans. In an interview 4 months postoperatively, the athlete admitted having experienced constant symptoms between the first and second injuries.*

Head injury is the leading cause of death in football[9] and in sport in general,[24] with subdural hematoma being the most common cause of death due to head trauma.[26] The injury rate for all types of head injury has been reported to be as high as 20%[9,12,28] to 40%.[6] Of those experiencing head injuries, 69% report losing consciousness for some period of time.[9] Athletic trainers see many head injuries during a football season; often, there are very few objective signs to observe. If a high school athlete does incur a head injury, postconcussive symptoms may last from 3 to 9 months.[1] Postconcussive symptoms include: headache, inability to concentrate, and an inability to maintain work, social relationships,[1] or both. Symptoms such as these may be difficult to separate from normal teenage behavior. Some authors report information-processing deficits and permanent brain damage in patients with multiple minor head injuries.[1,6,28] This report describes an athlete who sustained what appeared to be a minor head injury with no objective signs. He sustained a second head injury with near catastrophic results and later admitted having experienced symptoms between the first and second injuries. The case points to the difficulty in using traditional physical examination and even computerized tomographic (CT) scans to determine the extent of minor head injury.

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Presentation of the Case

A 16-year-old football player reported to the training room with a headache following a collision on the last play of the third football game of the season. He had a normal physical examination and was sent home with instructions for overnight care. Throughout the next week, he continued to complain of a headache. The team physician ordered a CT scan 7 days after the initial report of injury. The results of the CT scan (with contrast medium) were normal (Fig 1). The team physician prescribed Elavil 25 mg at bedtime for his headache, but the athlete continued to report headache pain.

Seventeen days after the collision, he reported the disappearance of symptoms. The athlete then underwent testing to recreate his symptoms. Testing consisted of running, push-ups, sit-ups, and squat thrusts. These tests failed to reproduce his symptoms, and the team physician cleared him for return to practice on a limited basis. For the next two games, the athlete kicked, punted, and played offensive back. He continued to deny any symptoms related to his head injury. At this point, he was cleared for full participation, including offense, defense, and

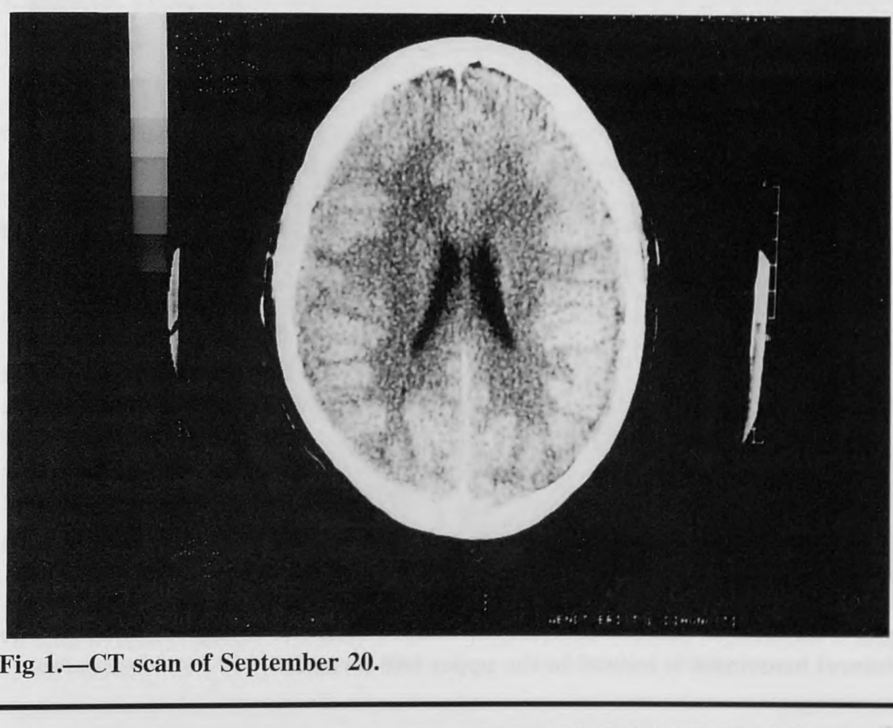

Fig 1.—CT scan of September 20.

all special teams, as well as being the punter and place kicker. During the following game, he played linebacker during the second quarter. In the third quarter, he was blindsided by a blow to his right temple. He continued to assist on the tackle and then motioned to the sidelines for a substitution. When he arrived at the sidelines, he denied any focal neurological symptoms. He complained of left elbow pain. Upon further questioning, he complained of dizziness and headache. The physical examination was unremarkable at this time.

Shortly thereafter, while being monitored on the sideline, the athlete began to projectile vomit, and became pale and unresponsive. His left pupil was slightly dilated, he had no verbal response, his eyes opened to painful stimulation, and he displayed decerebrate posture. The team physician rated him as a Glasgow Coma Score of five. The team physician initiated cervical spine control. The local Emergency Medical Squad intubated the athlete, started an intravenous (IV) line, ran an electrocardiogram, and hyperventilated him on the way to the hospital emergency room. Upon arrival at the emergency room, the athlete received a second CT scan (Fig 2). This CT scan revealed an acute right-sided subdural hematoma with a midline shift.

Operative Findings

Surgeons performed a right-sided burr hole craniotomy to evacuate the acute subdural hematoma. The surgeon opened the dura approximately 1 cm when the subdural clot evacuated spontaneously. The surgeon removed the entire clot and noted a small area of chronic membrane formation consistent with some type of subdural trauma in the past. This lesion had escaped detection on both CT scans. The surgeon placed a subdural catheter for measuring intracranial pressure through a separate stab wound. It was removed when the athlete's intracranial pressure stabilized. The surgeon discharged the athlete from the hospital 10 days after admission to the emergency room.

Outcome

The athlete continued to improve, and his neurosurgeon cleared him 4 months after his surgery for noncontact athletic activity. He ran with the track team that spring and set the school record in the 300-meter intermediate hurdles. The athlete was also a member of the 320-meter relay team that placed third in the state track meet. The following spring, he was conference champion in the 300-meter intermediate hurdles, 100-meter high hurdles, and the high jump. Upon graduation from high school, he accepted an academic scholarship to college where he hopes to continue his career in track and field.

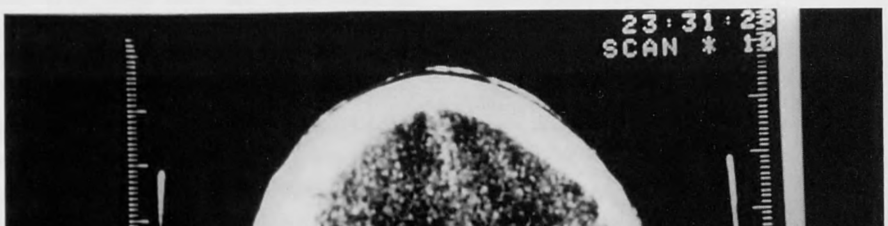

Fig 2.—CT scan of October 18. Note the midline shift and collapsed ventricle. The subdural hematoma is located in the upper left corner.

Discussion

When interviewed 4 months postoperatively, the athlete admitted having had symptoms between the first and second injuries consistent with postconcussive syndrome.[1,22] He reported nearly constant headaches, diminished concentration, and a disrupted sleep pattern. He took acetaminophen with codeine for his headache, which had been prescribed for a family member for another ailment.

Diamond[5] suggested that headache of posttraumatic origin results from one of three mechanisms: migraine, cluster, or tension type. Each headache is classified as acute or chronic depending on symptom duration, acute being less than 8 weeks and chronic 8 weeks or longer. This athlete's headache was unilateral, a characteristic of either the migraine or cluster-type headache.[5]

Outcomes from head injuries have been recorded according to many variables.[3,4,7,8,14,17,21] Glasgow Coma Scale scores have been used for many years as a way to compare patients according to a standardized criterion.[27] Head-injured patients with symptoms demonstrated by the athlete in this study have been reported as having mortality rates of 74% and good recovery of only 8%.[8]

The brain controls and integrates all life functions, and maintaining an environment for continued function is most crucial in an emergency situation. Symptoms often appear in direct relation to the areas affected by a lesion. The brain is encased in a closed, nonexpandable structure. Unlike other skeletal joints that are enclosed in a capsule that may swell to accommodate intra-articular fluid, the cranium cannot oblige. The brain does provide some accommodative mechanisms for space occupying matter. Increased intracranial pressure is compensated for by venous compression and cerebrospinal fluid displacement in its early stages. As these mechanisms exceed their capacity, the only avenue left for accommodation is caudal herniation through the tentorial notch.[15,24] Herniation may push structures out of the midline and compress the brain stem. This compression affects centers controlling vital functions such as blood pressure, respiration, pulse, and temperature regulation.[24]

After the brain is severely injured, its ability to use oxygen is reduced. Increased intracranial pressure leads to cellular hypoxia as it approaches or exceeds systemic arterial pressure. Without adequate respiratory exchange, the partial pressure of carbon dioxide (P_{CO_2}) may rise to dangerous levels, leading to brain damage or death. Hyperventilation during the early stages of respiratory distress will decrease resultant brain damage in a head-injured athlete.[15]

Schenk and Kinney[25] identify papilledema, headache, nausea, and vomiting as the cardinal signs of increased intracranial pressure. The decerebrate posturing is associated with transtentorial herniation of the upper brain stem.[15,24] The football player's symptoms on the sideline during the game included headache, projectile vomiting, involuntary posturing, and pupillary inequality. His symptoms correlate with the areas of involvement by the subdural hematoma.

When dealing with head injuries, the athletic trainers' tradition of finding faster ways to get athletes back to competition perhaps needs to be reviewed. Shell et al[4] report information processing deficits of 25%, 33%, and 40% with the third, fourth, and fifth concussions, respectively. Athletes who suffer a single minor head injury have a fourfold greater risk for sustaining another.[1,3] Athletic performance parameters aside, this fact may significantly impair the student-athlete in pursuit of future educational or career endeavors.

Athletic trainers who do not teach or have regular contact with faculty members may be unaware of dramatic changes in academic performance that may result from reduced information processing during the postconcussive period.[1,3,10,11] When this is combined with the difficulty in noticing substantial changes in an otherwise normal teenager's psychosocial development, the difficulty in making objective observations becomes apparent.

Neuropsychological testing probably would have been another way to determine the ongoing effect of the headache between the first and second injury in this case study, had the athlete been honest about his symptoms. The only problem with a test such as this would be the lack of a pretest for comparison. Although baseline testing would be ideal, logistical and financial considerations make it an impractical solution.

It may be argued that the potential for injury may be increasing,[13] although the rate of death from head injury is decreasing.[16] The literature is quite clear in its implications for cumulative concussion damage.[17–23] Some authors have already called for a more conservative approach in the classification system.[4,26] Given the evidence, a review or development of protocols relating to the long-term management of head injuries may be in order. In addition, educating coaches in the choice of technique when teaching blocking and tackling seems like a good practice.[1,2,13,27,28]

This case raises more than a few questions. Have athletic trainers traditionally been one-dimensional in their treatment of so-called mild head injuries by focusing mainly on symptom reduction and return-to-play criteria? Should we consider some kind of classroom performance criteria to add to our protocols when considering return to competition? Can we who deal with high school athletes be objective in our data collection without being distracted by normal adolescent moodiness? How many of the mild head injuries seen in contact sports are ticking time bombs, and how many just portend some quietly declining mental functions that may impair livelihoods and relationships? The long-term management of mild head injury seems to be fertile ground for development of the ingenious assessment and management techniques for which athletic trainers are known.

Acknowledgment

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Recurrent Metatarsal Stress Fractures in a College Football Lineman

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Abstract: *Stress fractures are common overuse injuries of bone attributed to repetitive trauma, training errors, and/or structural abnormalities. A 21-year-old, 252-lb football lineman participating in spring conditioning drills complained of right foot pain following a plantar flexion, inversion injury that occurred while cutting. Pain was concentrated over the dorsum of the foot in both weight bearing and at rest. X-ray evaluation indicated an acute stress fracture of the fourth metatarsal and two nonunions of the second and third metatarsals. Additionally, x-rays revealed metatarsus adductus, a congenital anatomic deformity. The athlete demonstrated compensatory hyperpronation in the right hind foot during a follow-up biomechanical evaluation. He was removed from weight-bearing activities, treated symptomatically for pain and swelling, and placed in a rigid orthotic. He has returned to full activity without further incident. This case report emphasizes the important role that biomechanical factors may have in osseous stress injuries.*

Stress fractures are common overuse injuries of bone attributed to repetitive trauma, training errors, and/or structural abnormalities. Stress fractures are not only among the most common overuse injuries suffered by athletes, but are also among the more potentially serious injuries.[2] Despite the frequency with which stress fractures are seen in orthopedic, sports medicine, and military clinics, their actual incidence is not well documented. Approximately 85% of 44 reported stress fractures occurred in the lower extremity.[7,9] The tibia was the most common site reported (52%), followed by the metatarsals (19%), and the fibula (16%).[7,9] The second (39%) and third (41%) metatarsals revealed the highest concentration. The skewed distribution toward second and third metatarsal stress fractures suggests the presence of underlying factors. The second metatarsal is the least resistant to bending stresses but is asked to absorb the greatest load during running.[4] This structural deficiency and excess load bearing[4] combined with sudden changes in training patterns[1] or foot pathology[1,5,6] predispose an athlete toward metatarsal stress fractures.

This case study presents an example of metatarsus adductus and its relationship to metatarsal stress fractures. Cases such as this reinforce the need to consider foot pathology as an important component in the evaluation of metatarsal stress fractures.

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Presentation of the Case

A 21-year-old black, 252-lb football lineman participating in spring conditioning drills during his junior year complained of dorsal right foot pain following a plantar flexion inversion injury. He had no previous history of ankle injuries; however, he had reported three previous incidents of foot pain following similar mechanisms of injury. Two incidents occurred before entering our institution. The first was diagnosed as a fifth metatarsal stress fracture treated by intramedullary screw fixation (Fig 1). The second was an episode of foot pain for which the athlete did not seek medical attention.

While participating in spring conditioning drills during his sophomore year, the athlete incurred his third injury. At that time, x-rays revealed a stress fracture of the third metatarsal, a nonunion of the second, and a retained intramedullary lag screw in the fifth metatarsal. The third metatarsal fracture was treated nonoperatively (Fig 2).

Physical examination of the current injury revealed tenderness along the shaft of the fourth metatarsal. Extension and flexion of the toes increased the tenderness. Swelling was present over the dorsum of the foot. Weight bearing revealed mild metatarsus adductus, more significant on the right than the left (Fig 3), calcaneal valgus, and mild hind foot pronation (Fig 4). X-rays revealed an acute stress fracture of the fourth metatarsal, nonunions of the second and third metatarsals, and metatarsus adductus (Fig 5).

The athlete was removed from weight-bearing activities for 6 weeks, placed in a rigid orthotic, and treated symptomatically for pain and swelling with cold whirlpool and Sof-Roll compression dressing (Johnson & Johnson, New Brunswick, NJ). Additionally, longitudinal arch and ankle exercises were prescribed along with a functional progression for return to activity. Criteria for return included pain-free weight-bearing activity and equal strength bilaterally. He completed the 1993 football season and the 1994 spring drills without further incident, although he continues to have periodic pain and swelling associated with repeated cutting activities. Further evaluation is being conducted to as-

Fig 1.—AP radiograph showing intramedullary screw fixation of a fifth metatarsal stress fracture and mild metatarsus adductus.

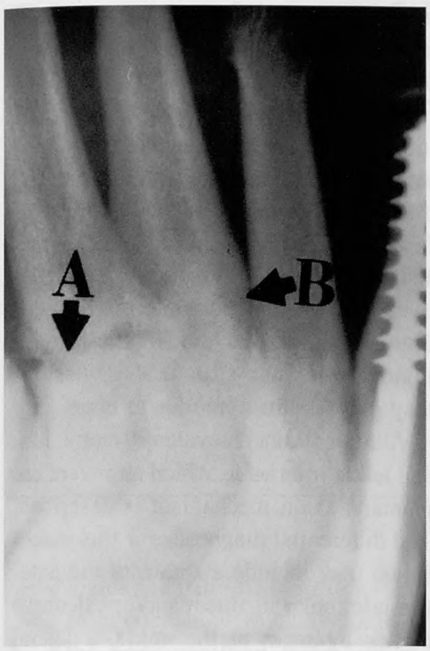

Fig 2.—A) Nonunion of a stress fracture in the second metatarsal (see arrow); B) acute stress fracture of the third metatarsal (see arrow).

certain the biomechanical efficiency of this athlete's feet.

Discussion

The uniqueness of this case is due to the location of the stress fracture and the athlete's predisposition to abnormal foot biomechanics. Orava and Hulkka[7] and Sullivan et al[9] reported that 37 (19%) of 199 recorded stress fractures were located in the metatarsals. Further breakdown of the metatarsal fractures revealed a high concentration in the second (77 (39%)) and third (81 (41%)) metatarsal shafts. The fourth and fifth metatarsals (22 (11%) and 13 (7%), respectively) accounted for all but one of the remaining fractures. These data indicate a relationship between location of greatest structural demand and most frequent metatarsal stress fracture. According to Gross and Bunch,[4] the second and third metatarsals incur the greatest strain during running activites but are the least resistant to strain structurally. In addition to the normal strain on the foot presented by running, abnormal structural alignment resulting in pathomechanical difficulties can produce a stress fracture in an unusual location.

Fig 3.—Weightbearing positions of the right foot depicting metatarsus adductus deviation of the metatarsals in the transverse plane.

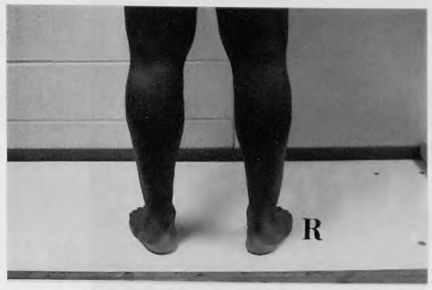

Fig 4.—Posterior view of the right foot depicting calcaneal valgus indicative of pronation.

Metatarsus adductus is an abnormal foot condition that may create compensatory action in the foot sufficient enough to cause osseous injuries.[6] It is an "osseous deformity consisting of a medial deviation of all of the metatarsals in the transverse plane."[6] The etiology is unknown; the incidence is 1:1000 with no gender predilection.[6] Clinically, there is a prominent fifth metatarsal base, a concave medial border, and a convex lateral border giving the foot the appearance of being "C"-shaped.[6] As compensation occurs, hyperpronation, soft tissue ankle equinus, and collapse of the medial longitudinal arch appear.[6] The compensated deformity is the cause of much morbidity in the adult.[6]

Fig 5.—A) Nonunion second metatarsal stress fracture; B) nonunion third metatarsal stress fracture; C) acute fourth metatarsal stress fracture.

The inability or failure of a hyperpronated foot to go into inversion produces large vertical and mediolateral forces in the fifth metatarsal that may lead to an injury.[5] An adduction stress to the forefoot, with the foot in a plantar flexed, inverted position may also predispose an athlete to an injury.[1] Both of these conditions, adducted forefoot and compensated hyperpronation, are present in metatarsus adductus.

In the case presented, the athlete had incurred a previous fifth metatarsal fracture that was treated surgically with an intramedullary screw, followed by stress fractures of the second and third metatarsal, and, finally, a fourth metatarsal fracture. The work of several researchers[2,3,5,10] indicates that the fifth metatarsal stress fracture may have occurred due to the hyperpronated, adducted foot of the football player. A confounding factor associated with the second and third metatarsal fractures may include the athlete's weight (252 lb).

The stress fracture located in the fourth metatarsal may be attributed to intramedullary screw fixation of the fifth metatarsal. DeLee, Evans, and Julian[3] have noted alterations in metatarsal stiffness and alignment following intramedullary screw fixation. Additionally, the fourth metatarsal is ligamentously bound to the fifth.[1] The increased stiffness in the fifth metatarsal transmits more stress to the fourth, thereby placing an overload on this metatarsal, resulting in osseous damage. Further, the fourth metatarsal stress fracture occurred during spring conditioning drills. Byrd's[1] research demonstrated that bones are most vulnerable to stress reactions during intense training because the strength of the bone lags behind the increase in muscle power.

Although stress injuries are commonly associated with military training and vigorous sports, we only have a vague idea of their true incidence.[8] Also, while there is still debate regarding the exact etiology of stress injuries of bone, there is evidence that training errors, repetitive trauma, and structural abnormalities all play a role. This case study presents an athlete who repeatedly stressed the bones of a biomechanically unsound foot, the result being multiple metatarsal stress fractures. The recurrent nature of these injuries, under similar training conditions, emphasizes the important etiological role that structural deviations may play in stress injuries to bone.

Athletic trainers evaluate many foot and ankle injuries in which an inversion, plantar flexion mechanism is described. The differential diagnoses for this mechanism may include a sprain of the anterior talofibular ligament and/or calcaneofibular ligament at the ankle, a lateral longitudinal arch sprain, a metatarsal stress fracture, a dorsal intermetatarsal ligament sprain, or an extensor digitorum longus strain. Appropriate diagnostic tools such as x-ray, special stress tests, and manual muscle strength assessments should be included to differentiate between osseous and soft tissue pathology. Foot biomechanics and pathomechanics should also be assessed.

Acknowledgments

We would like to thank Ted J. Waller, MD, and Robert B. Anderson, MD, for their assistance with this case study.

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Prevention of Lateral Hip Injuries in Competitive Figure Skaters

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Johnny Johns

Fig 1.—Greater trochanter area which is often contused if a skater over-rotates a jump.

Singles and pairs skaters often suffer from contusions to many points of the body resulting from falls involved with jumping. Wrist and elbow contusions commonly occur to the upper extremity; lateral hip and lateral knee contusions to the lower extremity. Protective padding is rarely worn in practice, however, because of the cumbersome nature of most sports padding.

Brown and McKeag[2] reported several upper extremity and low back injuries in male pairs skaters, with high incidences of pain in the hips and feet of female pairs skaters. Injuries to the lower extremities were more common in singles skaters. A survey of Canadian national competitors[2] showed a lack of preskating warm-up time, with 50% of all traumatic injuries usually occurring during practice. There was no correlation between injury rate and the level of the skater's experience.[1,4] In addition, a study of pairs skaters and ice dancers[4] revealed a high incidence of lower extremity injuries unrelated to age, height, weight, or national ranking.[3]

The majority of both singles and pairs skaters skate right-foot dominant; the jump is set with either the toe pick or blade, and the body rotates upward and counterclockwise (as viewed from above). The jump is completed by landing on the back outside edge of the right skate blade. Jumps are categorized as either pick or edge jumps, and also according to which edge of the skate initiates the jump (see Table).

If the skater over-rotates a jump, the forward rotational motion of the body causes him/her to land on the lateral aspect of the hip on the jumping leg, contusing the greater trochanteric region (Fig 1). Often, this is only a mild injury that responds well to icing and stretching of the lateral leg. During extended practices while training for competition, however, the frequent number of contusions to this region often lead to long-term pain and time off the ice.

Our experience with competitive figure skaters follows those described above, with the majority of soft-tissue injuries to both singles and pairs competitors. The common occurrence of lateral hip contusions led us to investigate and design an inexpensive, easily worn protective pad for hip protection during practices. It has been tested on skaters at all levels of competition, and has met with excellent results. It is less bulky than conventional hip pads, it is much more functional and practical to wear, and it will help prevent severe contusions to the hip, keeping competitors on the ice rather than in the training room and doctor's office.

Materials

- One 6-inch × 8-inch Orthoplast sheet (Johnson & Johnson, Raynham, MA)
- One sheet blue Tempastick (Kees-Gobal, Hamilton, OH)
- One roll 3-inch prewrap
- One roll 2-inch elastic wrap
- Two or three 4- or 6-inch elastic wraps
- Heavy-duty shears
- Hot water (160° to 175°F)
- One 2.25- to 2.5-inch diameter × 1-inch height circular mold

Categories of Figure Skating Jumps

Name of Jump	Starting point of jump
Toe	Outer edge of right foot with left toe pick assist*
Flip	Inner edge of left foot with right toe pick assist*
Lutz	Outer edge of left foot with right toe pick assist*
Salchow	Back inner edge of left foot†
Loop	Back outer edge of right foot†
Axel	Forward outer edge of left foot†

* Pick jumps.
† Edge jumps.

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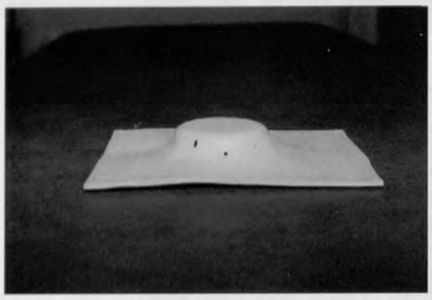

Fig 2.—Orthoplast sheet with doughnut formed in the center.

Pad Construction

Instruct the skater to wear his/her tights to ensure correct fitting of the pad and to prevent the pad from burning the skin as it cools. Before the athlete's arrival, warm the Orthoplast sheet in water and form a doughnut shape in the center of the Orthoplast. We use an aerosol can lid, cut down to 1 inch, as a mold (Fig 2). This "doughnut" will be placed over the area of the greater trochanter and will serve as protection during a fall.

Apply a spica to the hip with prewrap. Reheat the Orthoplast shell and put the mold back into the doughnut. Place the shell over the area of the greater trochanter and fix the hip spica using elastic wrap (Fig 3). Take care to ensure that the shell is not crimped to prevent ridges from forming that may cause skin irritation. Allow the shell to cool for 3 to 5 minutes. As the shell cools, it regains its rigid properties and retains the contour of the area. Remove the elastic wrap and trace the area to be covered on the shell. Trim excess shell away using heavy-duty shears, which will leave adequate protection for the area of the greater trochanter (Fig 4). Label the pad by marking the top and bottom to ensure correct fitting at all times.

Fig 3.—Orthoplast shell secured over hip spica in the area of the greater trochanter with elastic wrap.

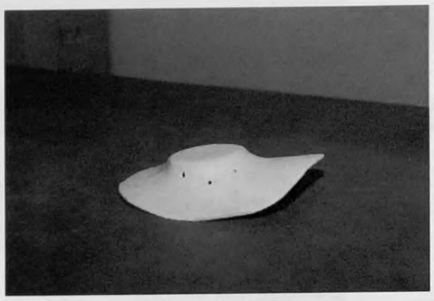

Fig 4.—Trimmed shell.

When the final shell is fully cooled, apply a sheet of blue, self-adhesive Tempastick to the inner surface of the shell. Be careful to first fill the central doughnut with Tempastick to assure sufficient padding on the section of shell that will be in contact with the bony greater trochanter. Trim the excess Tempastick using shears. Tempastick effectively provides the shock absorption during a fall, while the rigid structure of the shell transfers the force of impact away from the area of the greater trochanter. Provide a final touch by covering the rough outer edges of the pad using elastic wrap (Fig 5). The pad is best used by placing it under the shorts or tights during practice (Fig 6). It does not require straps or tape.

The structural properties of molded Orthoplast prove to be quite resistant to breaking, even in the colder temperatures of an ice rink. In addition, it is an effective means of dispersing the load of impact away from the protected area. Tempastick has been found to be an adequate means of shock absorption while providing the ability to rebound to its original thickness. Tempastick does, however, tend to break down with long-term use and sweat accumulation, but is easy to replace. The outer shell, on the other hand, rarely requires replacement, adding to the long-term economy of the pad. Reports from athletes using the pad attest to the fact that the pad is rather light and unobtrusive, and is not a hindrance during practice.

Fig 5.—Completed pad with Tempastick and elastic wrap applied.

Fig 6.—Pad in place under tights.

Acknowledgment

We would like to thank Ryan Jahnke, 1993 USFSA Novice Men's National Champion, for his assistance in developing this article.

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Abstracts

Clint Thompson, MS, ATC

Rubinstein RA Jr, Shelbourne KD, McCarroll JR, VanMeter CD, Rettig AC. The accuracy of the clinical examination in the setting of posterior cruciate ligament injuries. *Am J Sports Med.* 1994;22:550–557.

Thirty-nine subjects volunteered for this blinded, randomized, and controlled study to assess the clinical examination skills of orthopedic surgeons with fellowship training in sports medicine. Eighteen of the patients had 19 chronic isolated posterior cruciate ligament tears. The controls were 9 patients with 9 anterior cruciate ligament-deficient knees, 12 subjects with normal knees, and the contralateral normal knees of the ligament-deficient patients. To eliminate preexamination bias, all examiners were blinded from the examinee's history, identity, and diagnosis. The overall clinical examination accuracy for all orthopedic surgeons was 96%. The accuracy for detecting a posterior cruciate ligament tear was 96%, with a 90% sensitivity and a 99% specificity. The examination accuracy was higher for grade II and III posterior laxity than for grade I laxity. Eighty-one percent of the time, the examiners agreed on the grade of the posterior cruciate ligament tear for any given patient. The posterior drawer test, which included palpation of the tibia-femur step-off, was the most sensitive and specific clinical test. A thorough and precise physical examination, coupled with a patient history, can be considered diagnostic in the majority of isolated posterior cruciate ligament injuries. With this accuracy level known, the natural history of isolated posterior cruciate ligament tears can be reliably documented and studied.

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Ho SS, Coel MN, Kagawa R, Richardson AB. The effects of ice on blood flow and bone metabolism in knees. *Am J Sports Med.* 1994;22:537–540.

The effects of an ice wrap, applied to a knee for 20 minutes, on blood flow and bone metabolism were measured using triple-phase technetium bone scans. Twenty-one subjects between 29 and 63 years of age were studied. A commercially available ice wrap was applied to one knee 20 minutes before scanning, while an identical wrap left at room temperature was applied to the opposite knee to act as a control. Scans of the knees were obtained at the completion of cooling, and the images were quantified by computer image analysis for each knee at each phase of the scan. Percentage of decrease in blood flow and subsequent bone uptake of technetium for the iced knee as compared with the opposite knee were calculated. All iced knees demonstrated decreased arterial and soft tissue blood flow as well as decreased bone uptake, which is a reflection of changes in both bone blood flow and metabolism. The average decrease was 38.4% $\pm$ 4.97% in arterial blood flow, 25.8% $\pm$ 2.04% in soft tissue blood flow, and 19.3% $\pm$ 2.0% (SE of the mean in each) in bone uptake. This ice effect was not related to age, sex, knee circumference, or skin temperature after cooling. By decreasing blood flow and cell metabolism, ice theoretically can limit hemorrhage and cell death in the setting of acute traumatic injury. This study thus provides a scientific rationale for the use of ice as tested for such injuries to a large joint, whether in the soft tissues or bones.

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Zatterstrom R, Friden T, Lindstrand A, Moritz U. The effect of physiotherapy on standing balance in chronic anterior cruciate ligament insufficiency. *Am J Sports Med.* 1994;22:531–536.

Body sway movements in the frontal plane in a single-limbed stance test were used to assess postural control in 26 patients with chronic anterior cruciate ligament insufficiency. The injured and the noninjured legs were tested before the patients were committed to physiotherapy for 3 to 6 months. Follow-up tests were made after 3, 12, and 36 months. Significant disturbance of the balance of both legs was found before training, compared with a reference group of normal subjects. Values of the noninjured leg were normalized after 3 months of training, but the injured leg still showed an increased body sway. Normal balance parameters on the injured side were found at examination after 12 months. Follow-up examination after 36 months proved persistent normalization of the single-limbed balance on both sides.

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Reider B, Sathy MR, Talkington J, Blyznak N, Kollias S. Treatment of isolated medial collateral ligament injuries in athletes with early functional rehabilitation. A five-year follow-up study. *Am J Sports Med.* 1994;22:470–477.

A prospective study was designed to provide 5-year followup of the treatment of isolated grade III sprains of the medial collateral ligament with early functional rehabilitation in 35 athletes. After injury, patients were placed in lateral hinged braces to provide valgus support without restricting flexion or extension of the knee. Treatment was initiated with range-of-motion exercises performed in a whirlpool or swimming pool. Patients were then started on quadriceps setting and leg raises. When 90° of flexion was present, resistive exercises were added. Upon recovery, patients were allowed to return to unrestricted sports. Followup consisted of both questionnaires and physical examination, and was graded on the 50-point Hospital for Special Surgery scale. Mean followup was 5.3 years (range, 2.5 to 8); mean Hospital for Special Surgery knee rating score was 45.9 points (range, 41 to 50). These results are comparable with those achieved with surgery or immobilization by earlier investigators. Thus, early functional rehabilitation treatment of complete medial collateral ligament sprains produces results comparable with those achieved with surgery or immobilization while minimizing treatment-related morbidity and allowing more rapid return to sports participation.

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Paulos LE, Wnorowski DC, Greenwald AE. Infrapatellar contracture syndrome. Diagnosis, treatment, and long-term follow up. *Am J Sports Med.* 1994;22:440–449.

Infrapatellar contracture syndrome is an uncommon but recalcitrant cause of reduced range of motion after knee surgery or injury. The results and conclusions presented here are based on a retrospective clinical study evaluating the long-term outcome in 75 patients who developed infrapatellar contracture syndrome. These 75 patients (76 knees) were evaluated at an average followup of 53 months after the index (inciting) procedure or injury. Comparing subgroups within the study population, factors that correlated with poorer results or more severe infrapatellar contracture syndrome were found to be acute anterior cruciate ligament repair or reconstruction, the use of patellar tendon autograft for anterior cruciate ligament reconstruction, nonisometric graft placement, multiple surgical procedures, use of closed manipulation, and the development of patella infera. We concluded that appropriate procedures can substantially increase the range of motion in patients with infrapatellar contracture syndrome. However, residual functional morbidity persists in many patients, and the outcome, as determined by subjective knee function scores, is only fair. The natural history of an anterior cruciate ligament-deficient knee appears to be more benign than the natural history of a knee that develops infrapatellar contracture syndrome.

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Zavatsky AB, Beard DJ, O'Connor JJ. Cruciate ligament loading during isometric muscle contractions. A theoretical basis for rehabilitation. *Am J Sports Med.* 1994;22:418–423.

A model of the knee in the sagittal plane was used to investigate the ligament forces resulting when an external load applied to the tibia resisted either extension or flexion of the knee under increasing isometric quadriceps or hamstrings contractions, respectively. An elementary mechanical analysis showed which ligament, the anterior or posterior cruciate, was loaded at a given flexion angle and known line of action of the external load. Ligament force, as a proportion of the external load, was also calculated. The results serve as guidelines for the design of injury-specific physical therapy techniques for use after cruciate ligament reconstruction.

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Haimes JL, Wroble RR, Grood ES, Noyes FR. Role of the medial structures in the intact and anterior cruciate ligament-deficient knee. Limits of motion in the human knee. *Am J Sports Med.* 1994;22:402–409.

We measured motion limits in human cadaveric knees before and after sectioning the anterior cruciate ligament and the medial structures. Sectioning the medial collateral ligament in an anterior cruciate ligament-deficient knee increased the anterior translation limit at 90° of flexion but not at 30° of flexion. The tibia displaced straight anteriorly without exhibiting the coupled internal rotation that occurred in intact and anterior cruciate ligament-deficient knees. A lateral 15 N-m abduction moment produced a coupled external rotation in the medial collateral ligament-deficient knee. This was in marked contrast to intact, anterior cruciate ligament-deficient, or combined medial collateral ligament and anterior cruciate ligament-deficient knees, in which an abduction moment produced a coupled internal rotation. Sectioning only the medial collateral ligament caused a small but significant increase in the abduction rotation limit, whereas larger increases in the abduction rotation limit occurred when the posterior oblique ligament and posterior medial capsule were cut in addition to the medial collateral ligament. Cutting the medial collateral ligament increased the external rotation limit. The increase was independent of whether the anterior cruciate ligament was intact or sectioned. Subsequent cutting of the posterior oblique ligament and posterior medial capsule further increased the external rotation limit.

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Perrin DH. Open chain isokinetic assessment and exercise of the knee. *J Sport Rehab.* 1994;3:245–254.

This paper reviews the concepts associated with isokinetic open chain assessment and exercise of the quadriceps and hamstring muscle groups. Following a review of the isokinetic concept of exercise, the paper addresses principles of musculoskeletal and cardiovascular screening, warm-up, body position, stabilization, and joint alignment. Gravity correction, test and exercise velocity, and duration of exercise are also addressed. Interpretation of an isokinetic evaluation of the knee is also addressed within the context of force-velocity relationship, peak torque relative to body weight and bilateral and reciprocal muscle group relationships. Joint range of motion and test velocity are also discussed with respect to patellofemoral and tibiofemoral joint forces. Finally, recommended protocols for isokinetic assessment and exercise of the quadriceps and hamstring muscle groups are presented.

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Rosenthal MD, Baer LL, Griffith PP, Schmitz FD, Quillen WS, Finstuen K. Comparability of work output measures as determined by isokinetic dynamometry and a closed kinetic chain exercise. *J Sport Rehab.* 1994;3:218–227.

The purpose of this study was to determine if a relationship existed between work output as measured by the Lateral Step-Up Test (LSUT) and work output as measured by a Kin-Com isokinetic dynamometer test (KCT). Forty subjects were randomly assigned to one of two different testing orders. Subjects performed each test with their dominant leg only. Group 1 performed the LSUT followed by the KCT. The second group performed the same two exercises in reverse order. A multiple linear regression analysis was performed (Kin-Com work = Constant + Age + Gender + Lateral step-up work) and was found to provide a good fit to the data. Gender, age, and lateral step-up work were each subsequently analyzed, with the other independent variables held constant. A significant relationship existed ($r = .74$, $p < .01$) between the calculated work performed on the LSUT and Kin-Com work. This preliminary finding suggests that clinicians may consider employing standardized closed kinetic chain exercise tests as an objective measure of musculoskeletal performance.

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Sinacore DR, Jacobson RB, Delitto A. Quadriceps femoris muscle resistance to fatigue using an electrically elicited fatigue test following intense endurance exercise training. *Phys Ther.* 1994;74:930–939; discussion 939–942.

Background and Purpose—Electrical stimulation has been used to assess skeletal muscle resistance to fatigue. The purpose of this study was to test the hypothesis that 12 weeks of intense endurance exercise training on a bicycle ergometer would reduce the percentage of decline in quadriceps femoris muscle torque during an electrically elicited fatigue test. **Subjects and Methods**—Eleven nondisabled subjects performed 12 weeks of high-intensity endurance exercise training, and six subjects served as controls and did not exercise. Two electrically elicited fatigue tests, one with and one without prior voluntary fatiguing exercise, were administered to each subject before and after the 12-week training period. **Results**—The percentage of decline in peak torque of the quadriceps femoris muscle over 50 electrically elicited muscle contractions did not change as a result of endurance exercise training, despite significant improvements in maximal oxygen consumption and quadriceps femoris muscle endurance. The recovery of maximal isometric torque immediately after exhausting voluntary exercise followed by electrical stimulation was significantly greater after 12 weeks of intense exercise training. **Conclusion and Discussion**—The percentage of decline in peak torque during an electrically elicited fatigue test does not detect improvements in quadriceps femoris muscle endurance induced by endurance exercise training. The percentage of initial torque recovered immediately after fatiguing exercise, however, is improved by endurance training.

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Snyder-Mackler L, Delitto A, Stralka SW, Bailey SL. Use of electrical stimulation to enhance recovery of quadriceps femoris muscle force production in patients following anterior cruciate ligament reconstruction. *Phys Ther.* 1994;74:901–907.

Background and Purpose—Electrical stimulation has been shown to be effective in aiding the recovery of quadriceps femoris muscle force production after anterior cruciate ligament reconstruction. The actual dosage of stimulation (training intensity) has not been well described. The purpose of this investigation was to establish a dose-response curve for electrical stimulation regimens designed to improve quadriceps femoris muscle recovery in patients after anterior cruciate ligament reconstruction. **Subjects and Methods**—We analyzed data from a subsample of patients ($n = 52$) receiving electrical stimulation ($n = 110$) who were involved in a large, multicenter randomized clinical trial investigating treatment strategies designed to enhance quadriceps femoris muscle recovery. Fifty-two subjects (40 male, 12 female), with an age range of 15 to 43 years (mean = 25 ± 7), participated in 4 weeks of quadriceps femoris muscle training using either portable, battery-powered home stimulators or console stimulators designed for clinical use. Training intensities were monitored by logging the electrically elicited knee extension torque and expressing this torque as a percentage of the uninvolved quadriceps femoris muscles' maximal voluntary contraction force. After the 4 weeks of training, isometric muscle torque was assessed and a dose-response curve was generated. The relationship between training intensity and quadriceps femoris muscle torque was assessed with Pearson Product-Moment Correlation Coefficients. **Results**—A significant, linear correlation was found between training intensity and quadriceps femoris muscle torque. Subjects training with console, clinical generators trained at higher intensities than those training with portable, battery-operated generators; such training resulted in higher quadriceps femoris muscle torque. **Conclusion and Discussion**— These results support the use of high-intensity electrical stimulation and do not support the use of low-intensity or battery-powered stimulators when the goal is recovery of quadriceps femoris muscle force production in the early phases of rehabilitation after anterior cruciate ligament surgery.

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Kaikkonen A, Kannus P, Jarvinen M. A performance test protocol and scoring scale for the evaluation of ankle injuries. *Am J Sports Med.* 1994;22: 462–469.

The aim of the study was to introduce and evaluate a standardized test protocol and scoring scale for evaluation of ankle injuries. After evaluation of 11 different functional ankle tests, questionnaire answers, and results of clinical ankle examination, the final test protocol consisted of three simple questions describing the subjective assessment of the injured ankle, two clinical measurements (range of motion in dorsiflexion, laxity of the ankle joint), one ankle test measuring functional stability (walking down a staircase), 2 tests measuring muscle strength (rising on heels and toes), and one test measuring balance (balancing on a square beam). Each selected test showed excellent reproducibility when tested with a reference group of 100 uninjured persons. According to the test results of a population of 148 patients with an operatively treated grade III lateral ligament injury of the ankle, each test could significantly differentiate healthy controls and patients with excellent overall healing from those with poor or fair recovery. The final total test score correlated significantly with the isokinetic strength results of the ankle, subjective opinion about the recovery, and subjective-functional assessment. The scale presented is recommended for studies evaluating functional recovery after ankle injury.

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Sitler M, Ryan J, Wheeler B, et al. The efficacy of a semirigid ankle stabilizer to reduce acute ankle injuries in basketball. A randomized clinical study at West Point. ***Am J Sports Med.*** **1994;22: 454–461.**

This randomized clinical study was designed to prospectively determine the efficacy of a semirigid ankle stabilizer in reducing the frequency and severity of acute ankle injuries in basketball. Athletic shoe, playing surface, athlete-exposure, ankle injury history, and brace assignment were either statistically or experimentally controlled. Participants in the study were 1601 United States Military Academy cadets with no preparticipation, clinical, functional, or radiographic evidence of ankle instability. Subjects experienced a total of 13,430 athlete-exposures in the 1990 and 1991 intramural basketball seasons. Ankle injury was defined as acute trauma to the ankle ligaments that resulted in an athlete's inability to participate in basketball 1 day after the injury. Use of ankle stabilizers significantly reduced the frequency of ankle injuries. Reduction in ankle injuries, however, depended on the nature of injury (fewer contact injuries occurred among those who wore braces). Injury severity was not statistically reduced, and wearing the ankle stabilizer did not affect the frequency of knee injuries. Attitude toward ankle stabilizer use improved as use of the stabilizer increased.

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Worrell TW, Booher LD, Hench KM. Closed kinetic chain assessment following inversion ankle sprain. ***J Sport Rehab.*** **1994;3:197–203.**

The purpose of this study was to compare the injured versus noninjured lower extremity on three single-leg hop tests following inversion ankle sprain. Twenty-two subjects with a history of unilateral inversion ankle sprain participated in this study. Subjects performed the three single-leg hop tests (hop for distance, hop for time, and agility hop). An independent t test was used to compare extremities. No significant differences existed on any hop test for the 22 subjects. In 8 of the 22 subjects who reported pain with activities of daily living and/or sports activities, an independent t test revealed no significant difference on hop test performance between extremities. We conclude that these single-leg hop tests lack sensitivity (validity) in detecting lower extremity performance deficits as reported by the subjects following inversion ankle sprain.

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Meyer SA, Callaghan JJ, Albright JP, Crowley ET, Powell JW. Midfoot sprains in collegiate football players. ***Am J Sports Med.*** **1994;22:392–401.**

We studied midfoot sprains in collegiate football players to define and document incidence, mechanisms, injury patterns, and disabilities. Twenty-three athletes with 24 injuries from 1987 through 1991, with a mean followup of 30.8 months, were identified for the study. The injuries occurred in 4% of the football players per year with offensive linemen incurring 29.2% of the injuries. The location of maximal tenderness on physical examination was an important prognostic indicator such that injuries with medial and global midfoot tenderness to palpation had the longest time loss from participation and time until full healing. Lateral midfoot sprains required short periods of disability, and players were able to return to participation with the use of an orthosis. Nineteen athletes with 20 injuries responded to a questionnaire. Four players reported residual functional problems. Only one of these players had to modify his recreational activities because of pain. The other players remained very active with only mild complaints of pain after high-demand activities. Midfoot sprains were associated with acute disability that required prolonged restriction from competition, but for most players the long-term residual problems were minor.

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Mont MA, Cohen DB, Campbell KR, Gravare K, Mathur SK. Isokinetic concentric versus eccentric training of shoulder rotators with functional evaluation of performance enhancement in elite tennis players. ***Am J Sports Med.*** **1994;22:513–517.**

Thirty elite tennis players were randomly assigned to three groups to evaluate shoulder isokinetic internal and external rotation training: an isokinetic concentric group, an isokinetic eccentric group, and a control group with no training. Subjects were tested before and after training both concentrically and eccentrically using an isokinetic dynamometer. Functional output before and after training was assessed by the average and peak velocity of six maximal serves. The effect of training on serve velocity endurance was also assessed. Statistically significant concentric and eccentric strength gains (11%) were obtained in both training groups when compared with controls (decreased total average strain of 2%) ($p < .0004$). Serve velocity increased by greater than 11% in both training groups, which was a significant increase from the average of 1% in the control group ($p < .0001$). In the endurance study, training group subjects displayed a tendency to maintain their serve velocity (loss of approximately 2%) greater than controls (loss of 6.4%) ($p < .05$). Isokinetic training led to increases in objective and functional output in elite tennis players. This training regimen may have significance in the final stages of the rehabilitation of injured shoulders as well as in improved performance and reduced injury risk.

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Dowdy PA, O'Driscoll SW. Recurrent anterior shoulder instability. *Am J Sports Med.* 1994;22:489–492.

The purpose of this study was to compare two radiographic methods for measuring anteversion and to determine whether glenoid anteversion is a significant factor in recurrence of instability after anterior repair. West Point axillary roentgenograms were obtained in 128 patients (138 shoulders) at a mean of 9 years after surgery. Two methods to measure glenoid anteversion were compared: the angle between the glenoid and the body of the scapula, and the angle between the glenoid and the posterior margin of the acromion. There was less variation in the measurements using the glenoid margin-posterior acromion angle. By this method, anteversion was 11° ± 4° for the 15 patients with multiple (two or more) recurrences, 8° ± 3° for the 15 patients with one recurrence, and 6° ± 5° for the 109 patients with no recurrences. Although these differences are statistically significant ($p = .003$), they probably are not clinically important because they are small (mean of only 5°). The differences obtained by measuring the angle between the glenoid and the body of the scapula were not statistically significant.

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Dillman CJ, Murray TA, Hintermeister RA. Biomechanical differences of open and closed chain exercises with respect to the shoulder. *J Sport Rehab.* 1994;3:228–238.

Confusion of the terms open and closed kinetic chain and scarcity of research comparing kinetic chain exercises that have similar mechanics and loading prompted this case study. Exercises were classified by the boundary condition of the distal segment and presence of an external load. Classifications included a fixed boundary condition with an external load (FEL), a movable boundary with an external load (MEL), and a movable boundary with no external load (MNL). It was hypothesized that if the direction and mass of loading in MEL and FEL exercises were similar, the electromyographic activity of the primary muscle groups involved would be comparable. Muscular activity was monitored from six shoulder muscles during one MNL, four MEL, and five FEL exercises. The results indicated that MEL and FEL exercises having similar biomechanics produced comparable muscular activity. Evaluation and selection of exercises for patients should be based upon mechanics and loading that achieve appropriate muscle activity.

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Itoi E, Motzkin NE, Morrey BF, An KN. Contribution of axial arm rotation to humeral head translation. *Am J Sports Med.* 1994;22:499–503.

The contribution of axial arm rotation to translation of the humeral head with the arm in the hanging position was examined using nine fresh-frozen cadaveric shoulders. Three standard clinical tests were simulated: anterior and posterior translation and sulcus tests. In both the anterior translation and sulcus tests, anterior and inferior displacements were significantly restricted in internal rotation but not in neutral and external rotation. In the posterior translation test, no significant differences in displacement could be observed in internal, neutral, or external rotation. Since anterior and inferior translations of the humeral head were significantly affected by the rotation of the arm, we recommend that the anterior translation and sulcus tests be performed in various rotations.

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Kelley JD, Lombardo SJ, Pink M, Perry J, Giangarra CE. Electromyographic and cinematographic analysis of elbow function in tennis players with lateral epicondylitis. *Am J Sports Med.* 1994;22:359–363.

Lateral epicondylitis occurs frequently in tennis players and appears to be caused by tears in the extensor aponeurosis. The purpose of this study was to compare the electromyographic activities of five muscles in players with lateral epicondylitis with those of injury-free players during the single-handed backhand tennis stroke. Fine wire electrodes were placed into the extensor digitorum communis, extensor carpi radialis longus and brevis, pronator teres, and flexor carpi radialis muscles in competitive tennis players; 8 players had lateral epicondylitis and 14 had normal upper extremities. The backhand stroke then was recorded on high-speed film and synchronized with the electromyographic signal. The injured players had significantly greater activity for the wrist extensors and pronator teres muscles during ball impact and early follow-through. This activity increase may have been caused by the abnormal mechanics evident on film, including a leading elbow, wrist extension and an open racquet face near the time of ball impact, and ball contact in the lower half of the strings. These mechanics not only result in a lower level of play but also leave the wrist extensors and the pronator teres muscles vulnerable to injury. This is the first study that documents increased activity in muscles that have been previously injured.

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Kantor G, Alon G, Ho HS. The effects of selected stimulus waveforms on pulse and phase characteristics at sensory and motor thresholds. *Phys Ther.* 1994;74:951–962.

Background and Purpose—The purposes of this investigation were to determine the effect of five commonly used voltage waveforms (four pulsed and one sinusoidal) on excitation of sensory and motor nerves and to characterize variables associated with reaching threshold.

Subjects—Eighteen healthy subjects were stimulated during one session via surface electrodes placed over the forearm and leg. **Methods**—Stimulation amplitude was increased at a constant rate, and the threshold of sensory and motor excitation was determined. Measured variables included peak voltage, peak current, phase charge, and total pulse charge. **Results**—Three-factorial, repeated-measures analysis of variance and Newman-Keuls tests revealed that phase charge varied the least during excitation induced by the five waveforms. Total pulse charge markedly increased when bursts of 10 symmetrical pulses, 25 symmetrical pulses, or amplitude-modulated waveforms were used. Monophasic and symmetrical biphasic waveforms required the least amount of total pulse charge. All measurements were higher during motor threshold than during sensory threshold, and the measurements were higher in the leg than in the forearm. **Conclusion and Discussion**—The authors concluded that all five studied waveforms were effective at threshold excitation of peripheral sensory and motor nerves. Of the five waveforms, the symmetrical biphasic waveform, having a low total pulse charge, may be the preferred waveform, and the 25 symmetrical pulses and amplitude-modulated waveforms may be considered the least preferred, due to high total pulse charge.

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Lindenfeld TN, Schmitt DJ, Hendy MP, Mangine RE, Noyes FR. Incidence of injury in indoor soccer. *Am J Sports Med.* 1994;22:364–371. Review article: 25 refs.

All injuries occurring over a 7-week period at a local indoor soccer arena were documented for analysis of incidence rates. All injury rates were calculated per 100 player-hours. The overall injury rates for male and female players were similar, 5.04 and 5.03, respectively. The lowest injury rate was found among the 19- to 24-year-old athletes and the highest injury rate was found among the oldest age group (≥ 25 years). Collision with another player was the most common activity at the time of injury, accounting for 31% of all injuries. The most common injury types were sprains and muscle contusions, both occurring at a rate of 1.1 injuries per 100 player-hours. Male players suffered a significantly higher rate of ankle ligament injuries compared with female players (1.24 versus 0.43, $p < .05$), while female players suffered a significantly higher rate of knee ligament injuries (0.87 versus 0.29, $p < .01$). Goalkeepers had injury rates (4.2) similar to players in non-goal keeper positions (4.5).

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Mayhew TP, Rothstein JM, Finucane SD, Lamb RL. Performance characteristics of the Kin-Com dynamometer. *Phys Ther.* 1994;74:1047–1054.

Background and Purpose—The purpose of this study was to assess the performance characteristics of a Kin-Com dynamometer (model #500–11) under controlled conditions. **Methods**—Comparisons were made between measurements of force, angle, and velocity obtained from the Kin-Com and measurements acquired from an external recording system of known weights, angles, and user-set velocities. The strength of the linear relationships between measurements obtained with the different recording systems was analyzed using a coefficient of determination (r^2). An intraclass correlation coefficient (ICC[2,1]) was used to examine the reliability of the force, angle, and velocity measurements obtained with each recording system on two different days. **Results**—In all conditions, the coefficient of determination for the force, angle, and velocity comparisons was above .99. The ICC for between-day comparisons for all force, angle, and velocity measurements was above .99. **Conclusion and Discussion**—Our results indicate that the static measurements of force and angle that are necessary for use in the gravity-correction procedure and isometric testing are accurate and replicable between days. The Kin-Com dynamometer's control system regulating lever arm velocity is also accurate and replicable under a no-load condition. It was ascertained during the velocity testing that the use of any acceleration and deceleration mode other than high resulted in a loss of excursion of the lever arm.

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Domholdt E, Flaherty JL, Phillips JM. Critical appraisal of research literature by expert and inexperienced physical therapy researchers. *Phys Ther.* 1994;74:853–860.

Background and Purpose—In this study, critical appraisal skills of both inexperienced and expert physical therapist researchers were compared and the effect of the following independent variables on the appraisal skills of novices was examined: years of physical therapy practice, postgraduate experience with research, level of comfort with research, journal reading habits, and content-specific expertise. **Subjects and Methods**—Four expert and 20 inexperienced researchers critiqued the same research article. A content analysis of the expert critiques was used to develop a set of 12 items of concerns about the study. **Results**—Experts identified a mean of 7.75 items of concern; novices identified a mean of 3.95 items. For 10 of the 12 items, a greater proportion of experts identified each concern compared with the novices. Novices had comparatively less difficulty identifying concerns with internal validity than they did identifying issues relating to construct validity. Only one of the variables—content-specific expertise—was associated with differences in critical appraisal skills among the novices. **Conclusion and Discussion**—These findings suggest that analysis of construct issues in research articles is a more advanced skill than analysis of research design and that critical appraisal of research literature is enhanced by clinical experiences related to the subject of the research report.

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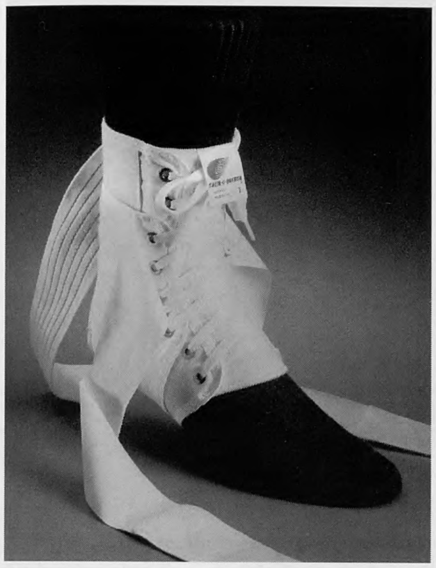
New Products

Barrie Steele, MS, ATC

Swede-O, Inc. Adds the Swede-O Strap Lok™ Ankle Brace to Product Line

Swede-O, Inc announces the addition of the Swede-O Strap Lok™ to its line of sports medicine products.



The Swede-O Strap Lok combines Ankle Lok straps with the exclusive patented Ankle Lok offset flap in a cooler, lightweight brace made of ballistic-type nylon material. The new nonstretch nylon straps surround the ankle in a figure-eight pattern, locking it in a protected position, while the offset eyelets provide optimum leverage for the most secure lace-up in the industry. As with other Swede-O products, the Swede-O Strap Lok is available in both classic white or jet black material.

Designed for comfort as well as protection, its thin, low-bulk design fits easily in any regular athletic shoe. An all-elastic back ensures complete unrestricted blood flow to the Achilles tendon and virtually eliminates blistering. The Swede-O Strap Lok also features a short-curved arch that allows for a comfortable full range of motion.

For more information call 800-525-9339.

3M Active Strips Bandages with Extra Sticking Power for Damp or Perspiring Skin

3M Active Strips Flexible Foam Bandages provide excellent adhesion in challenging conditions such as patients with diaphoretic or damp skin. Unlike many conventional bandages that can curl up, fall off, or chafe the skin, 3M Active Strips bandages stretch and conform to the skin—making them ideal for protecting venipuncture sites, finger sticks, small surgical procedures, and minor wounds.

3M Active Strips bandages offer patient comfort and protection as well as excellent moisture resistance. Hypoallergenic Active Strips bandages are easy to apply and provide adhesion around the wound to help keep dirt or other contaminants out of the site. Their soft, absorbent pads won't stick to wounds.

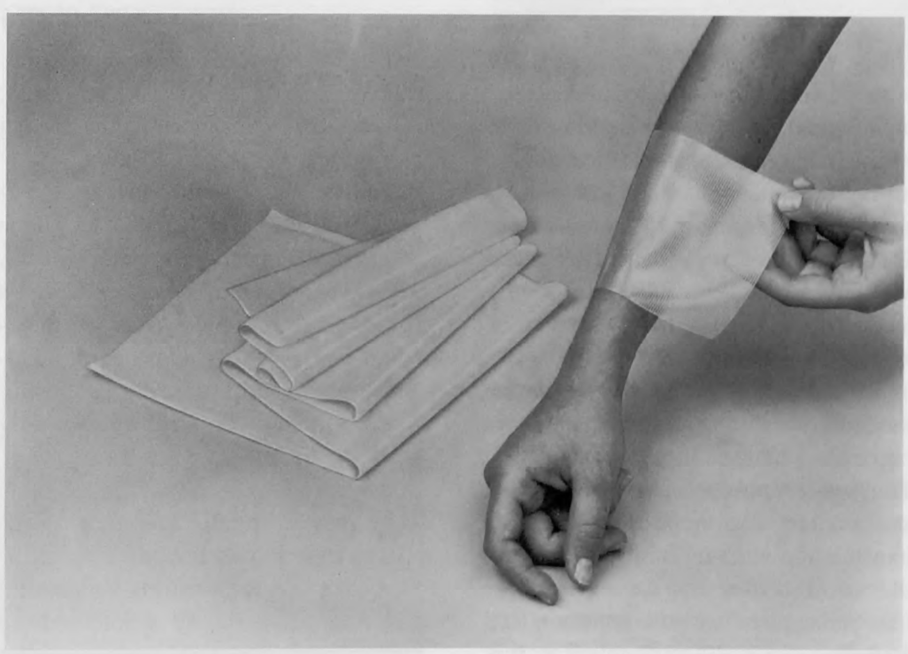
The strip and knuckle bandages are packed 100 per box with 12 boxes per case. The spot bandages are packed 100 per box, with 18 boxes per case. The large patch-sized bandages are packed 50 per box with 18 boxes per case.

For more information call 612-733-3139.

Siloskin: A New Sterilized Barrier Dressing

Available in both 4″ × 4″ and 6″ × 8″ configurations, Siloskin, when applied to the affected, painful area, acts as a protective second layer of skin as it simultaneously alleviates friction and shear forces. The sterile 1-mm thick dressing releases a patented gel onto the skin that softens, soothes, and helps seal out bacteria to prevent infection.

Siloskin can be used on scar tissue and over sutured areas. It is also recommended for the treatment and prevention of blisters and/or irritated skin. Available in individual sealed sterile packages, Siloskin can be cut to any size or shape and held in place with an adhesive. Derma-



tologist tested, Siloskin is both washable and waterproof. The 4 × 4 is available in packages of 5 and 10, each individually sealed; the 6 × 8 is available in packages of 3 and 5, each individually sealed.

For a complimentary sample of Siloskin, call 800-229-4404.

New Mettler Portables Are Super Ultrasound Values

Mettler Electronics is pleased to announce the new Sonicator® 715 and 716 portable ultrasounds. With new state-of-the art electronics, old-fashioned Mettler quality, and very affordable pricing, these new Sonicators add up to super ultrasound values.

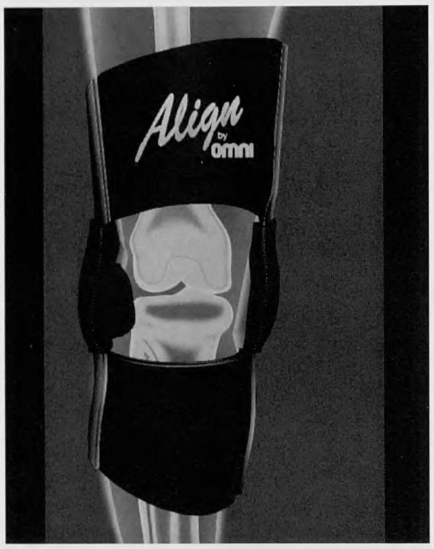
The Sonicator 715 and 716 are packed with performance advances like self-tuning circuitry to maximize ultrasound transmission, surface mount technology to improve reliability, and microprocessor control for safe and easy operation. Clinicians now have a pair of advanced Mettler ultrasounds, available at a very modest price, to meet a wide range of therapeutic applications.

With its compact 5-cm^2 transducer, the Sonicator 715 is ideal for maneuvering around narrow or angular anatomy. The small transducer maintains good skin contact and optimizes ultrasound transmission even in hard-to-treat areas like ankles or feet. For more general ultrasound applications, the Sonicator 716 features a larger, 10-cm^2 applicator. It is well suited for treating shoulders, backs, and other large, muscular areas.

For more information, call 800-854-9305.

OMNI Align Custom Correctional Knee Orthosis

OMNI announces the new OMNI Align (O.A.) prestressed correctional knee orthosis. The O.A. is scientifically designed and engineered to produce alignment of an affected knee compartment, reducing symptomatic pain and compartmental instability associated with a variety of diagnoses including mild to severe osteoarthritis, ligamentous instability, and adjunct treatment for osteochondritis dissecans.



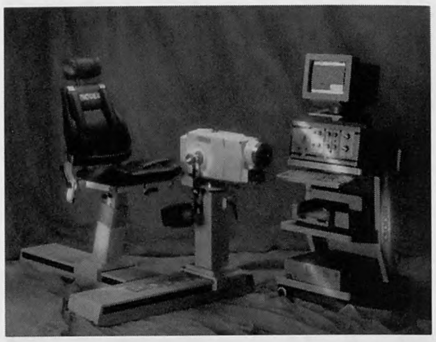
The O.A. provides effective pain relief and stabilization for patients radiographically diagnosed with 10° to 12° valgus and 8° to 10° varus by correcting the leg to a mechanical neutral position.

The O.A. is custom fabricated, employing an advanced cast mold technique to produce a precise correction and fit. The O.A. orthosis incorporates OMNI's X-Cell thigh restraint system which accommodates soft tissue changes, eliminating brace pistoning and migration.

For further information call 800-448-6664.

Give your Clinic the Advantage with Advantage Software v4.0

Biodex Medical Systems has just released their new Advantage Software v4.0 created to enhance the Multi-Joint System 2AP Single or Double Chair. In addition to auto-programming, real-time adjustments and biofeedback, version 4.0 includes pathology specific reports to quantify ACL functional deficiency and ACL functional outcome for comparison with normative data. Unlike most generic, statistical reports, these new reports have real meaning and are easy to understand—for the clinician, the patient, third-party payers, and referring physicians.



To support the Biodex Managed Outcome philosophy, Advantage Software v4.0 is available with PTEX, a software program that allows the therapist to create patients' home/clinic exercise programs for their specific needs (reps, sets, weights). Once selected from a menu of more than 470 exercises, reports are presented with exercise instructions, illustrations, and a check-off compliance chart to keep patients motivated. PTEX helps patients to actively comply with their exercise program while helping clinicians to restore patient function within the imposed time frames of healthcare reform policies.

Packaged with every new Biodex Multi-Joint System, Advantage Software v4.0 is also available as an upgrade option to current System 2 owners. For more information call 800-224-6339.

Stabilize Shoulder Joints, Post injury/post surgery

SPORLASTIC of Germany introduces to the US sports medicine market a completely new concept in shoulder stabilization. Designed by a professional trainer for the Munich hockey team, the Shoulder Dislocation Orthotic is a custom-moldable brace that will firmly position the shoulder joint post surgery, post injury. This brace is totally adjustable: the thin-wall synthetic shells can be heat molded and cut to fit, and the straps and Velcro connectors are adjustable to comfortably fit any size individual. Mobility is restricted by a torsion joint and screw fitting at the shoulder joint and by the stabilizing effect of the shell, straps, and foam pads.

Excellent for shoulder dislocation injuries in wrestling, football, hockey, etc, the brace is lightweight, completely adjustable, and can be worn under clothing. Parts are replaceable, foam is washable, and shells can be reheated, reshaped.

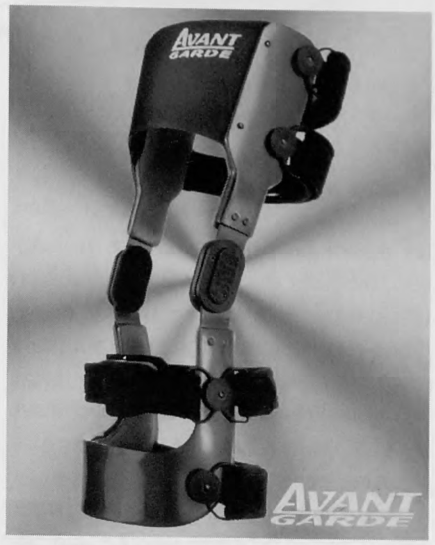
The Shoulder Dislocation Orthotic is available in right or left, one size, and can be cut and shaped to fit individuals. It is billable as a "custom orthotic," available at a special introductory sports medicine price of $129.

For further information call 800-453-0804.

The AVANT GARDE Carbon Composite Brace

Omni Scientific announces the introduction of the Avant Garde carbon composite brace. The lightweight Avant Garde custom knee orthosis is the optimum, high-strength lightweight brace design for the future.

The Avant Garde is a custom-crafted high strength carbon composite structure using advanced high modulus "sandwich" structural design techniques. A unique and proprietary composite structure molding process developed by OMNI provides a precision custom fit for each patient for optimum comfort and control.



The Avant Garde incorporates the Omni X-Cell thigh restraint system which accommodates soft tissue changes, eliminating brace pistoning and migration. The Avant Garde is available in a wide variety of colors and comes with a 10-year warranty on the frame.

For more information call 800-448-6664.

Fabrifoam Products: Medi-Wrap™ and Pro-Wrap™

Fabrifoam Products, a division of Applied Technology International, Ltd, has introduced a series of unique, multi-functional, adjustable "compression/support therapy" wraps.

Medi-Wrap™ and Pro-Wrap™ are fabricated from Applied Technology International, Ltd's patented composite material, Fabrifoam®. These two wraps have been clinically tested by several well-recognized Athletic Trainers and other medical professionals, who have found both products to be effective in treating injuries and problems related to

joints (ankles, knees, elbows, wrists), digits, tendons, quadriceps, hamstrings, and lumbar area.

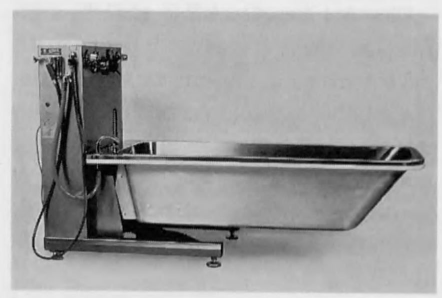
Medi-Wrap and Pro-Wrap *breathe* ... greatly reducing or eliminating maceration. Because of the coefficient of friction of the unique cushionized composites, these therapy wraps will not migrate. The substrate materials are totally Velcro™ receptive, allowing for infinite adjustability.

Medi-Wrap and Pro-Wrap are washable, sterilizable, autoclavable and are designed for repeated uses. The application of these two extremely effective support wraps eliminate the discomfort and irritation of adhesive tapes. Medi-Wrap and Pro-Wrap are packaged in dispenser boxes and available in 2″, 3″, 4″, and 6″ rolls, in 5-yard lengths.

For more information, call 610-363-1077.

Ferno Ille Introduces Stainless Steel Hydro-Massage Systems

Ferno Ille, a division of Ferno-Washington, Inc, announced the introduction of Models 891 and 991 Stainless Steel Hydro-Massage Therapy Systems. Model 891 is a fixed-height system, while Model 991 offers a height-adjustable tub.



The ergonomically-designed control panels feature a unique thermoscopic mixer, providing for both therapy and bathing usage such as burn treatments, full-body hydro-massage, and resident or patient bathing.

Both units offer important safety features such as a mixer that both maintains accurate temperature settings, regardless of varying water pressure, and completely shuts off the flow of water within 1.5 seconds if the cold-water pressure drops to a critical level.

Both systems offer a built-in disinfection system and both are compatible with Ferno Ille's Model 9650 Patient Lift, which offers both stretcher and chair options.

For more information, call 513-382-1451.

New Breakthrough in Achilles Heel Pain

New from Silipos, the Achilles Heel Pad is a breakthrough product for individuals who suffer from chronic Achilles heel pain. Silipos' patented polymer gel is molded into a soft, comfortable, elastic anatomical shaped tube that conforms around the heel of the foot.

The Achilles Heel Pad absorbs friction and shear forces as it moisturizes and softens hard, dry, and calloused skin. The product is recommended for individuals who suffer from Achilles heel pain, pump bumps, or Haglund's deformity. It can be worn with ladies, men's, and children's dress and casual shoes. One size fits all.

For a complimentary sample of the gel and to find out more information about this product call 800-229-4404.

Ferno Ille Introduces New Treatment Table

Ferno Ille announced the introduction of the Flexion™ 7000 Physical Therapy Treatment Table. The new 7000 offers many design improvements over traditional tables.

The Flexion 7000 features a tapered look, reminiscent of European design, and pads with increased thickness to of-

fer maximum patient comfort. In addition, the pads are covered with a unique fabric-textured, vinyl upholstery that is flame-retardant, tear-resistant, and easy to clean and disinfect.

The table angles can be adjusted, down to 90° at the head and up to 45° at the foot, by using either a foot- or hand-operated switch. The table is also height-adjustable with a range between 18-1/2″ and 36-1/2″. The Flexion 7000 is available with or without wheels and in six colors.

For more information, call 513-382-1451.

DonJoy Introduces Wraps Wrist Guard

Smith & Nephew DonJoy has introduced the Wraps Wrist Support to help control hyperflexion and hyperextension. The slip-on Wraps outer shell is constructed of woven nylon for stability, and the neoprene inner lining surrounds the wrist with padding and warmth. Hook and loop strapping allows for secure adjustment and individual fitting. Interchangeable foam inserts allow the patient to vary the degree of support.

"The Wraps is an excellent substitute for sport tape." It can be used over and

over and eliminates the need for wrapping and rewrapping required by traditional taping. The slip-on design encourages patient compliance. It comes in three sizes, and can be worn on the left or right wrist. DonJoy also can put any custom logo on the product.

For more information on the Wraps call 800-336-5690.

INF Plus™

BioMedical Life Systems, Inc announces the newest generation in its Interferential Device line, the INF Plus™. Using microprocessor technology with

tolerance levels of less than 1%, this portable device incorporates a sinusoidal wave form usually found only in large clinical models. Three preprogrammed sweeps; 1–10 Hz, used for edema reduction, 80–150 Hz used for pain relief, and 1–150 Hz for total treatment allow for easy setup and patient instruction.

The device offers bipolar stimulation using two electrodes where the interferential stimulation is already "mixed" or full interferential stimulation with the use of four electrodes. It has a timer for the desired treatment time and operates from four AA batteries or the Nova Series™ Wall Adaptor. A hidden switch allows the therapist to change from milliamps to microamps for even wider treatment parameters.

For more information call 800-726-8367.

Current Literature

Clint Thompson, MS, ATC

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Video Review

Bob Stahara, ATC, PT

YMCA Healthy Back Video
Human Kinetics
Box 5076
Champaign, IL 61825–5076
1–800-747–4457
45 minutes

The *YMCA Healthy Back Video* is copyrighted and sold by Human Kinetics. It was developed as an adjunct to the *YMCA Healthy Back Book* to explain and demonstrate exercises discussed in the book.

The video begins with a brief discussion of materials presented in the book such as management of acute stages through first-aid techniques, proper warm up, and indications and contraindications to exercise. After the introductory materials, the video proceeds to explain and demonstrate first-, second-, and third-level back exercises. At the conclusion of each specific exercise, there is a break in the tape so the viewer can stop the video and perform the exercises.

The tape concludes with discussion and demonstration of good posture in various activities of daily living. These include, but are not limited to, sitting, lying, driving, car transfers, lifting from a car and from a crib.

This video is good for demonstrating basic back exercises to an individual who has had minimal prior experience with them. I believe that a few of the exercise techniques discussed in this video could and should be improved. Specifically, the video instructs viewers to hold all stretches for "5 to 10 seconds," and instructs the viewer to lie prone with "the head turned to one side." I would instruct participants to hold their stretches for 30 to 40 seconds. Also, I would instruct the participant to maintain his/her cervical spine in a neutral position with a towel under the forehead in prone lying. Other minor changes could be suggested but are not as significant as the two mentioned.

I would recommend this video for individuals who have had minimal experience participating in low back exercises. I would encourage the health care professional providing the video to review the video first and make any adjustments in the exercises that would be appropriate for the individual who will be using it.

Authors' Guide

(Revised February 1992)

The *Journal of Athletic Training* welcomes the submission of manuscripts that are of interest to persons engaged in or concerned with the progress of the athletic training profession (athletic injury prevention, evaluation, management, and rehabilitation; administration of athletic training facilities and programs; and athletic health care counseling and education). Manuscripts should conform to the following:

SUBMISSION POLICIES

1. Submit one original and three copies of the entire manuscript (including photographs, artwork, and tables) to the editor.
2. All manuscripts must be accompanied by a letter signed by each author, and must contain the statements below. By signing the letter, the author(s) agrees to comply with all statements. Manuscripts that are not accompanied by such a letter will not be reviewed. "This manuscript contains original unpublished material that has been submitted solely to the *Journal of Athletic Training*, is not under simultaneous review by any other publication, and will not be submitted elsewhere until a decision has been made concerning its suitability for publication by the *Journal of Athletic Training*. In consideration of the NATA's taking action in reviewing and editing my (our) submission, the author(s) undersigned hereby transfers, assigns, or otherwise conveys all copyright ownership to the NATA, in the event that such work is published by the NATA."
3. Materials taken from other sources, including text, illustrations, or tables, must be accompanied by a written statement giving the *Journal of Athletic Training* permission to reproduce the material. Photographs of individuals must be accompanied by a signed photograph release form. Accepted manuscripts become the property of the National Athletic Trainers' Association, Inc.
4. The *Journal of Athletic Training* uses a double blind review process. Authors should not be identified in any way except on the title page.
5. Manuscripts are edited to improve the effectiveness of communication between the author and the readers, and to aid the author in presenting a work that is compatible with the style policies found in the *AMA Manual of Style*, 8th ed. (Williams & Wilkins) 1989. The author agrees to accept any minor corrections of the manuscript made by the editors.
6. Published manuscripts and accompanying work cannot be returned. Unused manuscripts will be returned when submitted with a stamped, self-addressed envelope.

STYLE POLICIES

7. The active voice is preferred. Use the third person for describing what happened. "I" or "we" (if more than one author) for describing what you did, and "you" or the imperative for instruction.
8. Each page must be typewritten on one side of 8.5 × 11 inch plain paper, double spaced, with one-inch margins. **Do not right justify pages.**
9. Manuscripts should contain the following, organized in the order listed below, with each section beginning on a separate page:
   a. Title page
   b. Acknowledgements
   c. Abstract and Key Words (first numbered page)
   d. Text (body of manuscript)
   e. References
   f. Tables—each on a separate page
   g. Legends to illustrations
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10. Begin numbering the pages of your manuscript with the abstract page as #1; then, consecutively number all successive pages.
11. Titles should be brief within descriptive limits (a 16-word maximum is recommended). The name of the disability treated should be included in the title if it is the relevant factor; if the technique or type of treatment used is the principle reason for the report, it should be in the title. Often both should appear.
12. The title page should also include the names, titles, and affiliations of each author, and the name, address, phone number, and fax number of the author to whom correspondence is to be directed.
13. A comprehensive abstract of 75 to 200 words must accompany all manuscripts except **Tips From the Field**. Number this page one, type the complete title (but not the author's name(s)) on the top, skip two lines, and begin the abstract. It should be a single paragraph and succinctly summarize the major intent of the manuscript, the major points of the body, and the author's summary and/or conclusions. It is unacceptable to state in the abstract words to the effect that "the significance of the information is discussed in the article." Also, do not confuse the abstract with the introduction
14. List three to six key words or phrases that can be used in a subject index to refer to your paper. These should be on the same page as, and following your abstract. For **Tips From the Field**, the key words should follow immediately after the title on the first numbered page.
15. Begin the text of the manuscript with an introductory paragraph or two in which the purpose or hypothesis of the article is clearly developed and stated. Tell why the study needed to be done or the article written and culminate with a statement of the problem (or controversy). Highlights of the most prominent works of others as related to your subject are often appropriate for the introduction, but a detailed review of the literature should be reserved for the discussion section. In the one to two paragraph review of the literature, identify and develop the magnitude and significance of the controversy, pointing out differences between others' results, conclusions, and/or opinions. The introduction is not the place for great detail; state the facts in *brief* specific statements and reference them. The detail belongs in the discussion. Also, an overview of the manuscript is part of the abstract, not the introduction.
16. The body or main part of the manuscript varies according to the type of article (examples follow); however, the body should include a discussion section in which the importance of the material presented is discussed and related to other pertinent literature. Liberal use of headings and subheadings, charts, graphs, and figures is recommended.
   a. The body of an **Experimental Report** consists of a methodology section, a presentation of the results, and a discussion of the results. The methodology section should contain sufficient detail concerning the methods, procedures, and apparatus employed so that others can reproduce the results. The results should be summarized using descriptive and inferential statistics, and a few well planned and carefully constructed illustrations.
   b. The body of a **Review of the Literature** article should be organized into subsections in which related thoughts of others are presented, summarized, and referenced. Each subsection should have a heading and brief summary, possibly one sentence. Sections must be arranged so that they progressively focus on the problem or question posed in the introduction.
   c. The body of a **Case Study** should include the following components: personal data (age, sex, race, marital status, and occupation when relevant—but not name), chief complaint, history of present complaint (including symptoms), results of physical examination (example: "Physical findings relevant to the rehabilitation program were..."), medical history (surgery, laboratory results, exam, etc.), diagnosis, treatment and clinical course (rehabilitation until and after return to competition), criteria for re-turn to competition, and deviation from the expected (what makes this case unique). NOTE: It is mandatory that the *Journal of Athletic Training* receive, with the manuscript, a release form signed by the individual being discussed in the case study. Case studies cannot be reviewed if the release is not included.
   d. The body of a **Technique Article** should include both the *how* and *why* of the technique, a step-by-step explanation of how to perform the technique, supplemented by photographs or illustrations; and why the technique should be used. The discussion of *why* should review similar techniques, point out how the new technique differs, and explain the advantages and disadvantages of the technique in comparison to the other techniques.
   e. A **Tip From the Field** is similar to a technique article but much shorter. The tip should be presented and its significance briefly discussed and related to other similar techniques.
17. The manuscript should not have a separate summary section—the abstract serves as a summary. It is appropriate, however, to tie the article together with a summary paragraph or list of conclusions at the end of the discussion section.
18. Citations in the text of the manuscript take the form of a superscripted number, which indicates the number assigned to the citation. It is placed directly after the reference or the name of the author being cited. References should be used liberally. It is unethical to present others' ideas as your own. Also, use references so that readers who desire further information on the topic can benefit from your scholarship.
19. The reference page(s) accompanying a manuscript should list authors numerically in alphabetical order, should be in the following form: a) articles: author(s) (list all) with the family names then initials, title of article, journal title with abbreviations as per *Index Medicus* (italicized or underlined), volume, year, inclusive pages; b) books: author(s), title of book (underlined), city, state of publication, publisher, year, inclusive pages of citation. Examples of references to a journal, book, presentation at a meeting are illustrated below. See the *AMA Manual of Style* for other examples.
   a. Knight K. Tips for scientific/medical writers. *Athl Train, JNATA.* 1990;25:47–50.
   b. Day RA. *How to Write and Publish a Scientific Paper.* 3rd ed. Phoenix, AZ: Oryx Press; 1988;54–55.
   c. Albohm M. Common injuries in women's volleyball. In: Scriber K, Burke EJ, eds. *Relevant Topics in Athletic Training.* Ithaca, NY: Mouvement Publications; 1978:79–81.
   d. Behnke R. Licensure for athletic trainers: problems and solutions. presented at the 29th Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association; June 15, 1978; Las Vegas, NV.
20. Tables must be typed. See references cited in #5 or #19a for table formatting.
21. Type legends to illustrations on a separate page followed by Xerox copies of the illustrations. Photographs should be glossy black and white prints. Do not use paper clips, write on photos, or attach photos to sheets of paper. Carefully attach a write-on label to the back of each photograph so that the photograph is not damaged. Graphs, charts, or figures should be of good quality and clearly presented on white paper, 3½" or 7¼" wide, with black ink, 8 to 10 point sans serif typeface, no box, and printed on laser printer—no dot matrix.
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CEU Quiz

The NATA Board of Certification accepts this continuing education offering for .5 hours of prescribed CEU credit in the program of the National Athletic Trainers' Association, Inc, provided that the test is used and completed as designed.

To participate in this program, read the material carefully, photocopy the test, and answer the test questions. Mark your answer by circling the correct letter. Then fill in your name, address, and other information and mail with $15 for processing to the address below. **FOR CREDIT, the form must be postmarked by May 15, 1995.**

A passing score is 70% and those who pass are entitled to .5 CEU credit. Letters will be sent to all persons who participate, and will serve as proof of CEUs for those who pass. It is the individual's responsibility to report his/her CEUs to the NATA Board of Certification at the end of the year or when asked. Participation is confidential.

Answers to the December '94 CEU quiz.
Volume 29, Number 4

1. b	4. e	7. b	10. e	13. c
2. e	5. b	8. c	11. c	14. d
3. d	6. e	9. a	12. b	15. d

This CEU credit quiz contains questions from articles in this issue.

CEU CREDIT QUIZ

NATA Membership Number ____________
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Please indicate below the setting in which you work:
❑ High School ❑ Junior College ❑ College
❑ University ❑ Sports Medicine Center
❑ Other (please specify) ____________

Instructions

1. Photocopy these pages and write on the copy.
2. Read the articles listed above.
3. Answer the questions.
4. Mail with $15 fee (checks made payable to Indiana State University) postmarked by May 15, 1995, to:

JAT—CEU Quiz
Department of Athletic Training
Indiana State University
Terre Haute, IN 47809

Circle the correct answer.

1. Which (if any) of the following statements is true about cold water immersion treatment?
   a. Wearing a toe cap appears to increase one's sensitivity to pain.
   b. Knowledge of expected sensations decreases the pain felt during treatment.
   c. It is better to disclose all treatment information and risk increased affective pain.
   d. It is better to keep treatment information to a minimum and thus reduce anxiety.
   e. None of the above.

2. Postconcussive symptoms of a football head injury might last from 3 to 9 months and might include: headache, inability to concentrate, and an inability to maintain work, social relationships, or both; symptoms difficult to separate from normal teenage behavior.
   a. True
   b. False

3. Suprascapular neuropathy is:
   a. associated with marked atrophy of the trapezius muscle.
   b. most commonly caused by ganglionic cysts.
   c. a rare and often misdiagnosed injury to the shoulder complex.
   d. associated with localized arm pain, no loss of strength, and normal scapulohumeral mechanics.
   e. All of the above.

4. A study of interscholastic women's lacrosse injuries showed the head to be the most commonly injured, followed by the eye and nose; thus, it is strongly recommended that helmets be required for women's lacrosse players.
   a. True
   b. False

5. Imagery is useful in rehabilitation programs because it:
   a. can reduce physiological and verbal expressions of fear and pain.
   b. can help send blood to the injured area for faster healing.
   c. has been shown to reduce the effects of chronic injuries.
   d. All of the above.
   e. a and b only

6. Prevention of acute muscular strains might include:
   a. adequate preseason screening of flexibility and strength balances in major joints such as the knee, shoulder, and ankle.
   b. evaluation of previous muscle injuries to assess flexibility, strength, endurance, and proprioception.
   c. preseason and in-season conditioning of muscle groups.
   d. All of the above.
   e. a and c only.

7. According to a survey on football spearing, level of enforcement of the spearing penalty is:
   a. extremely low.
   b. extremely high.
   c. on average, about 10 per game.
   d. almost never called because football spearing is almost nonexistent.
   e. None of the above.

8. Common mechanisms of injury resulting in PCL rupture include:
   a. knee hyperflexion with an anterior blow to the anterior superior tibia.
   b. hyperflexion without trauma to the tibia by a downward force on the femur.
   c. Sudden hyperextension.
   d. All of the above.
   e. None of the above.

9. A study of academic achievement (based on final GPA) in an NATA-approved graduate athletic training education program showed that:
   a. GRE quantitative and GRE verbal scores were the best predictors of academic success.
   b. total athletic training hours and type of program were the best predictors of academic success.
   c. preadmission GPA was the best predictor of academic success.
   d. students in a curriculum program fared better than those in an internship program.
   e. both c and d.

10. Athletes who suffer from isolated PCL ruptures will usually have:
   a. mild-to-moderate effusion.
   b. maximal pain beyond knee flexion of 90°.
   c. abrasion or lacerations on the anterior tibia.
   d. All of the above.
   e. a and c only.

11. Which of the following variables can affect a candidate's score on the Athletic Training Certification Exam?
   a. The structure of the candidates' academic and clinical learning experiences.
   b. Psychological pressures of the examination process.
   c. Inherent differences between the minimum academic requirements of the curriculum and internship routes.
   d. Number of clinical hours accumulated by a student athletic trainer.
   e. All except d.

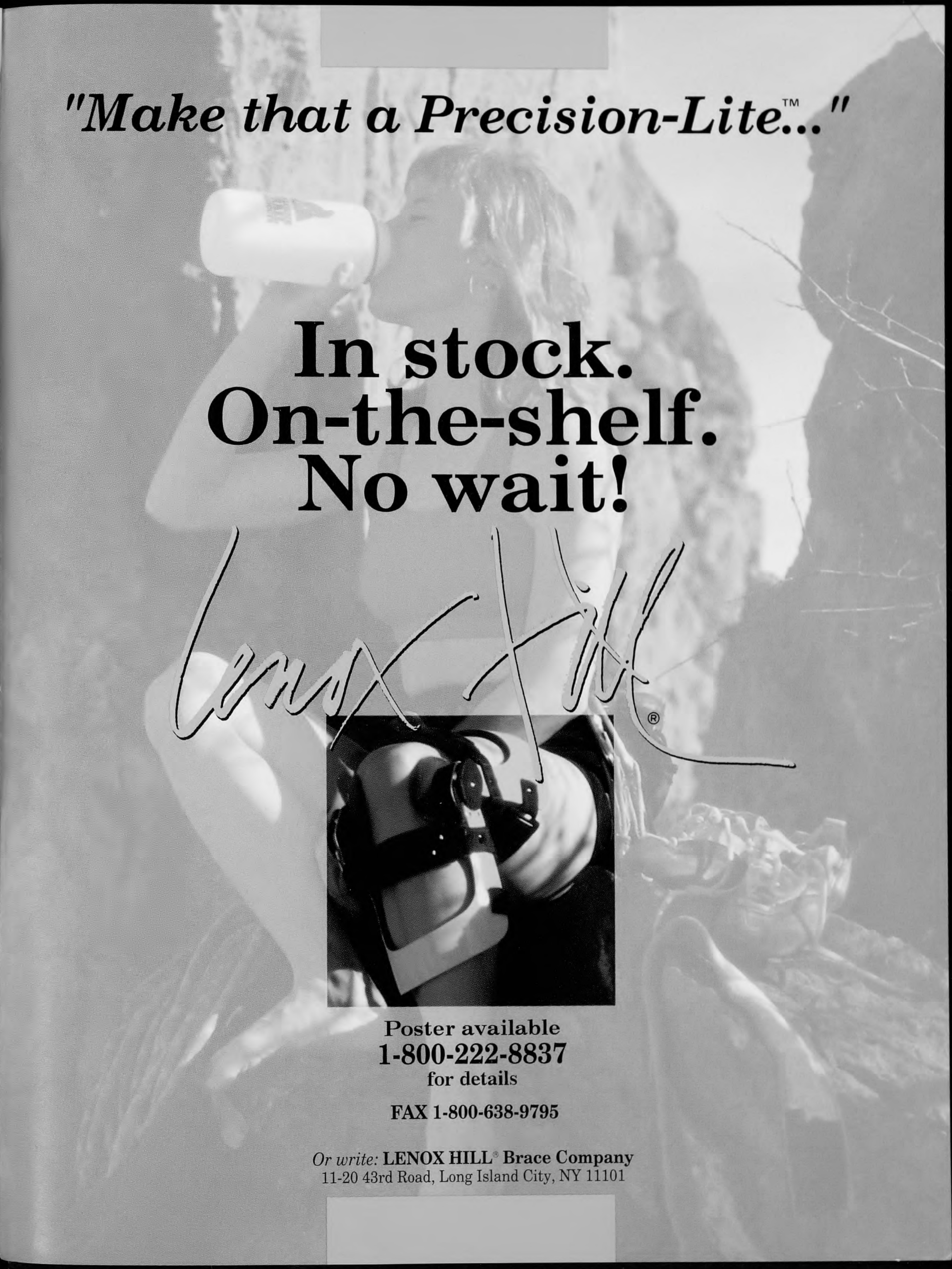
12. Plyometric exercises:
   a. are also referred to as stretch-lengthening exercises.
   b. involve a prestretch of a muscle just before its contraction.
   c. performed properly, do not affect the inhibition provided by the GTO.
   d. do not stimulate body proprioceptors such as the muscle spindle.
   e. a and b

13. The study on football spearing showed that:
   a. enforcement of spearing rules requires action by athletic trainers as well as organizations.
   b. the level of enforcement of spearing rules suggests that officials' impact on decreasing the incidence of spearing has been minimal.
   c. if the incidence of spearing has decreased since the inception of spearing rules, the coaches may have played the most significant role in the reduction.
   d. All of the above.
   e. a and b only.

14. In using imagery techniques as an additional healing protocol, the athlete can practice skills associated with his/her sport over and over again in his/her mind. In time, he/she can gain some control over the injury. This technique demonstrates the close connection between the mind and the body and how it facilitates the healing process.
   a. True
   b. False

15. A study of performance on the athletic training certification examination revealed that internship candidates had significantly greater scores on each of the three parts of the examination.
   a. True
   b. False

ADVERTISING INDEX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