Journal of Athletic Training

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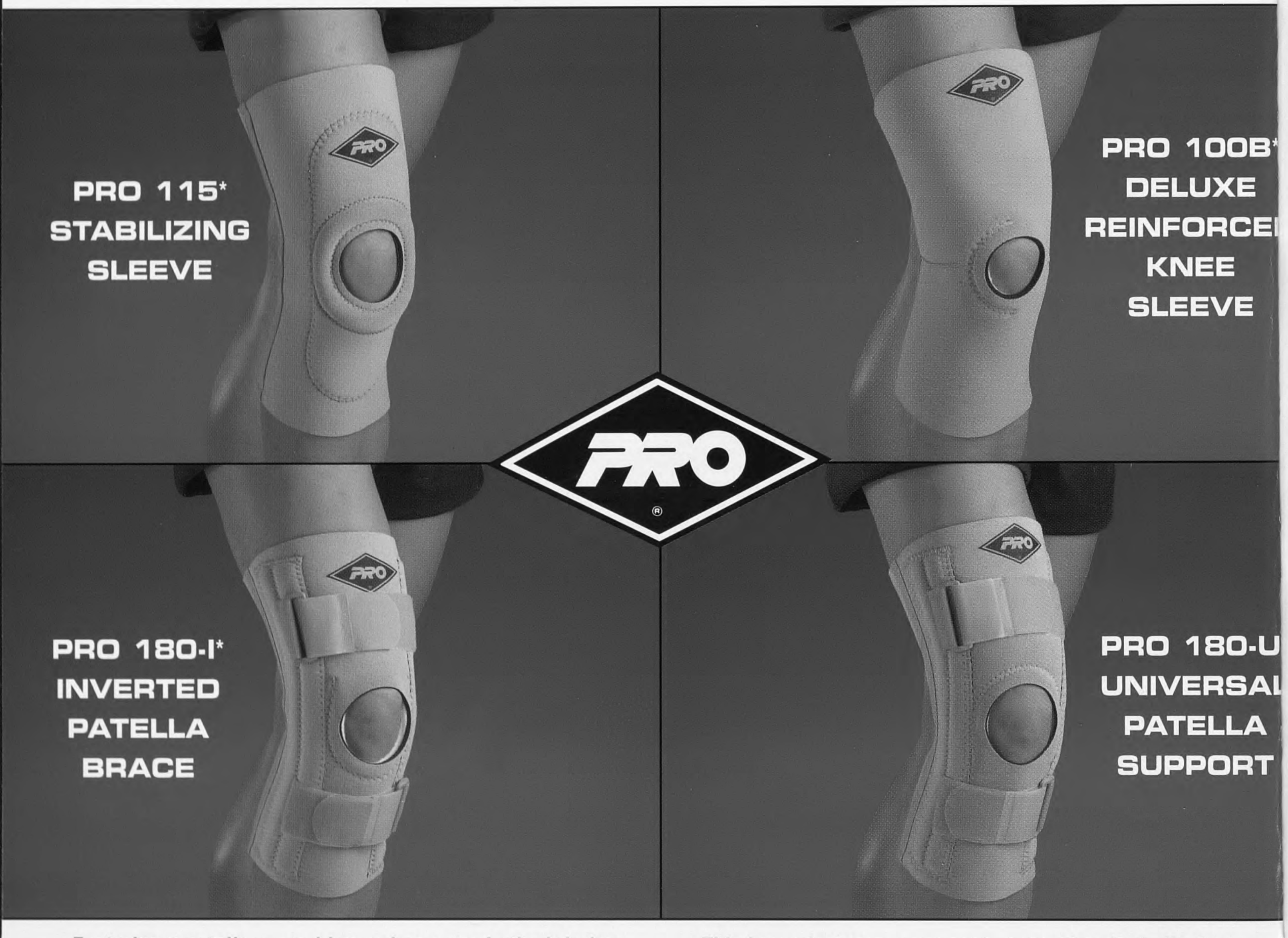

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Volume 32, Number 2, April-June

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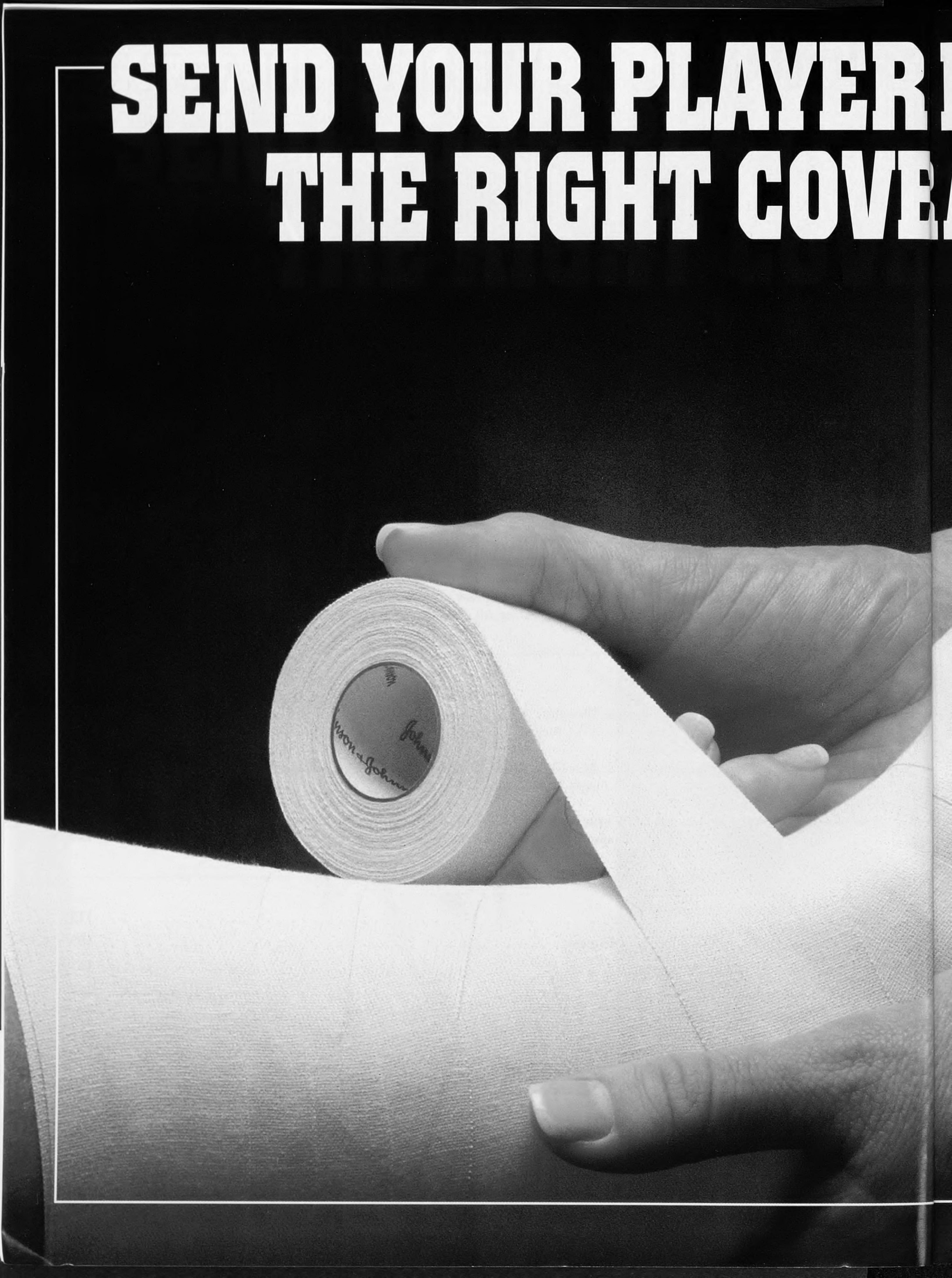
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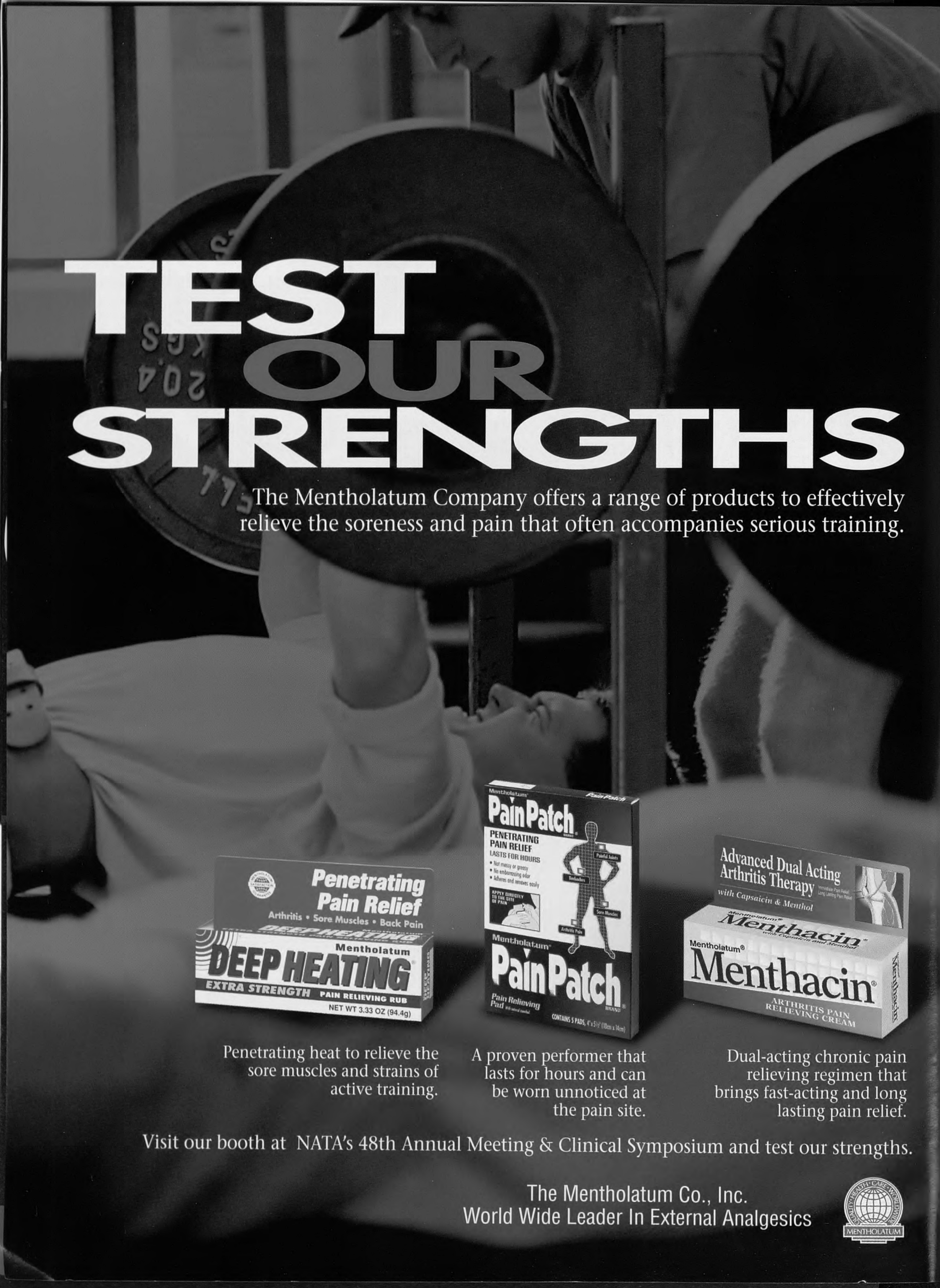
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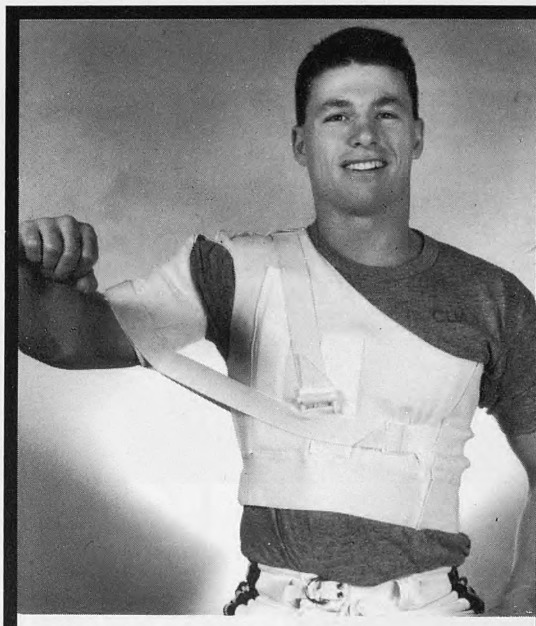

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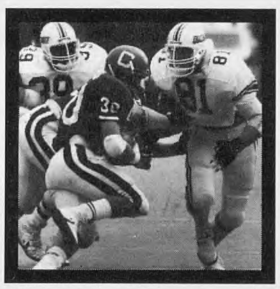

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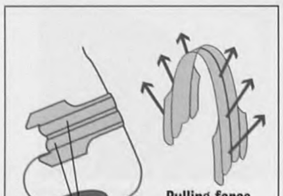

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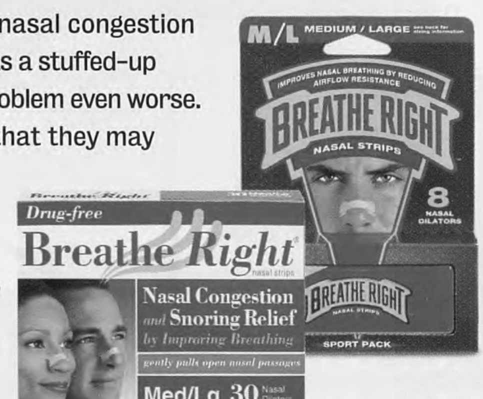

Editorial

Reforming Athletic Training Education

Chad Starkey, PhD, ATC

Developing the minds and skills of athletic trainers does not fall under the auspices of any one organization or individual. Rather, effective education requires the interaction and cooperation of a wide range of entities, the Joint Review Committee-Athletic Training, the NATA Board of Certification, the NATA Foundation, and the Convention Committee. The *Journal of Athletic Training* plays an essential role in our professional growth by disseminating high-quality research not only within our profession but also, just as importantly, to other allied health professions. As a means to this end we should embrace Dr. Perrin's goal for the *Journal* to be included in *Index Medicus*.

Our profession has undergone an amazing amount of growth during a relatively short amount of time. In less than 50 years, we have progressed from the equipment room to the athletic training room, and we are now entering clinics, hospitals, and industrial settings. While the face of our client population base has changed rapidly, our educational methods and content have not evolved as swiftly.

Competition in the healthcare arena, disparities in the preparedness of entry-level athletic trainers, and the proliferation of new work environments all motivated the NATA's Board of Directors to establish the Education Task Force. Cochaired by Richard Ray and John Schrader, this committee was charged to evaluate all aspects of athletic training education and make recommendations on how they could be improved. The Education Task Force completed its mission by submitting 18 recommendations to the Board of Directors aimed at improving and standardizing entry-level, graduate, and continuing education of athletic trainers. In March 1996 the Board of Directors formed the Education Council (EC) to oversee the implementation of these recommendations and provide ongoing vision and leadership for education. This agency will be, not an omnipotent agency, but rather a sounding board, advocate, and change agent for all other education-related agencies.

Athletic training education involves the incorporation of no fewer than five areas that could be considered the provinces of other professions. No other profession's clinicians are responsible for preventing injury and illness, for evaluation/management, for rehabilitation, for counseling, and for education of its clientele. We are the original multiskilled healthcare providers, although none of this knowledge or skill is unique to our profession.

Our marketability stems from our ability to combine these knowledge bases, apply them to a specialized population, and capitate the costs associated with injury. When dealing with the physically active population, athletic trainers must strive to be recognized as the experts, a label that comes only via education: not only education of athletic training students and continuing education of certified athletic trainers, but also education of the public, education of our potential employers, and, perhaps most importantly, education of legislators.

In light of the current healthcare reform movement, much emphasis has been placed on multiskilled practitioners. It is vital to understand, however, that multiskilled and multicredentialed are not equivalent terms. Dual credentialing is appropriate as a means for athletic trainers to expand their potential patient base. It is inappropriate when it is required for athletic trainers to practice our profession with our traditional patient base in nontraditional settings. Our educational foundation must be solidified to the point where athletic trainers are permitted to practice our profession in any setting without drawing criticism regarding the scope and breadth of our educational construct. Only by strengthening the quality, reputation, and educational requirements of the ATC credential will the status of the dual-credentialed athletic trainer be enhanced.

To compete in the healthcare arena, a term that includes the "traditional" high school, college, and professional settings, our educational model must begin to adapt to the expectations of the healthcare community. We must formally embrace the allied health care model of professional preparation. "Critical Challenges: Revitalizing the Health Professions for the Twenty-First Century," the Third Report of the PEW Health Professions Commission, describes the common set of competencies that all health care providers should possess by the year 2005 (www.futurehealth.ucsf.edu/pewcomm.html). As we plan our course into the next century, these recommendations should be a benchmark by which we measure educational excellence.

Among the most pressing issues to be addressed by the EC is clinical education. An initial question that must be posed is, "Are clinical hours an effective measure of a student's clinical learning?" The answer to this is most probably "No." The use of hours places a quantitative measure on what should be a qualitative experience. Is a student who has completed 400 hours of clinical experience halfway to being professionally prepared? What skills has this individual mastered? What are the student's strengths and weaknesses?

Our students' clinical education model should be based on a set of measurable, standardized, and referenced learning objectives that describe the type and nature of the experience obtained. Achieving these goals is contingent upon a common response to the question, "What is entry level?"

This definition will also assist in the identification of entry level-specific skills, answers that will be based on the next Role Delineation Study of the Entry-Level Athletic Trainer and a revision of the Competencies in Education. Then we can begin to develop the areas to be targeted in advanced master's programs and continuing education programs.

The Education Task Force's recommendations have been described, not as the elimination of one route to certification, but as "taking the best elements from each route to form a single, better educational model." One of the internship route's greatest strengths was in the clinical education of its students, but this is not to imply that the 1500-hour requirement was its strength. Most likely, we can point to the student-clinical instructor mentorship that occurred as being its hallmark. The requirement for a Certificate of Added Qualification for clinical instructors mandates that we must examine the nature of clinical interaction between the student and the instructor, teach mentoring skills, and understand the wants and needs of students who are learning in the clinical setting.

"Educating the Educator" will be a common theme within our profession over the next four or five years. This will integrate the newly developed entry-level Competencies in Education, Clinical Education Objectives, and the requirements to sit for the NATABOC certification examination. We must reemphasize the "student" in student athletic trainer and the "instructor" in clinical instructor to build a healthy, reasonable, and financially tolerable clinical learning environment for our students. We must also be cognizant that, in some cases, the way we approach clinical education may send the wrong message to our employers and the public, a message that is counterproductive to professional growth, improved salaries, and increased job opportunities for certified athletic trainers.

The benefits of these reforms will not be immediate, and the necessary changes may, at times, be painful. During these times we must remain focused on the betterment of our profession and the promise of a bright future for our students. We must all work together in this spirit of cooperation to better our profession, our professional image, and ourselves. The Education Council invites input from all members of our profession on achieving these goals. Please feel free to E-mail your comments and suggestions to the Education Council at: nataec@nata.org.

Editor's note: Dr. Starkey is chair of the NATA's Education Council. For more information on the Education Task Force report, see the February 1997 issue of the *NATA News*, "NATA Board takes first step in reform" (pp. 4–6, 25) and "Recommendations to reform athletic training education" (pp. 16–24).

Investigation of Quadriceps Femoris Function Through Electrical Stimulation

Alain Leroux, MSc; Georges Poumarat, PhD; Jean P. Boucher, PhD, FACSM

Objective: Patellofemoral dysfunctions are associated with problems in the knee extensor mechanism, including specific atrophy of the distal fibers of the vastus medialis, also known as the vastus medialis oblique. Rehabilitation of the vastus medialis in patellofemoral dysfunctions has been shown to be ineffective. This limitation had stemmed from the lack of understanding of the vastus medialis' specific functions. The purpose of this project was to investigate the role of four portions of the quadriceps femoris using surface electrical stimulation.

Design and Setting: Single-group and single-test (repeated measures on muscle portions) design. All tests were performed in a university laboratory.

Subjects: Eight healthy university students received electrical stimulation.

Measurements: Subjects were seated with the knee at 90° of flexion and the leg pushing against a strain gauge that measured the force exerted. Electrical stimulation was administered on the vastus lateralis, rectus femoris, and proximal and distal fibers of the vastus medialis to quantify the torque produced by the knee extensors. The electrical stimulation maximum intensity was adjusted to achieve specific fiber recruitment and the highest isolated contraction. Force was measured with a strain gauge placed on the anterior aspect of the distal end of the tibia. Force was recorded in two levels: force applied before the onset of electrical stimulation and force produced by the stimulation. Subjects also performed two maximum isometric knee extensions before and after electrical stimulation for normalization.

Results: Electrical stimulation elicited mean torques of 6.31%, 14.0%, 20.2%, and 28.0% of maximum isometric voluntary contractions of the distal and proximal fibers of the vastus medialis, the vastus lateralis, and rectus femoris, respectively.

Conclusions: The distal fibers of the vastus medialis do not contribute significantly to knee extension.

Key words: vastus medialis, vastus lateralis, rectus femoris, patellofemoral dysfunctions

It is now well accepted that the vastus medialis should be considered as two functional units: the proximal and the distal fibers, also known as the long and oblique fibers, respectively.[1–4] Patellofemoral dysfunctions are associated with problems in the knee extensor mechanism, including specific atrophy of the distal fibers of the vastus medialis.[2–6] Several studies have shown that the distal fibers of the vastus medialis are less active than the proximal fibers of the vastus medialis and the vastus lateralis (VL) during knee extension.[1,4,7] Further, patients with patellofemoral dysfunctions show a smaller electromyographic (EMG) ratio of distal fibers of the vastus medialis/VL than asymptomatic subjects for different knee-extension exercises.[6,7] Anatomical[8] and innervation[9,10] discrepancies help to explain the differences in activation levels found between the proximal and the distal fibers of the vastus medialis. Such discrepancies also point to mechanisms responsible for the specific atrophy of the distal fibers of the vastus medialis found in patellofemoral dysfunctions.

On the other hand, rehabilitation of the distal fibers of the vastus medialis in patellofemoral dysfunctions has proven to be largely ineffective[11–13] and, hence, frustrating. Many types of exercises, such as hip external rotation, straight-leg raises, and terminal knee extensions, are generally found ineffective in reactivating or restoring the medial component of the quadriceps femoris muscle.[7,14–16] These limitations stem from the lack of understanding of the vastus medialis' specific functions and, especially, how to rehabilitate these functions.

The purpose of this project was to determine the specific contributions of four portions of the quadriceps muscle using surface electrical stimulation. We believe that electrical stimulation can be used to study the function of each portion of the quadriceps because it replaces voluntary neural drive and allows specific controlled contractions of each portion tested. It is not possible to use voluntary contractions for this study because all portions receive a common innervation from the femoral nerve.

METHODS

Eight healthy subjects (age, 20 to 27 years) participated in this study. They all signed an informed consent document, and none reported history of lower limb dysfunction or neurological problems.

Experimental Procedures

During the experiment, subjects were seated with the hip and knee at 90° of flexion. Electrical stimulation was delivered by a Biostim stimulator (Model 6040, Mazet Electronique, Mazet, France). The current was composed of symmetrical, biphasic, square-wave pulses (pulse duration of 200 microseconds) delivered percutaneously to the muscles at a frequency of 80

This work was presented in part at the 40th annual meeting of the American College of Sports Medicine in 1994.

Alain Leroux and **Jean P. Boucher** are affiliated with the Department of Kinanthropology, University of Quebec at Montreal, Montreal, Quebec, Canada H3C 3P8. **Georges Poumarat** is affiliated with U.F.R. Sciences et Techniques des Activités Physiques et Sportives, University Blaise Pascal, B.P. 104, 63172, Aubiere CEDEX, France.

pps. Stimulation train duration was set at 5 seconds. Maximum intensity was adjusted to achieve specific fiber recruitment and the highest isolated contraction. The electrodes (Medtronic AREA pals plus, 3.0 cm diameter, Montreal, Canada) were located over the rectus femoris, VL, and proximal and distal fibers of the vastus medialis: one on the motor point and the other 2 cm distally with respect to muscle fiber orientation. Motor points were detected by moving the cathode to the point where the slightest visible fiber recruitment was obtained with the least amount of current.[1]

Data Acquisition

Force was measured with a strain gauge (model B.E.T.A., DPS Systemes, Cournon, France) placed on the anterior aspect of the distal end of the tibia. The force signal was acquired on-line (12 bit A/D model LSDAS 12) on a microcomputer at a sampling frequency of 100 Hz. Detailed analyses were carried out off-line as described below.

Quantification and Analyses

Electrical stimulation-evoked force recordings produced two levels (Fig 1). The first level corresponds to the force applied to the strain gauge before the onset of the electrical stimulation. It consists of a preload related to the segment weight. The second level represents the force produced by the stimulation. The difference between the two force levels was measured in order to establish the net electrical stimulation-evoked force.

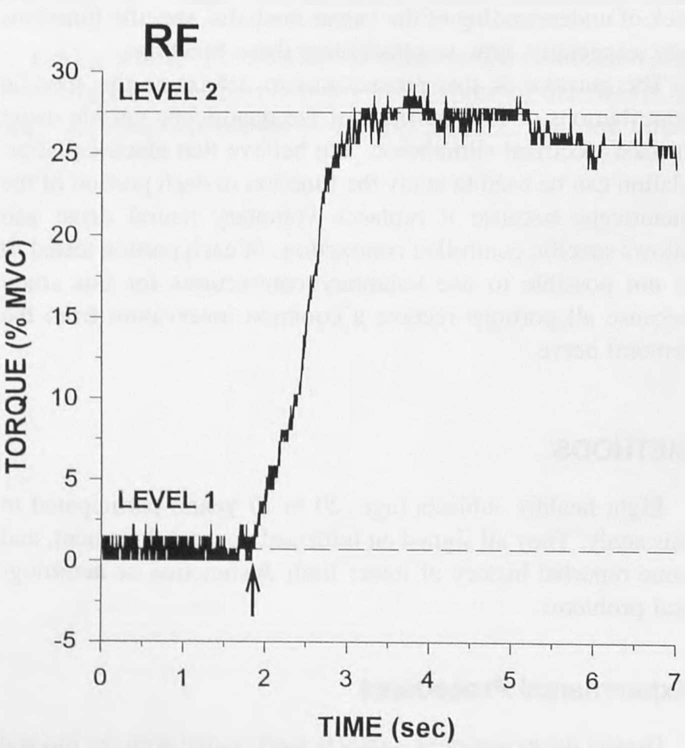

Fig 1. Torque evoked by the electrical stimulation of the rectus femoris (RF) fibers of a typical subject. On the ordinate, torque is expressed as a percentage of the mean maximum voluntary contraction (% MVC) while the abscissa shows the onset (indicated by ↑ below the abscissa) of the stimulation-evoked contraction.

For normalization purposes, subjects were asked to perform two maximum isometric knee extensions before and after electrical stimulation of the four quadriceps portions tested. Force obtained from electrical stimulation and isometric maximum voluntary contractions was expressed in torque. The torque was calculated by taking the force times the distance between the estimated knee joint center and the point of force application on the strain gauge. Results obtained from electrical stimulation were reported as a percentage of the average of the four isometric maximum voluntary contractions. Statistical comparison of the four portions of the quadriceps was done using a repeated measures analysis of variance (ANOVA) and Duncan multiple-range post hoc test to contrast the four portions two by two. The ANOVA statistical power was calculated according to the procedures outlined by Kirk[17] and expressed as the probability of a type II error (β) since power $= 1 - \beta$.

RESULTS

The table presents the mean torque expressed as a percentage of maximum voluntary contractions. Electrical stimulation was shown to elicit different torque output according to the tested portion of the quadriceps. These differences are more clearly illustrated in Figure 2. The rectus femoris, VL, and proximal fibers of the vastus medialis, which are known to be more active than the distal fibers of the vastus medialis in knee extension,[1,4,6] produced a greater response than the distal fibers of the vastus medialis. The differences found among the four portions reached the level for statistical significance ($F3, 21 = 7.57, p < .05, \beta = .01$). The Duncan post hoc test showed that the torque produced by the rectus femoris and the VL was significantly greater than for the distal fibers of the vastus medialis. Differences between rectus femoris and proximal fibers of the vastus medialis were also large enough to reach significant levels.

DISCUSSION

These results are in agreement with those obtained by Lieb and Perry.[3] Using amputated limbs, they found that the distal fibers of the vastus medialis, referred to by these authors as the vastus medialis oblique, do not contribute significantly to knee extension, while the proximal fibers of the vastus medialis assist the rectus femoris during this movement.

Of the four tested portions, electrical stimulation of the distal fibers of the vastus medialis produced the least amount of torque. The torque output of 6.31% of maximum voluntary contractions produced implies that the distal fibers of the vastus medialis have a negligible contribution to knee extension. The difference found between the distal and the proximal fibers of the vastus medialis did not yield statistically significant results but represented a 45% difference in favor of the proximal fibers. The large variance measured among subjects could explain this lack of statistical significance. However, this 45% difference found between the distal and the proximal fibers of the vastus medialis could still be functionally relevant. Hence, this negligible involvement of the distal fibers of the

Electrically Evoked Torque Expressed as a Percentage of Maximum Isometric Voluntary Contractions for all Muscle Portions Tested (Mean ± SD)

	Rectus Femoris	Vastus Lateralis	Proximal Fibers of the Vastus Medialis	Distal Fibers of the Vastus Medialis
Mean torque	28.0 ± 20.3	20.2 ± 10.6	14.0 ± 9.7	6.31 ± 3.5

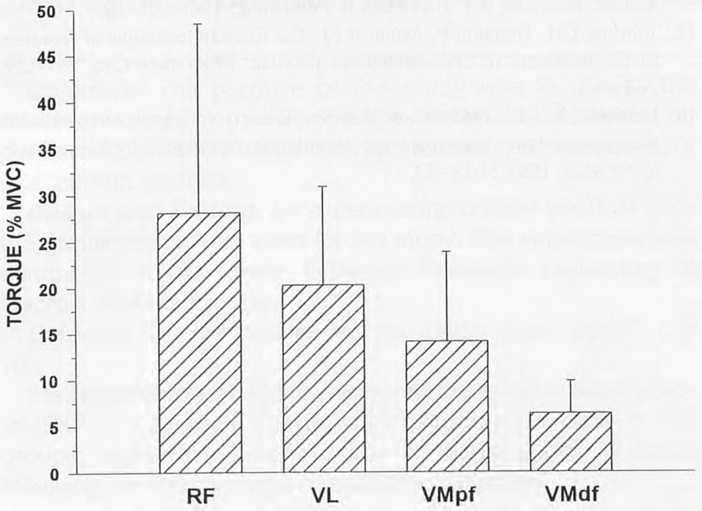

Fig 2. Means (histogram bars) and standard deviations (error bars) of the torque evoked by electrical stimulation in the four portions of the quadriceps femoris muscle. Torque is expressed as a percentage of the mean maximum voluntary contraction (% MVC). VMpf = proximal fibers of the vastus medialis; VMdf = distal fibers of the vastus medialis.

vastus medialis in knee extension can help explain the lack of positive traditional training results in distal fibers of the vastus medialis rehabilitation. This could also explain the persistent atrophy of the distal fibers of the vastus medialis. The clinical implications of these results are further discussed below.

The difference in torque output between the proximal and the distal fibers of the vastus medialis could be explained by anatomical differences between the two muscles. Distal fibers arise from the tendon of the adductor magnus muscle and insert directly on the superior medial portion of the patella, pulling it at an angle of 56°.[8,10] A few superficial fibers may also attach to the quadriceps tendon. Proximal fibers arise from the linea aspera and the medial intermuscular septum and insert directly on the rectus femoris tendon.[8,10] These different origins and insertions lead to different actions on the knee joint. Biomechanical investigations suggest that the role of the distal fibers of the vastus medialis is probably one of tracking the patella medially against the traction of the VL, with a minimal contribution in knee extension.[3] On the other hand, the proximal fibers of the vastus medialis and the VL seem to assist the rectus femoris in knee extension.[1,3] The results of our study support the contention that the distal fibers of the vastus medialis are not used significantly for knee extension, which helps to understand the great difficulty in reversing their atrophy in patellofemoral dysfunctions. Knee-extension exercises can reinforce the more proximal fibers involved in that movement but are mostly inefficient for strengthening the distal fibers.

Clinical Implications

Results presented in this study suggest that the contribution of the distal fibers of the vastus medialis to knee extension is minimal. Accordingly, our results further suggest that proximal fibers of the vastus medialis may be influenced by knee-extension training, while the distal fibers of the vastus medialis may not. This could explain why traditional knee-extension exercises are largely ineffective for patellofemoral dysfunction rehabilitation.[15,16] This reinforces the need for more specific methods when attempting to treat the atrophy of the distal fibers of the vastus medialis. Artificial recruitment techniques such as electrical stimulation[18,19] and biofeedback[14] could then be recommended.

CONCLUSIONS

Within the limitations of this study, we conclude that the distal fibers of the vastus medialis do not contribute significantly to knee extension. More specifically, our findings address the difficulties in retraining the distal fibers of the vastus medialis with active knee-extension exercises. In this study, artificial activation differences found between the proximal fibers of the vastus medialis and distal fibers of the vastus medialis through electrical stimulation provide much evidence and offer explanations for the specific atrophy of the distal fibers of the vastus medialis.

ACKNOWLEDGMENTS

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Effects of Microcurrent Treatment on Perceived Pain and Muscle Strength Following Eccentric Exercise

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Objective: The purpose of this study was to assess the effect of low-volt, microamperage stimulation (LVMAS) on perceived pain and muscle strength following an intense bout of eccentric exercise.

Design and Setting: An experimental pretest-posttest control group design was used for the study. The experiment was conducted in the Lower Extremity Research Laboratory at Georgia State University.

Subjects: Twelve females and six males (mean age 27 ± 5 yr).

Measurements: Subjects, randomly assigned to experimental (EXP, n = 6), sham (SHAM, n =6), and control (CON, n = 6) groups, were tested before, and at 24, 48, and 72 hours following, an intense bout of eccentric exercise.

Results: Three two-way (group × time) analyses of variance (ANOVAs) with repeated measures on the last factor were used to analyze the data. A significant time main effect was identified. Results indicated that perceived pain was not reduced in the EXP group as compared with the SHAM and CON groups. Muscle strength in the EXP group did not return to the initial baseline measure more rapidly than in the SHAM and CON groups.

Conclusions: We conclude that the use of LVMAS alone is not effective in reducing pain and increasing muscle function following an exhaustive bout of eccentric exercise.

Key Words: electrical stimulation, delayed-onset muscle soreness, musculoskeletal injury

For the past decade, athletic trainers and physical therapists have provided anecdotal praise for the use of low-volt, microamperage stimulation (LVMAS). LVMAS is used clinically to decrease pain precipitated by damaged muscles, tendons, and ligaments. Studies documenting successful pain reduction using LVMAS following musculoskeletal injury have been limited to a few clinical and experimental trials,[1–5] several nonexperimental trials[6] (L. Wallace, 1995, personal communication), and anecdotal recommendations (L. Wallace, 1995, personal communication; J. Halbach, 1995, personal communication). Collectively, these studies[3–5] have utilized a similar protocol: (1) polarity, biphasic mode; (2) intensity, 100 μamps; (3) frequency, 0.3 Hz; and (4) treatment time, 20 minutes (as described by Picker[7]). Results from several case studies have indicated that a long-term treatment protocol (> 8 hours) consisting of LVMAS, ice, and nonsteroidal anti-inflammatory drugs (NSAIDs) was effective in reducing pain and muscle soreness from musculoskeletal injuries[6,8] (J. Foley, 1995, personal communication). However, the effectiveness of LVMAS alone for treatment of perceived pain and muscle function has not been established.

Inducing delayed-onset muscle soreness (DOMS) in healthy subjects has been an acceptable approach for evaluating the treatment effects of therapeutic modalities such as LVMAS.[2] DOMS is commonly associated with an intense bout of unaccustomed exercise that involves eccentric actions and is characterized by pain, spasm, and weakness (ie, loss of force production) in the affected muscle(s).[9] The onset of pain resulting from DOMS is usually experienced 8 to 10 hours following intense eccentric exercise and peaks between 24 and 48 hours.[2,10,11] Since the symptoms associated with DOMS are similar to those experienced following musculoskeletal damage, we believe DOMS serves as an appropriate model for investigating the effects of LVMAS on musculoskeletal injuries.[2,8] Therefore, the purpose of this study was to assess the effects of a combined brief (20 minutes) and long-term (> 8 hours) application of LVMAS on perceived pain and eccentric isotonic muscle strength following muscle failure during eccentric exercise. We hypothesized that, following an exhaustive bout of eccentric exercise, the group receiving the LVMAS treatment would have significantly less perceived pain and a more rapid return of muscle strength than the groups not receiving LVMAS treatment.

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METHODS

Subjects

Twelve female and six male right-hand-dominant subjects, 21 to 41 years of age (mean age 27 ± 5 years) volunteered to participate in this study. Subjects who had been involved in an upper-extremity weight-training program within the past year, used their arms regularly in strenuous activity, or presently had pain in their nondominant arm were excluded from the study. All subjects provided informed consent prior to testing in compliance with Georgia State University's Institutional Review Board.

Subjects were randomly assigned to one of the following three groups: (1) an experimental (EXP) group that received an LVMAS treatment following exercise (n = 6); (2) a sham

(SHAM) group that received a sham treatment of LVMAS following exercise (n = 6); or (3) a control (CON) group that received no treatment following exercise (n = 6). Subjects were asked to refrain from taking any anti-inflammatory or pain-reducing medication and from applying heat, ice, massage, or stretching to the nondominant arm until the study was completed. Subjects were instructed to refrain from strenuous use of the nondominant arm. All subjects reported complying with the instructions each day.

Data Collection Protocol

Data collection for each subject in the EXP and SHAM groups consisted of the following: an orientation session, a baseline muscular strength measurement and a strenuous bout of eccentric exercise, four test sessions of muscle strength measures, and eight pain assessments using a modified graphic pain-rating scale[2,8] (Fig 1). During the orientation session, the subjects practiced applying the M.E.N.S. 2000S+ (Monad Corporation, Pomona, CA) electrodes to the skin over the nondominant biceps brachii muscle and adjusting the parameters on the unit. The baseline muscular strength session occurred during the orientation session. Data collection for each subject in the CON group consisted of the same test protocol as the one for the EXP and SHAM groups, except pain was measured at the pretest and at 24, 48, 72, and 96 (± 5) hours from the initiation of the muscle damage protocol for a total of five times. Each day after the exercise bout, pain was assessed using a graphic pain-rating scale before and after treatment for the EXP and SHAM groups. For the CON group, pain was assessed each morning for four consecutive days. An initial pain assessment was obtained to ensure that there was no pain in the nondominant arm prior to initiating DOMS for all three groups. Following the pain measurement, muscle strength was assessed with a one-repetition maximum (1RM) eccentric isotonic test using the nondominant arm of subjects in all three groups. Subjects were asked to perform a 1RM eccentric isotonic test using the nondominant arm to establish a baseline starting resistance. Following the baseline muscle strength assessment, the exercise bout was initiated. After measuring muscle strength, the EXP and SHAM groups received a 20-minute LVMAS treatment or sham LVMAS treatment, respectively.

Test Procedures

To determine initial muscle strength of the nondominant arm, each subject performed an eccentric isotonic 1RM of the elbow flexor group. Subjects were seated beside an exercise machine (Fig 2) designed to assess eccentric muscle strength of the elbow flexors. Subjects were instructed to sit up straight, place both feet flat on the floor, look straight ahead facing a full-length mirror, and keep the shoulders level. To ensure subject compliance with the exercise, another investigator, positioned behind the subject, manually stabilized the subject's shoulder and scapulae (Fig 3). The subject's lateral epicondyle was aligned with the axis of the exercise machine. The position of the lateral epicondyle was visually aligned and maintained by the investigator during the muscle damage protocol. DOMS was then induced in each subject's nondominant elbow flexor muscle group. All concentric lifting was performed by the investigator while another investigator stabilized the shoulder and the scapulae. Subjects lowered 90% of the 1RM until the weight could not be controlled for three seconds, at which time the resistance was decreased by 2.25 kg. The process continued in 2.25-kg decrements until the subject could not control 2.25 kg or had completed 10 repetitions with 2.25 kg. Perceived pain was assessed using a graphic pain-rating scale based on a verbal descriptive scale modified by Denegar et al.[8]

No Pain ______________________________ Unbearable Pain

Dull Ache — Slight Pain — More Slight Pain — Painful — Very Painful

Fig 1. Graphic pain-rating scale.

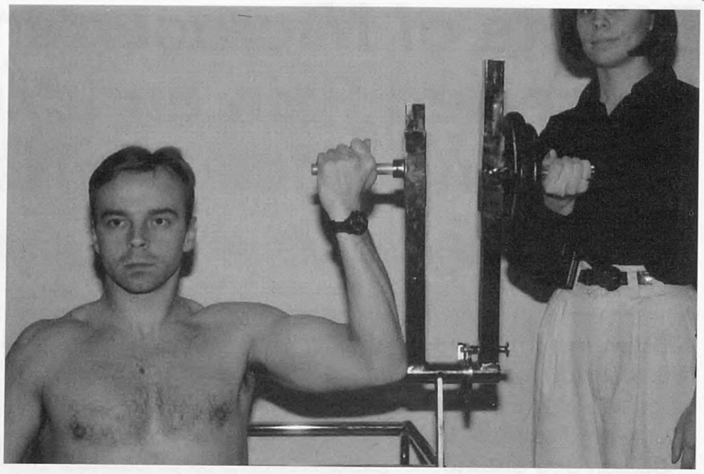

Fig 2. Subject seated at the designed exercise machine.

Treatment Procedures

The LVMAS was administered using a double-blind clinical protocol. Immediately following the assessment of the 1RM each day, subjects in the EXP and SHAM groups were given the LVMAS treatment through two oval (177-mm diameter) self-adhesive carbon-rubber electrodes. The electrodes were

Fig 3. Stabilization of the subject's shoulder and scapulae by investigator.

placed on the skin over the medial and lateral aspects of the biceps brachii muscle at the initial point of pain and were held in place with athletic prewrap and 3.8-cm (1.5-inch) white adhesive athletic tape. Electrical stimulation was produced with a M.E.N.S. 2000S+ Microcurrent Stimulator (Monad Corporation). All six stimulation units used were designed to provide auditory and visual feedback to the subject. However, the electrical mechanism that delivered the stimulation was detached for three of the six units prior to initiation of the study. One investigator was responsible for identifying and distributing the units but did not administer any treatment. A different investigator, without knowledge of the functional status of the units, was responsible for applying treatment to the subjects.

With a permanent black marker, circles (25-mm diameter) were drawn on the skin over the biceps brachii muscle on each subject at the reported initial point of pain in order that pad placement would remain consistent throughout the study. Subjects were instructed not to remove the black circle on the skin over the biceps brachii muscle. The black circle was assessed daily for clarity and blackened as needed. The parameters on the stimulation unit were set at 100 μamps and 0.3 Hz with a biphasic polarity. Treatment time during the day was 20 minutes.

Subjects in the EXP and SHAM groups were issued the same M.E.N.S. 2000S+ unit each day for short- and long-term treatment. Subjects were instructed to treat the damaged arm for at least 8 continuous hours overnight using the same protocol that was used during the 20-minute treatment during the day. None of the subjects reported any malfunction in the application of the unit during the 8-hour treatment. Each subject was educated and retested verbally each day on the operation of the M.E.N.S. 2000S+ unit to assure proper knowledge of the operation of the unit.

Statistical Analysis

Muscle strength measures were analyzed with a 3 × 5 (group × time) ANOVA with repeated measures on one factor (time). Perceived pain measures were analyzed with a 3 × 5 (group × time) ANOVA with repeated measures on one factor (time) to compare measures from each morning group. A 2 × 8 (group × time) ANOVA with repeated measures on one factor (time) was used to assess changes in perceived pain between the EXP and SHAM groups. This analysis included a pain score following each daily microcurrent treatment session.[12]

A post hoc power analysis was conducted to interpret nonsignificant group × time interactions reported in all three two-way analyses of variance (ANOVAs). Power calculated for each group × time interaction for each of the three two-way ANOVAs used for data analysis was as follows: (1) 0.86 for the 3 × 5 (group × time) ANOVA for muscle strength data; (2) 0.73 for the 3 × 5 (group × time) ANOVA for perceived pain; and (3) 0.71 for the 2 × 8 (group × time) ANOVA for perceived pain. The power values indicate that the possibility is relatively small that a significant group × time interaction would be found with a larger sample size or higher alpha level.[12]

RESULTS

Changes in strength measures are presented in Table 1. No significant effect over time among the three groups was found for strength measures, indicated by a nonsignificant two-way interaction (group × time) ($F(8,75) = 0.07$, $p = .9997$). A significant main effect for time was found using an analysis for a main comparison ($F(4,75) = 19.72$, $p = .0483$). Strength measures determined daily using an eccentric 1RM test were significantly decreased following 24 ($F(2,75) = 14.24$, $p = .034$) and 48 ($F(2,75) = 10.33$, $p = .0468$) hours for all three groups. Each of the three groups returned to baseline strength measures within 72 hours following the initiation of DOMS.[12]

Changes in pain measures for the three groups are presented in Table 2. A nonsignificant two-way interaction (group × time) was found for pain measures, indicating no significant effect over time among the three groups when pain was measured each morning ($F(8,75) = 0.30$, $p = .9636$). A significant main effect for time was found using an analysis for a main comparison ($F(4,75) = 19.81$, $p < .0001$). Pairwise comparisons for the CON group indicated that the initial mean pain score was significantly lower than the pain scores measures at 24 ($F(1,75) = 13.79$, $p = .0004$), 48 ($F(1,75) = 22$, $p < .0001$), 72 ($F(1,75) = 12.07$, $p = .0009$), and 96 ($F(1,75) = 5.54$, $p = .0212$) hours. In addition, the mean pain score at 48 hours was significantly greater than the mean pain score at 96 hours ($F(1,75) = 5.46$, $p = .0221$). Pairwise comparisons for the EXP group indicated that the initial mean pain score was significantly lower than the pain scores measures at 24 ($F(1,75) = 25.43$, $p < .0001$), 48 ($F(1,75) = 17.19$, $p < .0001$), 72 ($F(1,75) = 9.15$, $p = .0034$) and 96 ($F(1,75) = 4.40$, $p = .0394$) hours. In addition, the mean pain score at 48 hours was significantly greater than the mean pain score at 72 ($F(1,75) = 4.07$, $p = .0473$) and 96 ($F(1,75) = 28.21$, $p = .0043$) hours. Pairwise comparisons for the SHAM group indicated that the initial mean pain score was significantly lower than the pain scores measures at 24 ($F(1,75) = 17.19$, $p < .0001$), 48 ($F(1,75) = 19.52$, $p < .0001$), 72 ($F(1,75) = 9.06$, $p = .0036$), and 96 ($F(1,75) = 4.60$, $p = .0352$) hours. In addition, the mean pain scores at 24 ($F(1,75) = 4.00$, $p = .0490$) and 48 ($F(1,75) = 5.17$, $p = .0259$) hours were significantly greater than the mean pain score at 96 hours.[12]

Changes in pain measures between the EXP and SHAM groups determined using a 2 × 8 (group × time) ANOVA with

Table 1. Muscle Strength Measures (kg) (Mean ± SD)

Time (Day)	Experimental Group ($n = 6$)	Sham Group ($n = 6$)	Control Group ($n = 6$)
0*	30.1 ± 18.6	33.6 ± 14.8	34.7 ± 18.2
1	29.6 ± 17.2†	28.6 ± 12.4†	26.3 ± 15.0†
2	26.3 ± 17.9†	28.7 ± 9.9†	26.8 ± 16.4†
3	29.0 ± 15.6	32.5 ± 11.1	30.0 ± 17.4
4	30.7 ± 16.1	36.1 ± 13.3	35.2 ± 18.1

* Baseline 1RM.

† Significantly different from the baseline 1RM ($p \leq .05$).

Table 2. Mean (±SD) of Pain Measures (cm)

Time (h)	Experimental Group (n = 6)	Sham Group (n = 6)	Control Group (n = 6)
0*	0.0†	0.0†	0.0†
24	4.4 ± 2.8	3.4 ± 1.9	3.0 ± 2.1‡
29	3.4 ± 3.1	3.3 ± 1.7	
48	3.4 ± 2.5‡	3.7 ± 1.3‡, §	4.0 ± 1.7‡
52	3.2 ± 3.1	3.0 ± 0.4	
72	2.3 ± 2.7	2.2 ± 1.5	2.7 ± 1.7
77	1.6 ± 2.2	1.9 ± 1.6	
96	1.3 ± 1.6	1.4 ± 1.6	1.3 ± 2.0

* Baseline pain measure.
† Significantly less than all other pain measures within groups ($p \le .05$).
‡ Significantly greater than pain measured at 96 h within groups ($p \le .05$).
§ Significantly greater than pain measured at 72 h within groups ($p \le .05$).

repeated measures on one factor (time) are presented in Table 2. A nonsignificant two-way interaction (group × time) was found for pain measures, indicating no significant effect over time among the two groups when pain was measured each morning and following each daily treatment ($F(7,80) = 0.45$, $p = .9908$). A significant main effect for time was found using an analysis for a main comparison ($F(7,80) = 7.83$, $p < .0001$). Pairwise comparisons indicated that there were no differences following the 20-minute treatment each day for the EXP ($F(1,80) = 2.10$, $p = .8604$) or SHAM ($F(1,80) = 0.98$, $p = .9201$) groups.[12]

DISCUSSION

The purpose of this study was to assess the effects of a combined brief (20-minute) and long-term (> 8-hour) application of LVMAS on pain and eccentric muscle strength resulting from an intense bout of eccentric exercise. The results indicate that LVMAS does not reduce pain or facilitate more rapid return of eccentric strength. Based on these results, questions remain as to the clinical efficacy of LVMAS.

A combination of brief (20-minute) and long-term (>8-hour) LVMAS treatment did not produce a significant reduction in perceived pain in the EXP group compared with the SHAM and CON groups. Denegar et al[2] also reported that treatment with LVMAS did not produce a significant reduction in perceived pain caused by an eccentric bout of exercise. They did suggest, however, that a transient analgesic response may have been produced within 24 hours following a 20-minute LVMAS treatment. A transient analgesic response was not found in the EXP group in this study.

A significant reduction in pain following musculoskeletal injuries using the LVMAS treatment protocol described by Picker[7] has been reported[5,6] (J. Halbach, 1995, personal communication). According to the treatment protocols from these reports, ice and NSAIDs were also used simultaneously with the LVMAS treatment. Therefore, the combination of ice, NSAIDs, and LVMAS may reduce pain that results from musculoskeletal injuries. However, according to the results from our study, LVMAS alone is not effective in reducing pain following a heavy bout of eccentric exercise.

LVMAS treatment did not produce a more rapid return of eccentric isotonic muscle strength in the EXP group than it did in the SHAM or CON groups. A significant decrease in eccentric isotonic muscle strength was found in all three groups 24 and 48 hours following the muscle damage protocol, but there were no differences in muscle strength among the three groups. The decrease in muscle strength reported after 24 and 48 hours is consistent with results reported by Denegar et al[2] and Weber et al.[5]

Interestingly, eccentric isotonic muscle strength returned to baseline in the EXP, SHAM, and CON groups within 72 hours following the initiation of muscle damage. Weber et al[5] tested subjects only up to 48 hours following the initiation of muscle damage and did not determine the length of time necessary for isometric and concentric strength to return to baseline. In addition, Weber et al[5] did not measure eccentric muscle strength. Denegar et al[2] reported that concentric isokinetic strength had not returned to baseline levels when measured 7 days (168 ± 4 hours) following the initiation of muscle damage.

Other studies evaluating the effect of exercise on muscle strength following DOMS have utilized either isometric or concentric isokinetic testing to determine improvement in muscle strength following DOMS.[13,14] Donnelly et al[13] reported that light eccentric exercise performed 24 hours following an intense bout of eccentric exercise significantly reduced maximal isometric strength immediately after the exercise bout but did not hinder the return to baseline maximal voluntary strength measures. To date, no other study has utilized eccentric 1RM testing 24, 48, and 72 hours following an intense bout of eccentric exercise to determine changes in muscle strength. Results from this study suggest that the minimal amount of eccentric work (two to five trials) necessary to determine maximal eccentric isotonic strength of the elbow flexors may enhance the ability to return to baseline eccentric isotonic strength. However, the LVMAS treatment did not accelerate the return of eccentric isotonic muscle strength.

In summary, the results from our study substantiate previous findings that a combined brief (20-minute) and long-term (>8-hour) application of LVMAS alone is not effective in decreasing pain and restoring muscle function following an intense bout of eccentric exercise. With the extremely limited experimental research available concerning LVMAS and the treatment of pain, more controlled studies are warranted to validate the cause and effect of LVMAS and establish effective treatment protocols and parameters. Future studies include the need to determine (1) the efficacy between probes and electrode application for LVMAS treatment; (2) the cause-and-effect differences of other noninvasive methods in conjunction with LVMAS, such as ice, heat, or NSAIDs; and (3) the efficacy of LVMAS on edema or effusion from musculoskeletal injury.

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The Effect of Cryotherapy on Eccentric Plantar Flexion Peak Torque and Endurance

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Objective: The effects of cryotherapy on eccentric torque production and muscle endurance have been controversial. Our intent was to examine the effect of cryotherapy on isokinetic eccentric plantar flexion peak torque at 30°/sec and 120°/sec and on endurance at 120°/sec.

Design and Setting: Subjects were tested on an isokinetic dynamometer for peak torque and endurance and were then randomly assigned to one of four groups: (a) peak torque measurements at 30°/sec and 120°/sec after a 30-minute 10°C ice bath immersion, (b) peak torque measurements at 30°/sec and 120°/sec without ice bath immersion (control), (c) endurance measurement at 120°/sec after a 30-minute 10°C ice bath immersion, and (d) endurance measurement at 120°/sec without ice bath immersion (control). Subjects completed each of the four experimental conditions with 7 to 14 days between conditions.

Subjects: Eleven male and 11 female volunteers (mean age, 23.8 ± 3.5 years) were screened for normal ankle range of motion, past history of lower extremity injury, and contraindications to cryotherapy.

Measurements: Dependent t tests were used to analyze practice session data in order to establish reliable baseline measurements. A 2 × 2 analysis of variance (ANOVA) with repeated measures ($p < .05$) was used to analyze peak torque data. A one-way ANOVA ($p < .05$) was used to analyze endurance data in the form of total work.

Results: Velocity significantly affected peak torque production, with eccentric peak torque values significantly higher at 120°/sec than at 30°/sec for both the control and the immersion conditions. Cryotherapy had no effect on eccentric peak torque at either 30°/sec or 120°/sec, but it increased eccentric total work (endurance) at 120°/sec.

Conclusions: Cryotherapy has long been known to have beneficial therapeutic effects. In our study, cryotherapy did not significantly affect eccentric peak torque, but it did increase muscle endurance. An athlete can reap the beneficial effects of cryotherapy, such as pain reduction, vasoconstriction, and edema control, without compromising eccentric force production or endurance.

Key Words: isokinetics, strength, cold

The effect of cryotherapy on eccentric torque production and muscle endurance has been investigated by numerous researchers;[1–15] however, the results are not consistent. Researchers[3–6,8–10,12,14] have demonstrated that cryotherapy significantly increases concentric muscle endurance, but the effect on concentric torque production remains controversial. Cryotherapy has been shown to decrease,[1,2,13,15] increase,[5,6,11] and not impact[3,7,9,10] torque production. The majority of the research involved isometric torque production and/or endurance testing.[1,3,5–7,9,11,15] Only three studies involved the effect of cryotherapy on isokinetic concentric peak torque or endurance.[2,10,13] To date, no study has addressed the effect of cryotherapy on isokinetic eccentric torque production. The purpose of this study was to examine the effect of cryotherapy on isokinetic eccentric plantar flexion peak torque at 30°/sec and 120°/sec and on endurance at 120°/sec.

METHODS

Subjects

Subjects were 11 male and 11 female volunteers with age ranging from 20 to 32 years (mean = 23.8 ± 3.5). All subjects were screened for normal ankle range of motion, past history of lower extremity injury, and contraindications to cryotherapy. The research methodology was explained to all subjects and a consent form was signed.

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Instrumentation

The Biodex B-2000 isokinetic dynamometer (Biodex Corp., Shirley, NY) was used to collect data. The test protocol was supplied by the manufacturer and was strictly followed. Prior to data collection, the Biodex dynamometer was calibrated, the testing procedures were explained, and each subject was positioned.

Subjects were seated in the accessory chair with the torso stabilized with VELCRO® (VELCRO USA Inc., Manchester, NH) straps. The axis of the Biodex dynamometer was aligned with the lateral malleolus, with the hip and knee flexed to 55°. Additional VELCRO straps were applied to the pelvis, knee, and ankle. The ankle was allowed 40° of plantar flexion and 10° of dorsiflexion from the anatomically neutral position.

Data Collection

Subjects participated in at least 2 practice sessions at 30°/sec and 120°/sec. Dependent t tests were used to analyze the data from the practice sessions. Subjects continued to practice until there were no significant differences between the last two practice sessions. Consistency in the practice sessions implied that the subjects had learned how to use the isokinetic unit and could produce reliable data at the velocities at which they practiced. This is of particular importance when eccentric contractions are a component of the protocol.

Pretest data collection included peak torque and endurance testing. Peak torque measurements consisted of a warm-up of four submaximal repetitions and one maximal repetition, followed by a 1-minute recovery period, and a test of five maximal repetitions at 30°/sec and 120°/sec. The single highest value for each test was used for data analysis. Endurance testing consisted of a warm-up of four submaximal repetitions and one maximal repetition, followed by a 1-minute recovery period, and a test of 100 maximal repetitions at 120°/sec. Muscle endurance was quantified by summing the total work of each of the 100 eccentric repetitions performed. Subjects were then randomly assigned to one of four conditions: (a) peak torque measurements at 30°/sec and 120°/sec after a 30-minute 10°C ice bath immersion, (b) peak torque measurements at 30°/sec and 120°/sec without ice bath immersion (control), (c) endurance measurement at 120°/sec after a 30-minute 10°C ice bath immersion, and (d) endurance measurement at 120°/sec without ice bath immersion (control). The cryotherapy conditions involved a 30-minute leg immersion to mid thigh in a 10°C ice/water bath. These parameters are consistent with the methods of previous studies[1,3–5,7,9,16] and assured complete submersion of the plantar flexor musculature. The control conditions involved a 30-minute period in which the subject stood at room temperature with the leg in an empty canister. No more than 5 minutes elapsed between cooling and data collection. The subjects randomly completed each of the four experimental conditions with a minimum of 7 days and a maximum of 14 days between conditions.

Data Analysis

Dependent *t* tests were used to analyze practice session data in order to establish reliable baseline measurements.[17] A 2 × 2 analysis of variance (ANOVA) with repeated measures ($p <$ .05) was used to analyze peak torque data.[17] A one-way ANOVA ($p < .05$) was used to analyze endurance data in the form of total work.[17]

RESULTS

The means and standard deviations for eccentric plantar flexion peak torque values for control and immersion conditions at 30°/sec and 120°/sec are displayed in Table 1. Velocity ($F(1,21) = 18.48$, $p = .0003$) was shown to significantly affect peak torque production. Eccentric peak torque values were significantly higher at 120°/sec than at 30°/sec for both control and immersion conditions. However, the condition ($F(1,21) = 1.12$, $p = .30$) was not significantly different for peak torque measurements, thus indicating that cryotherapy had no effect on eccentric peak torque at 30°/sec or 120°/sec.

The means and standard deviations for eccentric total work are displayed in Table 2. Endurance ($F(1,21) = 8.14$, $p = .0095$) was significantly different for total work between control and immersion conditions. Cryotherapy increased eccentric total work at 120°/sec.

DISCUSSION

Cryotherapy is used extensively in the athletic environment. Athletic trainers administer cold packs during competition, practices, and at half-time. We frequently return players to activity after cryotherapy. The literature is not conclusive about the response of muscle torque to cryotherapy, especially as it relates to eccentric activity. The results of this study indicated that all subjects produced significantly higher eccentric peak torque values at 120°/sec than at 30°/sec, regardless of condition. These results are consistent with other previously published studies.[18–20] The eccentric force-velocity relationship indicates that peak torque increases as velocity increases and is inversely related to the concentric force-velocity relationship in which peak torque decreases as velocity increases. The results of this study indicate that cryotherapy did not change the eccentric force-velocity relationship (Table 1).

In addition, cryotherapy did not significantly affect isokinetic eccentric peak torque at 30°/sec or at 120°/sec. Although these results are consistent with those of other studies,[3,7,9,10] our study differed by addressing eccentric muscle activity. A study[15] measuring concentric and eccentric peak torque at 60°/sec after a 25-minute ice application to the quadriceps muscles found significant decreases in both concentric and eccentric peak torque after cooling. Initially, these results may appear to contradict the results of our study; however, the quadriceps muscle is composed primarily of fast-twitch fibers. Other studies[21,22] cooled muscle fibers of the soleus and extensor digitorum longus of cats and compared the response of fast- and slow-twitch fibers. The maximal twitch tension in fast-twitch fibers increased at temperatures down to 20°C, while that of slow-twitch fibers decreased.[21,22] At temperatures less than 20°C, the tension produced by both fast- and slow-twitch fibers decreased with decreasing temperatures.[21,22] Ranatunga and Wylie suggested that the decreased temperature may inhibit actin and myosin cross-bridge interaction.[22] Therefore, the magnitude of cooling may also play an important role

Table 1. Means and Standard Deviations for Eccentric Plantar Flexion Peak Torque Values for Control and Immersion Conditions*

Condition	30°/sec	120°/sec	Grand Mean
Control	86.56 ± 22.66	94.24 ± 28.35	90.41 ± 25.35
Immersion	90.70 ± 31.56	97.96 ± 27.75	94.34 ± 29.22
Grand Mean	88.63 ± 26.86	96.10 ± 27.14	

*All values are in newton meters.

Table 2. Means and Standard Deviations for Eccentric Plantar Flexion Total Work for Control and Immersion Conditions*

Condition	120°/sec
Control	2265.18 ± 864.23
Immersion	2643.00 ± 947.38
Grand Mean	2454.10 ± 905.84

*All values are in newton meters.

in the muscle force production. No differences in tension were observed when the temperature of an ice bath was greater than 18°C.[4] A decrease in tension was observed when water temperature was less than 18°C.[4] Clarke et al concluded that the decrease in blood flow in the superficial fibers of the muscle inhibited contraction. Another study[16] examined a cooling temperature spectrum from 0°C to 46°C. As the temperatures the subjects were exposed to decreased, there was a steady decline in force production and maximal voluntary contraction of the triceps surae.[16] Edwards et al and Davies et al concluded that the decrease was a result of decreased nerve conduction velocity and decreased speed of contraction.[8,16]

A review of the literature revealed 10 studies that involved the effect of cryotherapy on muscle endurance.[3–6,8–10,12–14] Regardless of the testing procedure or the cooling method, endurance increased. Our study was the only study that involved eccentric muscle endurance. The increase in total work following cryotherapy could be attributed to decreased pain during the exercise bout,[23] decreased rate of torque decline,[6,10] increased muscle viscosity and decreased metabolic byproducts,[5,6] and a more gradual increase in muscle temperature during the exercise bout. Muscle fiber recruitment order may also have been influenced.[14] A significant increase in endurance was recorded when slow-twitch muscle fibers were recruited before fast-twitch muscle fibers.[14] This was a result of a more substantial decline in fast-twitch fiber tension when cooled.[14] The fast-twitch fibers were consistently more fatigable than the slow-twitch fibers, regardless of the temperature. When the tension of the contraction depended more upon slow-twitch fibers than upon fast-twitch fibers, endurance increased.

In conclusion, cryotherapy has long been known to have beneficial therapeutic effects. The results of this study indicate that cryotherapy does not significantly affect eccentric peak torque but does increase muscle endurance. An athlete can reap the beneficial effects of cryotherapy, such as pain reduction, vasoconstriction, and edema control, without compromising eccentric force production or endurance.

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Effects of a 6-Week Strength and Proprioception Training Program on Measures of Dynamic Balance: A Single-Case Design

Carl G. Mattacola, PhD, ATC; John Wills Lloyd, PhD

Objective: To examine the effects of a 6-week strength and proprioception training program on clinical measures of balance, and to introduce characteristics of a single-case research design that may be beneficial to the athletic training profession as both a research and a clinical tool.

Design and Setting: A multiple baseline design across subjects was used to assess the effects of the intervention. The training program was performed three times a week and consisted of manual muscle strengthening and proprioception training for the plantar flexor, dorsiflexor, inversion, and eversion muscle groups.

Subjects: Three subjects (age = 17.6 ± 1.24 yr, wt = 78.6 ± 1.07 kg, ht = 186.2 ± 4.3 cm) who had previously sustained first-degree lateral ankle sprains.

Measurements: Dynamic balance was tested three times a week using a single-plane balance board (SPBB). Each subject was tested for two double-leg conditions (forward/backward, right/left) and one single-leg condition (forward/backward) for each extremity. The dependent variable was the number of times that the balance board made contact with the floor. Visual inspection was used to evaluate whether the treatment resulted in a change of performance.

Results: Although the intervention did not produce obvious improvements in balance for all evaluation criteria for all testing conditions, it is apparent that the strength and proprioception training program positively influenced all three subjects' ability to balance dynamically on an SPBB. A change in mean scores from baseline to intervention phase was evident for all testing conditions. However, a change in slope and level was not as apparent for all testing conditions, especially the single-leg conditions.

Conclusion: The results revealed that the strength and proprioception training program produced improvements in the ability to balance as assessed dynamically on an SPBB.

Key Words: ankle sprain, postural sway

A rehabilitative program integrating strength and proprioception concepts is common when treating lower extremity injuries.[1–3] Although functional implication for improving proprioception following injury to structures of the lower leg is still being examined,[3–7] proprioception training is often indicated following injury to the lower extremity. Proprioception (somatosensation) is a distinct component of balance. It is the cumulative neural input to the central nervous system from the mechanoreceptors in the joint capsules, ligaments, muscle tendons, and skin.[8] When these structures are subjected to mechanical deformation, action potentials are conducted to the central nervous system (CNS), where the information can influence muscular response and position sense. The integration of afferent neural input to the CNS contributes to the body's ability to maintain postural stability.

Deficits in proprioception are commonly evaluated with static measures of balance, such as the modified Romberg test, or with dynamic measures of balance assessed with computerized force platforms.[9–13] The expense of such computer-assisted evaluation limits the use of these tests with a broader population. We used a single-plane balance board (SPBB) to assess dynamic balance because of its affordability and ease of use.

Our purposes were to evaluate the effectiveness of a 6-week strength and proprioception training program on the ability to improve dynamic balance and to introduce characteristics of a single-case research design that may be beneficial to the athletic training profession as both a research and a clinical tool.

Single-case experimental designs offer a research approach that closely mimics a typical rehabilitation process. For example, the athlete reports to the athletic trainer with a problem. As clinicians, we identify a disorder and then offer an intervention. The identification of a problem is similar to establishing a baseline. As the athlete returns for treatment we continue to reevaluate and then proceed with the current treatment or, maybe, alter our treatment. The repeated measurement and interventions that we use in everyday practice offer an ideal arrangement for performing single-case examinations.

Single-case design, to our knowledge, has not been reported in the athletic training literature. A single-case or single-subject experimental design is characterized by the following: identification of a baseline measure, repeated measurement of the dependent variable, repeated manipulation of the independent variable, a comparison within the individual across differing conditions, one or a few subjects, a replication of effects, and, ideally, a measurement that is objective.[14] In contrast, case studies are frequently reported in the athletic training literature and are considered a prescientific mode of

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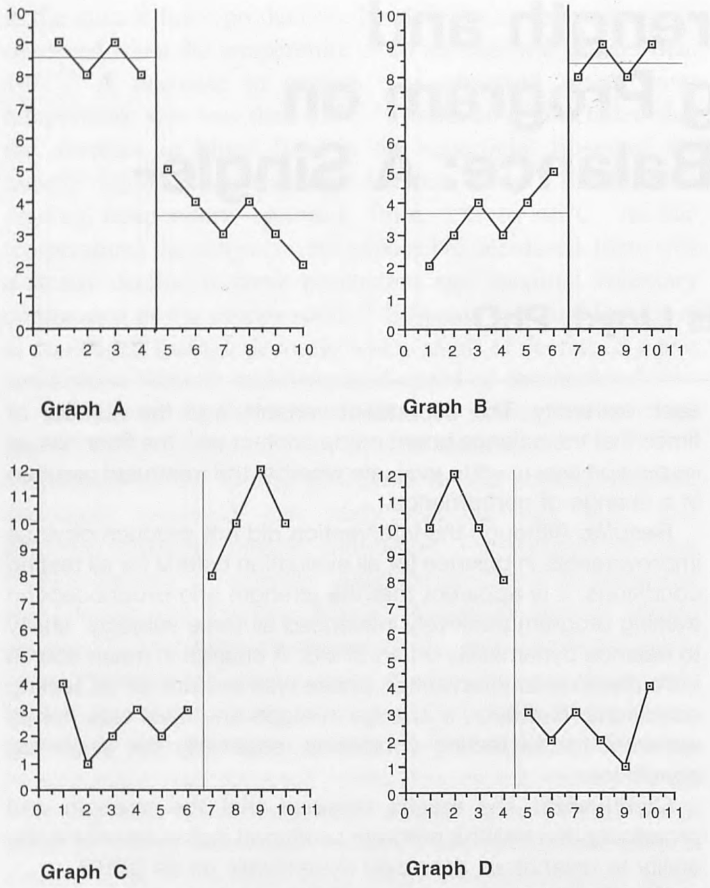

Fig 1. Visual representation of a change in means (graphs A and B) and a change in level (graphs C and D).

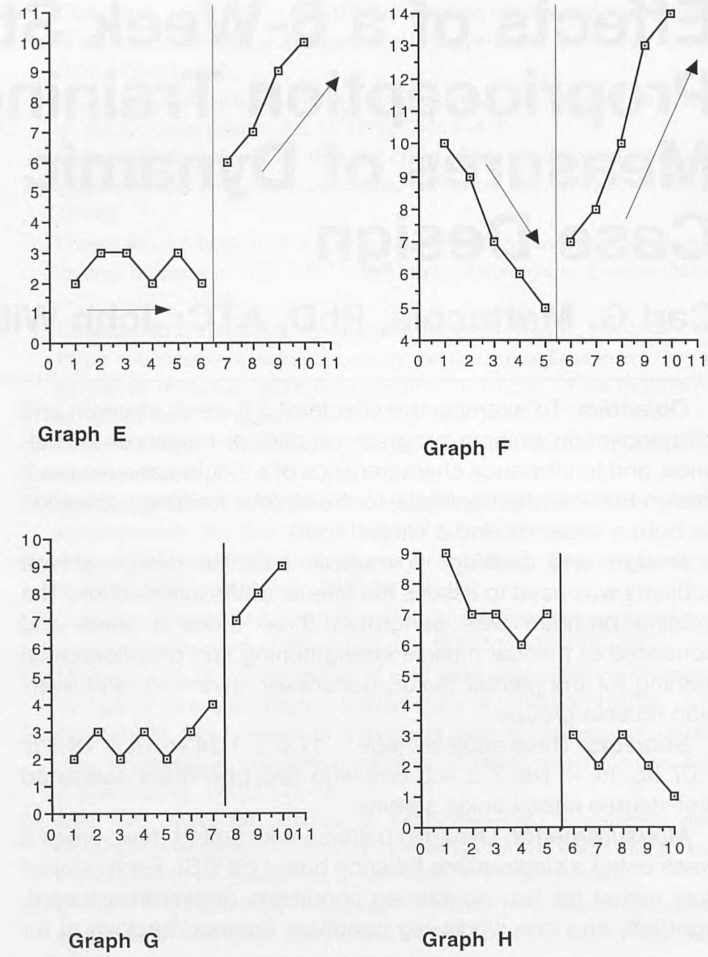

Fig 2. Visual representation of a change in trend, or slope (graphs E and F), and latency of change (graphs G and H).

reporting findings.[15] Case studies are not classified as experimental designs because they lack controls that would eliminate or minimize other possible sources of variations.[15] Case studies document clinical findings without controlling the independent variable in a stringent manner.

Single-case designs are most commonly evaluated by examining the effects of the intervention over time using visual analysis. Statistical analysis may also be used in single-case designs, but its use is often a subject of debate.[16] A recent discussion of the statistical considerations in single-case designs, specifically related to the discipline of sports medicine, was undertaken by Bates[17] and Reboussin and Morgan.[18] Similarly, interested readers may find a more comprehensive review of the topic in Kazdin[14] and Kratochwill and Levin.[16]

Data are often collected in phases, ie, baseline and intervention. The effect of the intervention is clear when systematic changes in behavior occur during each phase in which the intervention is being withdrawn or presented.[14] Thus, the magnitude and rate of change is evaluated. The magnitude of change is assessed by a change in mean or change in level. The change in mean refers to a change in the arithmetic mean from one phase or condition to another (see Fig 1, graphs A and B). A change in level refers to a shift or discontinuity of performance from the end of one phase to the beginning of the next phase.[14] A consistent change in level following the implementation or withdrawal of an intervention indicates that the changes were a result of the treatment (Fig 1, graphs C and D). The rate of change is determined by examining changes in trend and latency of the change. A change in trend, or slope, details systematic increase or decrease over time (Fig 2, graphs E and F). Therefore, a change in trend is demonstrated by a change in the direction of data pattern movement.[19] Latency of the change refers to the period between the onset or termination of one condition and changes in performance (Fig 2, graphs G and H).[14] The sooner that changes in performance follow an intervention, the more confident we can be of the treatment effect. A researcher/clinician can be confident that a treatment is effective when there are changes in mean, level, trend, and latency of change following the intervention.

METHODS

Participants

We measured three boarding school male subjects on their ability to balance. All subjects had signed a consent-to-participate form or had parental permission prior to testing. The three subjects were high-school-letter winners, had previously sustained first-degree lateral ankle sprains, had no occurrence of an injury to either lower extremity within the

Table 1. Descriptive Values (Means and Standard Deviations) for the Three Subjects

Subject	Age (y)	Weight (kg)	Height (cm)	Injured Extremity
S1	19	79.38	190.5	Left
S2	18	79.38	187.9	Right
S3	16	77.11	180.3	Right
Mean (SD)	17.6 (1.24)	78.6 (1.07)	186.2 (4.3)	

3-month testing period, and were not participating in any other lower extremity-strengthening program during the testing period. Descriptive information for the three subjects is presented in Table 1.

We selected these subjects because they were good candidates for a preventive strength and proprioception training program as a result of prior and recurrent inversion ankle sprains. All three subjects reported suffering what could be determined (from past history) to be first-degree inversion ankle sprains. Subjective information supplied by the subjects revealed that past inversion ankle sprains did not require the use of ambulatory aids, and dysfunction following injury did not exceed 1 week. Objective evaluation of each subject with the anterior drawer and talar tilt tests revealed no obvious mechanical laxity when compared with the contralateral extremity.

Setting

Subjects were tested in an office adjacent to the athletic training room. The testing area was partially isolated from distractions, but occasionally another athlete passed through the area. Prior to any baseline testing, subjects reported to the athletic training room and were introduced to the testing procedure and training apparatus.

Dependent Measure

We tested dynamic balance three times a week using an SPBB. The SPBB was a 16½ by 16½-inch wooden board with a 3½-inch axis of rotation (Fig 3). The balance board could contact the floor in one of two planes (forward/backward or right/left). Each subject was tested for two double-leg conditions (forward/backward, right/left) and one single-leg condition (forward/backward) for each extremity (Fig 3). The dependent variable was the number of times that the balance board made contact with the floor. A "touch" was recorded when the SPBB came in contact with the floor as evidenced either visually or audibly. At each testing session the observer counted and recorded the scores for each subject.

Agreement

We conducted observer agreement checks on 20% of the observation sessions for subjects 2 and 3 and calculated agreements by a method similar to the point-by-point agreement procedure.[14] Following each testing condition in which observer agreement was scored, observer agreement was determined from the total number of times that the SPBB touched in a particular direction. For example, if observer 1 determined that the board touched 12 times in the forward position and

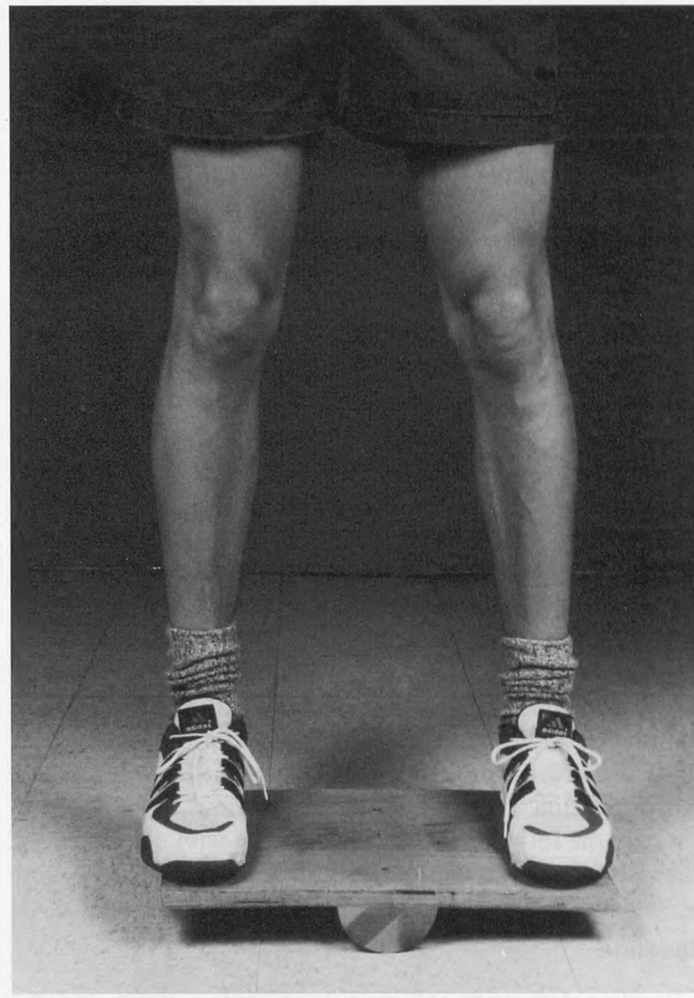

Fig 3. The single-plane balance board (SPBB), double-leg testing condition.

observer 2 determined that the board touched 11 times in the forward position, eleven was used as the score for agreement and one was used as the score for disagreement. Observer agreement was conducted for baseline and intervention phases. The mean agreements were 0.91 during baseline and 0.92 during the intervention phase, indicating that two independent scorers obtained highly similar scores.

Experimental Procedure and Design

The primary investigator performed all observations, except for the sessions when interobserver agreement was scored. The testing lasted approximately 5 minutes, and the training session lasted 10 minutes per session for three sessions per week. We observed the subjects under baseline and intervention conditions. The change from baseline to intervention phases was made according to time-lagged procedures required by a multiple baseline design. A multiple baseline design shows the effects of a treatment by revealing that a subject's performance during baseline differs from performance during treatment and that those differences are not simply the result of time passing. The intervention phase was initiated with 1-week time lags. For example, subject 1 (S1) began the intervention phase after 1 week of baseline testing, subject 2 (S2) began the intervention phase after 2 weeks of baseline testing, and subject 3 (S3) began the intervention phase after 3 weeks of baseline testing. The interventions were staggered in this way so that subjects could begin the strength and proprioception training session as soon as possible. In order to assess the effectiveness of the training program, we wanted the intervention to last minimally 4 to 6 weeks. As a result, we could not sustain longer baselines because the subjects would not be on campus to test.

During each 40-second testing procedure, we asked the subjects to focus on an "X" marked on a wall directly in front of them while they tried to maintain their balance on the board and to prevent the edge of the board from touching the ground.

Subjects stood with their knees slightly flexed (5–15°) and their arms held at their sides. In the single-leg testing condition the nonweightbearing extremity was not allowed to touch the supporting leg. We began recording when each subject was properly positioned on the board and indicated he was ready. On each occasion, subjects were tested for a total of four tests, all with the eyes open. Double-leg stance was tested in the forward/backward and right/left position, and single-leg stance was tested in the forward/backward position only. The right/left condition was not tested in single-leg stance because it was shown during pilot testing that the task was too difficult to perform. Rather than increase the width of the axis of rotation and have a different axis of rotation for different testing positions, we decided to test only the forward/backward condition with the single-leg stance condition.

Baseline

Baseline data were collected three times a week, and the testing period lasted approximately 5 minutes. Baseline conditions lasted for three testing sessions for S1, seven testing sessions for S2, and fifteen testing sessions for S3.

Strength Training

The strength and proprioception training program was performed three times a week for 6 weeks and was described previously. Data were collected under similar conditions for all subjects. At the conclusion of the study, S1 had received the treatment conditions for 20 sessions (6.7 weeks), S2 had

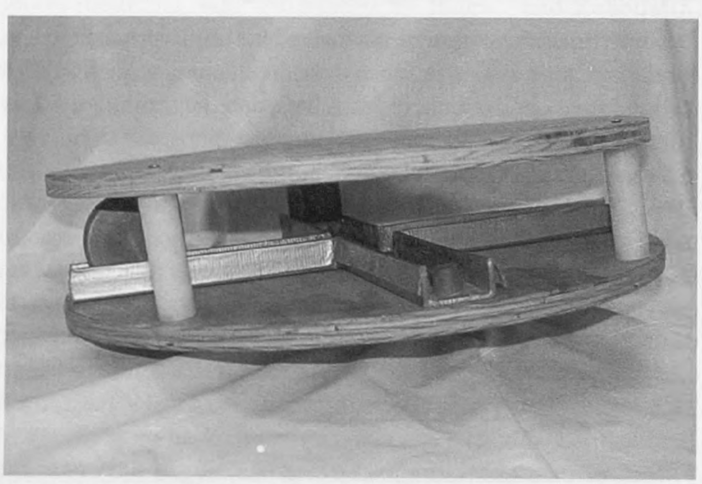

Fig 4. The kinesthetic ankle board (KAB).

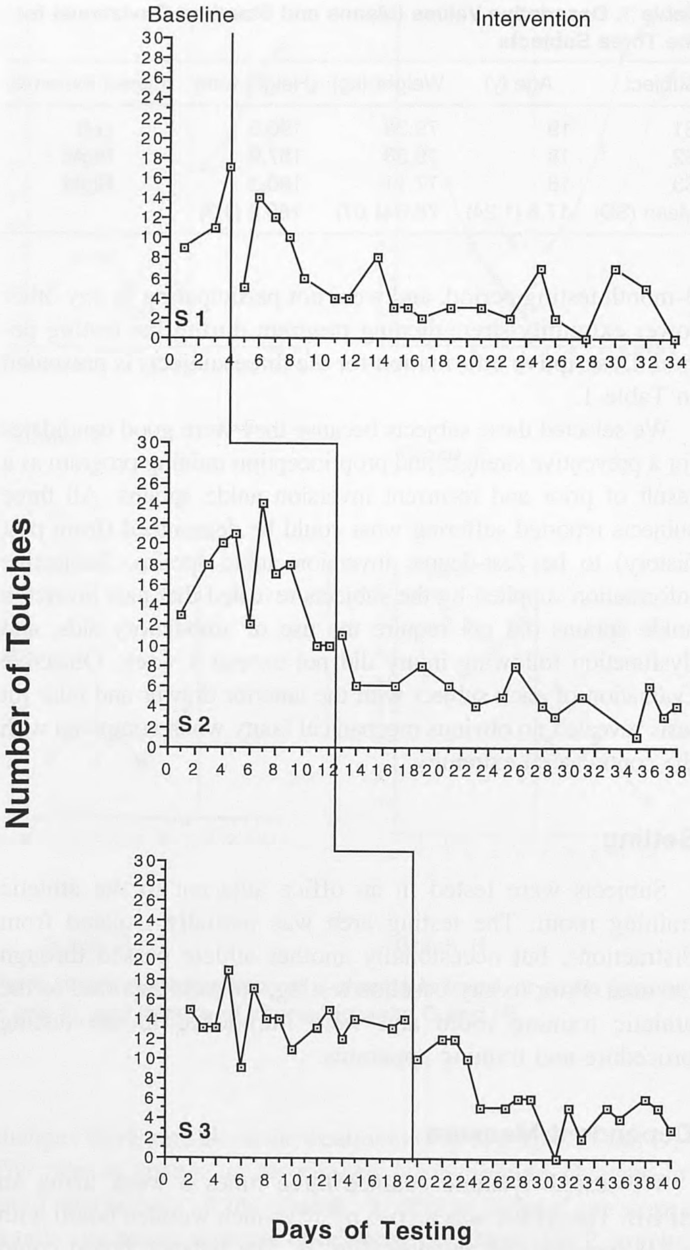

Fig 5. Values for all subjects for the double-leg forward/backward testing condition.

received the treatment conditions for 15 sessions (5.2 weeks), and S3 had received the treatment conditions for 16 sessions (5.5 weeks).

The strength program consisted of a manual muscle resistance program for both extremities. The resistance for the isotonic contractions was performed by the primary investigator and consisted of manually resisting the following lower extremity movements: ankle plantar flexion, dorsiflexion, inversion, and eversion. The subject was supine for all strength movements except for the plantar flexion movement. In this instance the subject was prone. The primary investigator provided a constant resistance in all of the four directions. The subject was instructed to push as hard as he could for each repetition. Each repetition lasted approximately 3 seconds. The primary investigator counted out loud to maintain a consistent 3-second duration for each repetition. Subjects performed 3 sets of 10 repetitions for each strength movement. Following each strength training session, subjects then performed exercises targeted to improve proprioception.

Proprioception Training

Proprioception training consisted of performing 3 sets of 25 repetitions (with a single-leg stance) on the kinesthetic ankle board (KAB) (patent pending), in both clockwise and counterclockwise directions (Fig 4). Proprioception training was performed bilaterally.

The KAB has two .45-kg (1-lb) cylinders that are contained on a track shaped like a "+" on the underside of the platform. The cylinders are free to roll in this track as the KAB is moved in varying directions. The purpose of the free-moving cylinders is to attempt to increase proprioceptive feedback to the mechanoreceptors and joint receptors in the ankle. To our knowledge, this is the first time that this training apparatus has been used.

Subjects were seated in a chair and were instructed to keep their knees at a 90° angle while maintaining contact with the top of the KAB with their respective extremities. Subjects were instructed to keep the periphery of the board in contact with the floor as they moved the board clockwise and counterclockwise. Proprioception training with a circular board is commonly used to attempt to increase range of motion and proprioception following injury to the lower extremity.

To evaluate whether the treatment resulted in a change of performance we applied the principles of visual inspection discussed previously. We looked for changes in the mean performance across phases, changes in the level of performance (shift at the point that the phase is changed), changes in trend (differences in the direction and the rate of change across phases), and latency of change (rapidity of change at the point that the intervention is introduced or withdrawn) to determine whether a reliable effect had occurred.[14]

Table 2. Number of Touches for Each Subject for the Baseline and Intervention Phases for All Testing Conditions (Means, Standard Deviations)

Subject (Test Condition)	Baseline Mean (SD)	Intervention Mean (SD)
S1		
Double-leg forward/backward	12.3 (3.3)	5.7 (3.6)
Double-leg right/left	25.6 (2.6)	10.7 (5.0)
Right leg forward/backward	12.3 (7.5)	3.4 (4.5)
Left leg forward/backward	13.6 (3.8)	2.2 (2.4)
S2		
Double-leg forward/backward	17.8 (3.9)	8.4 (3.9)
Double-leg right/left	15.8 (3.5)	9.6 (4.1)
Right leg forward/backward	19.7 (2.6)	7.6 (4.0)
Left leg forward/backward	13.8 (4.8)	7.2 (2.7)
S3		
Double-leg forward/backward	13.7 (2.2)	9.8 (2.5)
Double-leg right/left	18.7 (2.8)	12.0 (1.2)
Right leg forward/backward	16.7 (4.2)	8.6 (2.4)
Left leg forward/backward	15.4 (4.8)	6.6 (1.7)

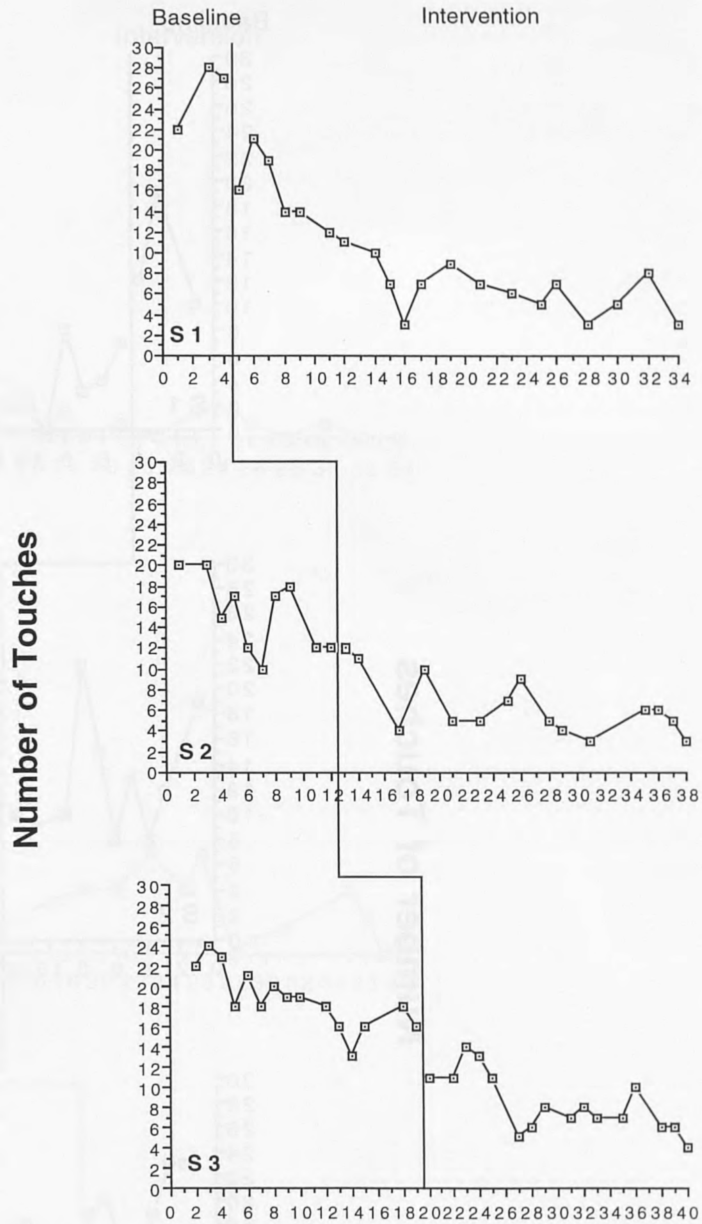

Fig 6. Values for all subjects for the double-leg right/left testing condition.

RESULTS

Double-Leg Forward/Backward Condition

There was a clear change in means from the baseline phase to the intervention phase for all three subjects (Table 2). There was a change in level and latency of change for subjects S1 and S3, but not for S2. There was a change in slope for S1 and S2 and appears to be a change in slope for S3. Thus the change in the dependent measure from baseline to the intervention phase can be attributed to the strength and proprioception training program for all three subjects for this condition (Fig 5).

Double-Leg Right/Left Condition

There was a clear change in the means from the baseline phase to the intervention phase for all three subjects (Table 2). There was a change in level and latency for subjects S1

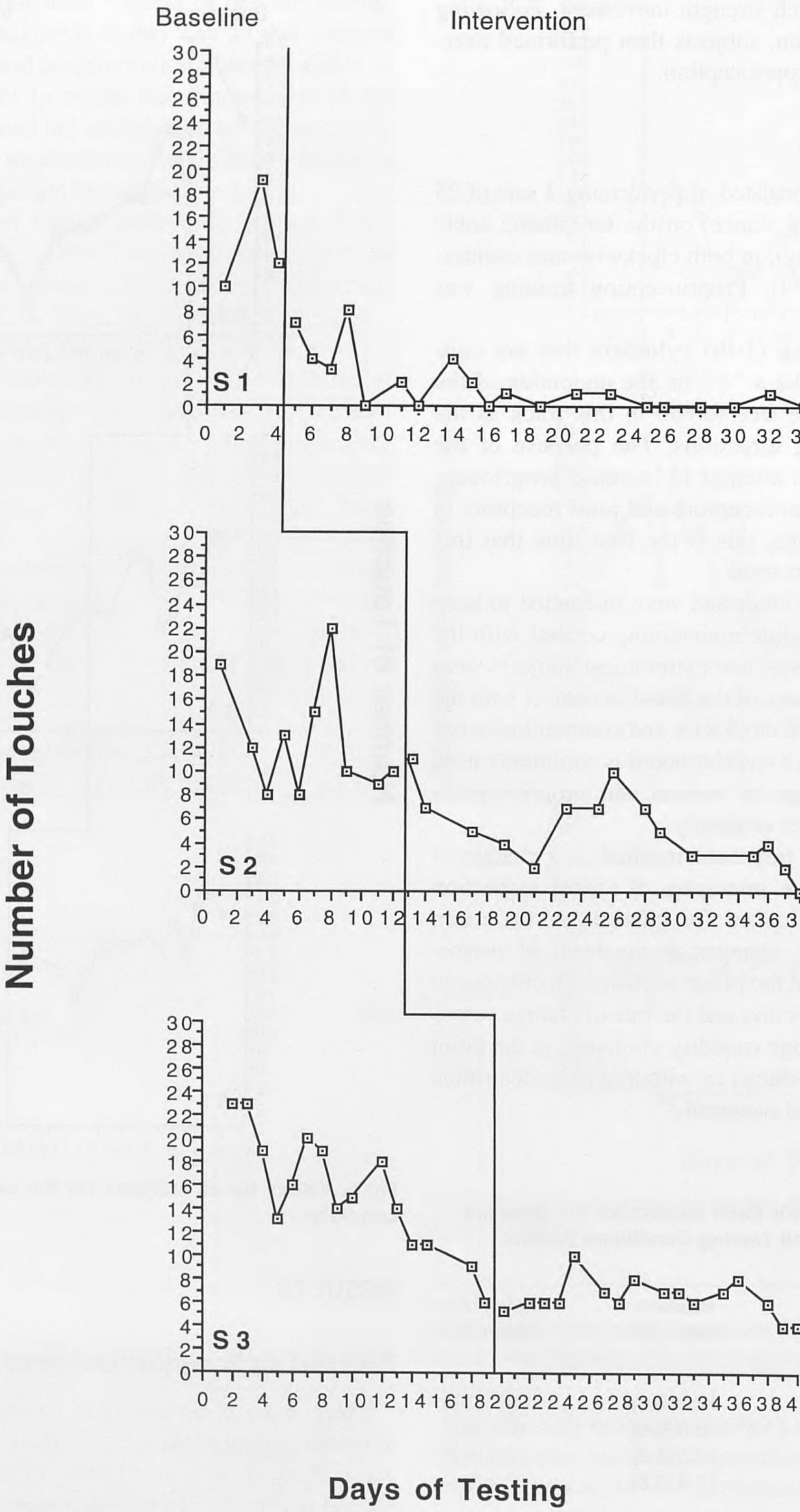

Fig 7. Values for all subjects for the right-leg forward/backward testing condition.

and S3, but not for subject S2. There appeared to be a change in slope for subject S1, but not for subjects S2 and S3. It appeared that the intervention was effective in improving the subjects' ability to balance on an SPBB for this condition (Fig 6).

Right-Leg Forward/Backward Condition

There was a clear change in the mean scores from the baseline phase to the intervention phase for all three subjects (Table 2). There was a change in level and slope only for S1.

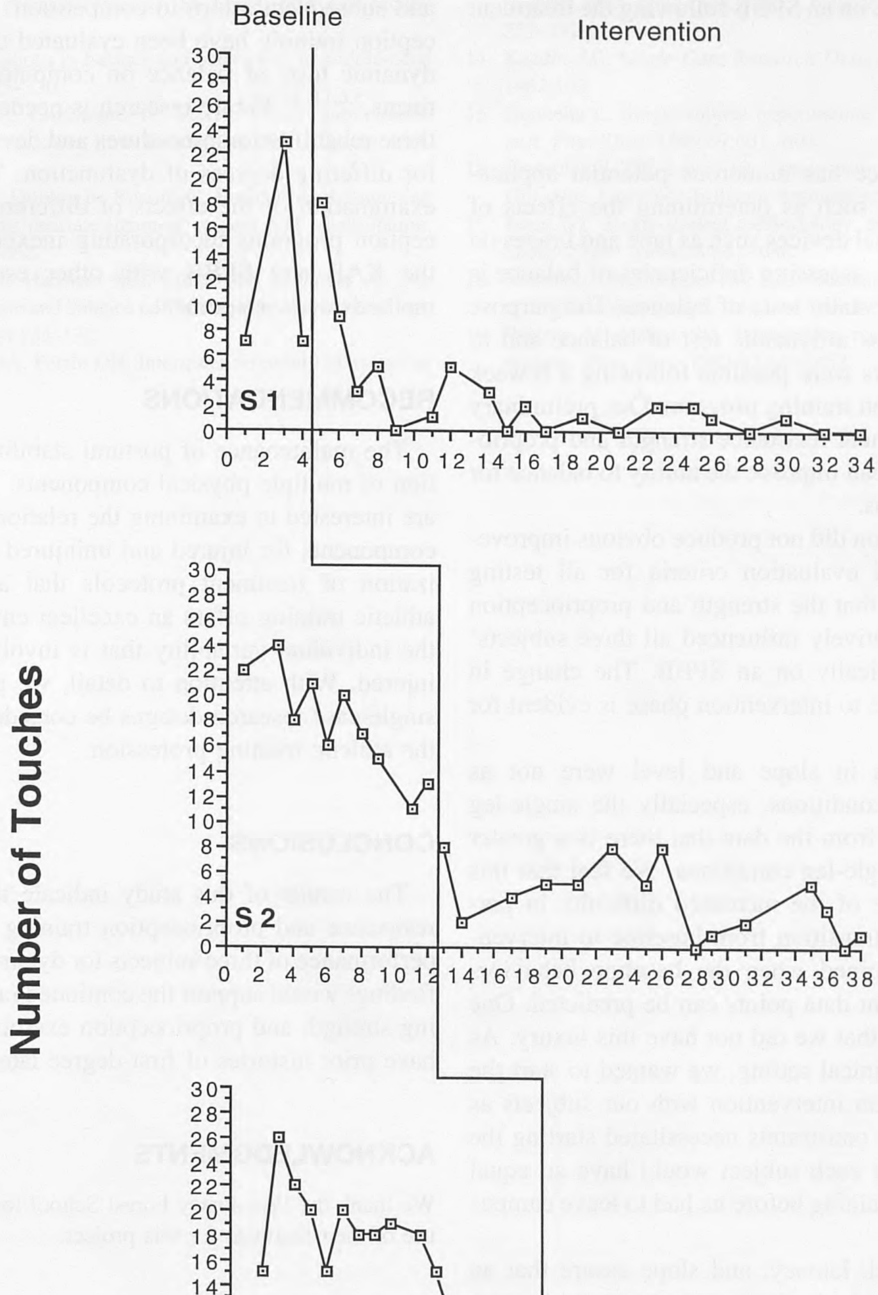

Fig 8. Values for all subjects for the left-leg forward/backward testing condition.

There was no change in latency for all three subjects. There was not a clear change in all criteria from baseline to intervention phase for the right-leg forward/backward condition. However, the clear change in mean score indicates that the treatment did have an effect on the improvement of all subjects' ability to balance dynamically even in the absence of other supporting criteria (Fig 7).

Left-Leg Forward/Backward Condition

There was a clear change in the mean scores from the baseline phase to the intervention phase for all three subjects (Table 2). There was a clear change in level, latency, and slope for S1 and S2, but not for S3. Based on these criteria, it can also be determined that there was an improvement in the subjects' ability to balance on an SPBB following the treatment phase (Fig 8).

DISCUSSION

Measurement of balance has numerous potential applications in athletic training, such as determining the effects of injury, surgery, and external devices such as tape and braces on balance. Following injury, assessing deficiencies of balance is often accomplished using static tests of balance. The purpose of our study was to assess a dynamic test of balance and to determine if improvements were possible following a 6-week strength and proprioception training program. Our preliminary results suggest that a manual resistance strength and proprioception training program can improve the ability to balance for dynamic testing conditions.

Although the intervention did not produce obvious improvements in balance for all evaluation criteria for all testing conditions, it is apparent that the strength and proprioception training program has positively influenced all three subjects' ability to balance dynamically on an SPBB. The change in mean scores from baseline to intervention phase is evident for all testing conditions.

However, the changes in slope and level were not as apparent for all testing conditions, especially the single-leg conditions. It is apparent from the data that there is a greater learning curve for the single-leg conditions. We feel that this can be explained because of the increased difficulty in performing these tests. The transition from baseline to intervention is commonly determined when the baseline behaviors stabilize so that subsequent data points can be predicted. One limitation of our study is that we did not have this luxury. As is often the case in the clinical setting, we wanted to start the strength and proprioception intervention with our subjects as quickly as possible. Time constraints necessitated starting the intervention phase so that each subject would have an equal and adequate interval of training before he had to leave campus for summer vacation.

Changes in mean, level, latency, and slope assure that an intervention is successful. A change in mean was evident for all conditions. However, a change in the other parameters was not as evident, especially when examining the injured extremity. For example, S1, who had injured his left ankle, demonstrated a change in all measures for the left-leg forward/backward conditions. Thus, the affected extremity was influenced in a positive manner via the treatments. The improvement for S2 and S3 (right ankle sprain) in the right-leg forward/backward conditions was not as clear when examining changes in level, latency, and slope. One explanation for this difference is that S1 received the treatment condition for a longer period of time. Further study is needed to examine objectively treatment parameters such as these that are commonly used in the clinical setting.

The integration of strength and proprioception training exercises is commonly employed following injury to the lower extremity. Recently, Leanderson et al[6] examined a group of ballet dancers and reported that proprioception can still be affected 1 year after injury following a rehabilitation program and subsequent return to competition. The effects of proprioception training have been evaluated using either static[4,10] or dynamic tests of balance on computer-interfaced force platforms.[5,6,11–13] Future research is needed to validate the use of these rehabilitation procedures and devices, with consideration for differing degrees of dysfunction. We recommend further examination of the effects of different strength and proprioception programs incorporating inexpensive devices such as the KAB and SPBB with other established computerized methods of measurement.

RECOMMENDATIONS

The maintenance of postural stability involves the integration of multiple physical components. As athletic trainers, we are interested in examining the relationships of these physical components for injured and uninjured athletes. The standardization of treatment protocols that are commonly used in athletic training offers an excellent environment to document the individual variability that is involved while an athlete is injured. With attention to detail, we propose that the use of single-case research designs be considered more frequently in the athletic training profession.

CONCLUSIONS

The results of this study indicate that a six-week manual resistance and proprioception training program improved the performance of three subjects for dynamic tests of balance. Our findings would support the continued rationale for recommending strength and proprioception exercises for individuals who have prior histories of first-degree lateral ankle sprains.[6]

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A Comparison of Moleskin Tape, Linen Tape, and Lace-Up Brace on Joint Restriction and Movement Performance

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Objective: There are several types of ankle prophylactics available. The purpose of this study was to compare the effectiveness of moleskin tape, linen tape, and a lace-up brace on motor performance and ankle/subtalar range of motion (ROM).

Design and Setting: Performance was measured in centimeters and seconds for vertical jump and Southeast Missouri (SEMO) agility test, respectively, under four conditions: control/no support, tape (T), tape with moleskin stirrup reinforcement (TwMSR), and a lace-up brace (B). Motor tests were conducted on two separate days. On another day ankle/subtalar ROM was measured before, during, and after 20 minutes of continuous exercise under the four conditions. All tests were conducted in the field house at Northern Illinois University.

Subjects: Ten college females with no recent history of ankle injury volunteered to participate in the study.

Measurements: Vertical jump was measured using a Vertec jump stand (centimeters), and the Southeast Missouri (SEMO) agility test was measured with a stopwatch (seconds) under the four conditions. Ankle/subtalar ROM was measured before, during, and after a 20-minute exercise protocol by a goniometer under the four conditions. The tape (T) application was a closed basketweave, the tape with moleskin stirrup reinforcement (TwMSR) consisted of a closed basketweave and a moleskin stirrup (7.62 cm, 3 inches), and the brace (B) was a Swede-O Universal (Swede-O, Inc, North Branch, MN).

Results: Vertical jumps were significantly shorter for all three ankle prophylactics when compared with the control/no-support condition. Among the three prophylactics, the vertical jumps were the same. Slower performance times were recorded for all three prophylactics as compared with the control/no-support condition. There were no significant differences, however, among the three ankle prophylactics. In comparison with the control/no-support condition, the TwMSR application significantly restricted four of the four ROMs (plantar flexion, dorsiflexion, inversion, and eversion) during the 20-minute exercise protocol. The T application significantly restricted three of the four ROMS (all ROMs except plantar flexion), and the B application also significantly restricted three of the four ROMs (all ROMs except eversion) during the 20-minute exercise protocol in comparison with the control/no-support condition.

Conclusions: There does not appear to be any benefit in choosing one prophylactic over the others if near optimal performance and adequate ankle/subtalar restriction is desired. Other factors, such as comfort, ease of application, and cost, should be considered.

Key Words: ankle, prophylactic, external support, vertical jump, range of motion, ankle sprain

It is a widely accepted practice in the athletic training profession to provide prophylactic ankle support to individuals exhibiting vulnerability to ankle sprains. Direct evidence from retrospective studies[1,2] suggests that this is an appropriate preventive procedure and demonstrates that the use of prophylactic ankle-taping applications and devices is associated with a decreased incidence of injury in basketball and football.

Gehlsen et al[3] proposed that the ankle joint is protected when the range of motion (ROM) is restricted. There are many prophylactic ankle-taping applications and devices (eg, tape applications, braces, and semirigid orthoses) that purport to restrict ROM and to protect the ankle from possible sprains. Numerous investigations[1,3–14] have examined the ability of ankle prophylactic applications and devices to restrict ROM.

The efficacy of prophylactic ankle support would be minimized if it impeded movement performance. The studies[6,15–18] that have examined the influence of prophylactic taping applications and devices on motor performance tasks (eg, speed, balance, standing long jump, vertical jump, and agility) are inconclusive.

With the exception of the recently published study by Lindley and Kernozek,[19] no studies have examined the restrictive properties of moleskin tape. Also, there are no published reports examining the influence of moleskin tape on performance. Based on our own observations and the literature, we hypothesized that (1) all ankle prophylactics would lose their restrictive properties after 20 minutes of exercise, (2) in comparison with the other ankle prophylactics, tape with a moleskin stirrup reinforcement (TwMSR) would significantly restrict inversion and plantar flexion after 20 minutes of exercise, and (3) in comparison with the other ankle prophylactics, TwMSR would significantly reduce motor performance. Finally, we suspected that TwMSR would be comparable to the tape (T) and brace (B) applications. Thus, the purpose of this study was twofold: (1) to compare the effects of four conditions (control/no support, T, TwMSR, and B) on selected motor performance tasks and (2) to compare the restrictiveness, as measured by

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ROM, between the three support conditions and the no-support condition.

METHODS

We examined the effects of three ankle prophylactic applications (T, TwMSR, and B) on the performance limitations as measured by vertical jump and Southeast Missouri (SEMO) agility test and on ankle and subtalar range of motion (ROM) measured before, during, and after a 20-minute exercise protocol. Ten female subjects gave informed consent to participate in this study. Their average ±SD age, height, and weight were as follows: 26.5 ±3.69 yr, 166 ±6 cm, and 57.19 ±7.72 kg. None of the subjects had a lower leg injury in the three months prior to the study. Several of the subjects had an occasional experience wearing ankle prophylactics.

Ankle prophylactics were applied to the ankle of the dominant foot. To determine the dominant foot, we asked each subject to stand with her feet together. Each subject was gently pushed in the back, causing her to overbalance in a forward direction. The foot that she moved forward to regain balance was considered to be dominant.

The performance tests (vertical jump and SEMO agility) took place on two separate days, the vertical jump test on the first day, followed by the SEMO agility test on the second day. After the performance tests, ROM (plantar flexion, dorsiflexion, inversion, and eversion) was measured before, during, and after the 20-minute exercise protocol on two separate days.

The Vertical Jump Test

With the subject's dominant arm fully extended above her head, we measured each subject's maximal reach in the flat-footed position. The subjects completed three vertical jumps, initiating each jump with both feet flat on the floor. We measured the jumps by a Vertec (Sports Import, Inc, Columbus, OH) vertical jump stand, and a mean vertical jump height was recorded. However, measurements were accurate only to the closest 1.27 cm. Subjects took three practice jumps before each trial started. The procedures for the vertical jump test were similar to those outlined by Safrit,[20] who had reported validity and reliability coefficients of 0.78 and 0.93, respectively. The Vertec machine was used instead of a chalkboard as described by Safrit.[20]

The SEMO Agility Test

The SEMO agility test was performed in the "lane" area on a basketball court. We asked subjects to perform the test three times, and mean scores were recorded for each condition. The SEMO agility test was validated for high school and college males and females, using three previously accepted measures of agility: (a) the AAHPER (American Alliance of Health, Physical Education, and Recreation) shuttle run ($r = 0.63$), (b) the dodging run ($r = 0.72$), and (c) the side-step test ($r = 0.61$). When trial 1 and 2 were performed on the same day, a Pearson correlation coefficient of 0.88 was found for the two trials.[21]

The 20-Minute Exercise Protocol

Each subject participated in a 20-minute run on a 200-m indoor track. Eight cones were placed in pairs, 5 m apart, with 3 m between each pair of cones at each end of the track. All subjects performed the run twice under each condition to determine stability reliability. We asked the subjects to increase the running speeds as they ran in and out of the coned section of the track.

Passive ROM of the ankle joint (dorsiflexion and plantar flexion) and subtalar joint (neutral inversion and neutral eversion) was measured manually by a certified athletic trainer, using a hand-held goniometer. We recorded ROM before and after the application of each ankle prophylactic, after 10 minutes of running, and at the end of the 20-minute exercise protocol. Each trial of the 20-minute exercise protocol, which included the ROM testing, took approximately 30 minutes. To control for fatigue, a rest period of 24 hours separated 20-minute runs.

Before the subjects were tested, the same certified athletic trainer, who applied all tape applications and braces, documented his reliability of measuring ROM with the goniometer, using the average of three measurements. Passive ROM of the twenty ankles was measured three times on the same day with approximately a 40-minute interval between sessions, and an intraclass correlation coefficient (ICC) (one-way analysis of variance (ANOVA) model for average of three measurements) was calculated for each range of motion. The coefficients were as follows: neutral inversion $r = 0.82$, neutral eversion $r = 0.84$, plantar flexion $r = 0.93$, and dorsiflexion $r = 0.94$.

Prophylactic Application

Our investigation examined the effectiveness of three ankle prophylactics: T, TwMSR, and B. The T application used a closed basketweave as described by Arnheim and Prentice,[22] which consisted of two heel locks and one figure eight. This application involved adhesive-backed, linen Coach athletic tape (3.81 cm, 1.5 inches, Johnson & Johnson, New Brunswick, NJ), tape adherent, heel and lace pads, and underwrap. The TwMSR application consisted of a closed basketweave, as previously described,[22] and a moleskin (7.62 cm, 3 inches) stirrup supplied by ProTecto Products (Union, NJ). Moleskin tape was applied around the ankle in a medial to lateral direction. We passed the moleskin stirrup under the heel, and over the lateral malleolus it was split into three tails (2.54 cm/1 inch). The middle tail continued up the lateral side of the leg, the anterior tail was wrapped proximally and anteriorly, and the posterior tail was wrapped proximally and posteriorly at the ankle joint (Fig 1). The Swede-O-Universal brace was the lace-up prophylactic chosen in our investigation. It was fitted and applied over each subject's sock according to the manufacturer's directions.

The trials under each test condition were carried out in a random order. The same certified athletic trainer, who had no knowledge of our hypotheses, applied all ankle prophylactics. The order in which the subjects completed each test was also randomized. Air temperature was measured and remained constant throughout the testing procedures. During the tests, we asked all

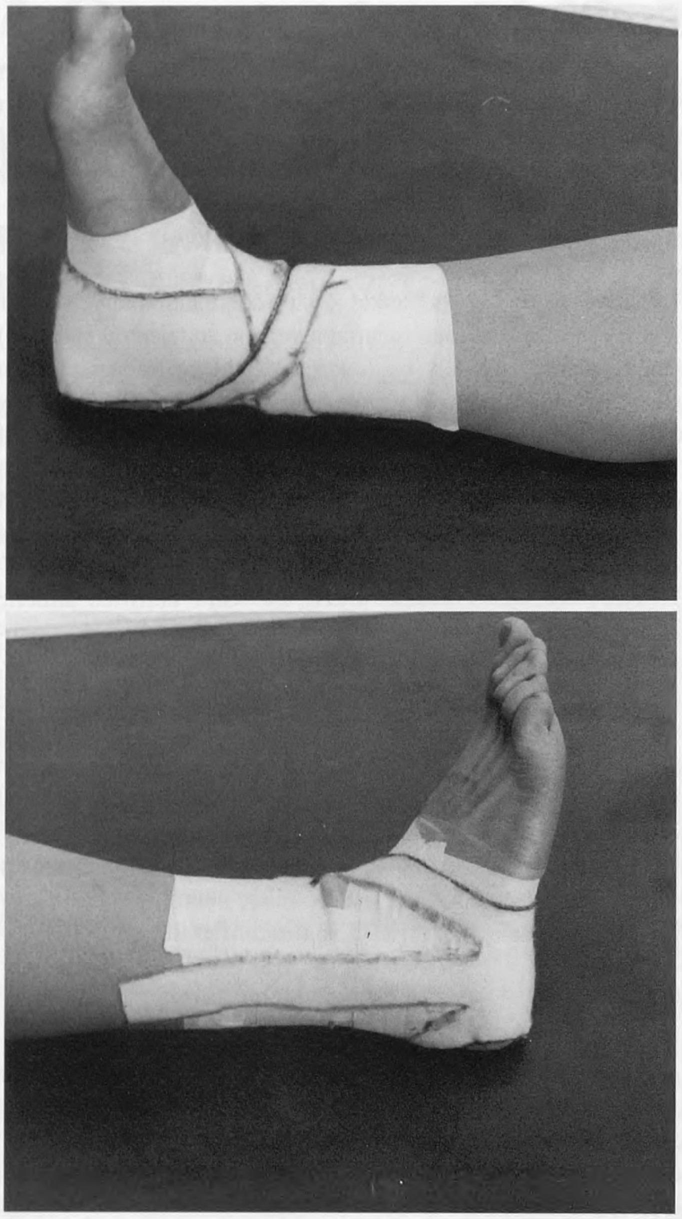

Fig 1. The TwMSR consisted of a closed basketweave using linen-backed tape (3.81 cm, 1.5 inches) and a moleskin stirrup (7.62 cm, 3 inches). (upper) The moleskin stirrup started on the medial side of the ankle and was pulled over the medial malleolus. (lower) It was passed under the heel, and, as it was passed over the lateral malleolus, it was split into three even tails. One tail was continued up the fibula, one was passed anteriorly, and one was passed posteriorly.

subjects to wear low-top athletic shoes of their choice, and they wore the same shoes throughout the testing. None of the subjects had a lower leg injury during the 3 months prior to the study, and no ankle sprains were reported during the study.

Statistical Analysis

Results were collected for each test and condition, and mean values were calculated. An intraclass correlation coefficient (ICC) (one-way ANOVA model) of the average of two trials was calculated to assess the stability of the ROM measures (plantar flexion, dorsiflexion, inversion, and eversion) associated with the 20-minute exercise protocol scores. A one-way repeated measures ANOVA determined whether significant differences in the limitation to performance existed across conditions for each of the performance variables (vertical jump and SEMO agility test). A 4×3 (condition by time) repeated measures ANOVA was conducted on ROM. ROM was described as the average of two trials across time. When appropriate, Tukey's post hoc comparison test was conducted. For all the statistical tests a 0.05 level of significance was used.

RESULTS

Intraclass Correlation Coefficients (ICC)

Intraclass correlation coefficients (ICC) were found for each range of motion, at each time interval (Table 1). In most cases, the coefficients were fairly high. For dorsiflexion and neutral inversion the coefficients ranged from 0.78 to 0.99; for plantar flexion and neutral eversion the range was 0.18 to 0.94.

Motor Performance Tests

Vertical jump performances were different among conditions ((F9,30) = 72.65, $p \leq .0001$) as compared with the no-support condition. The vertical jump heights were significantly shorter for all three prophylactics. The means and SD of the vertical jump performances for the four conditions in centimeters were (1) control/no support, 39.44 ±4.14; (2) B, 38.02 ±4.42; (3) T, 37.69 ±4.34; and TwMSR, 37.87 ±4.41. However, there were no significant differences among the three ankle prophylactics.

The ANOVA results were similar for the SEMO agility test. Performance times differed among conditions ($F(9,30) = 45.54$, $p \leq .0001$). Slower performance times (in seconds) for all three prophylactic supports as compared with the no-support condition were recorded. The means and SD of the SEMO agility test in

Table 1. Intraclass Correlation Coefficients (ICC) (Average of 2 Trials Across Days) of Ankle Joint ROM Measurements Associated with the 20-Minute Exercise Protocol

Condition	Time*	PF†	DF	IN	EV
Control/ no support	Initial	0.93	0.90	0.99	0.85
	10 min	0.87	0.89	0.98	0.67
	20 min	0.55	0.85	0.99	0.33
T	Initial	0.77	0.80	0.99	0.81
	10 min	0.37	0.78	0.96	0.68
	20 min	0.18	0.82	0.99	0.45
TwMSR	Initial	0.75	0.96	0.92	0.78
	10 min	0.70	0.85	0.96	0.89
	20 min	0.45	0.92	0.95	0.79
B	Initial	0.88	0.89	0.99	0.94
	10 min	0.50	0.92	0.98	0.94
	20 min	0.73	0.93	0.98	0.89

* Initial, measurement of the ROM before exercise; 10 min, measurement of the ROM after 10 min of exercise; 20 min, measurement of the ROM after 20 min of exercise.

† PF, plantar flexion; DF, dorsiflexion; IN, neutral inversion; EV, neutral eversion.

seconds for the four conditions were (1) control/no support, 12.05 ±0.74; (2) B, 12.38 ±0.76; (3) T, 12.37 ±0.86; and (4) TwMSR, 12.39 ±0.77. There were no significant differences, however, among the three ankle prophylactics.

20-Minute Exercise Protocol

No significant interactions were found for the 4 × 3 ANOVA (condition by time) performed for the ROM variables ($p > .05$). The condition main effect was significant for each ROM variable (plantar flexion: $F(3,27) = 13.51$, $p \leq .0001$; dorsiflexion: $F(3,27) = 37.82$, $p \leq .0001$; inversion: $F(3,27) = 18.03$, $p \leq .0001$; eversion: $F(3,27) = 15.75$, $p \leq .0001$). The results are presented in Table 2. In comparison with the control/no-support condition, there was a significant reduction in plantar flexion during exercise when wearing the TwMSR and B applications. The T and TwMSR applications significantly restricted eversion when compared with the control/no-support condition. All three ankle prophylactics were significantly effective in restricting dorsiflexion and inversion in comparison with the control/no-support condition.

When the ankle and subtalar ROM was examined at 10-minute intervals during the 20-minute run, there were significant differences. The time main effect was significant for each ROM variable (plantar flexion: $F(2,18) = 71.55$, $p \leq .0001$; dorsiflexion: $F(2,18) = 88.18$, $p \leq .0001$; inversion: $F(2,18) = 135.04$, $p \leq .0001$; eversion: $F(2,18) = 160.54$, $p \leq .0001$). Thus, there were significant increases in plantar flexion, dorsiflexion, inversion, and eversion when the mean values after 10 minutes were compared with the initial values and when the mean values after 20 minutes were compared with the initial values. Tukey post hoc procedures revealed no difference between values recorded after 10 minutes and after 20 minutes. Since there was no interaction, all ankle prophylactics lost their restrictive properties in a similar pattern over time.

DISCUSSION

Motor Performance

All three stabilizing devices significantly limited performance in both the vertical jump and the SEMO agility tests. These findings are in agreement with those of Mayhew,[17] Paris,[18] and Juvenal,[16] who also found that taping or bracing ankles led to a significant reduction in performance.

Mayhew[17] examined the effects of closed basketweave taping application on vertical jump, 50-yd sprint, standing long jump, and the Illinois agility run. He reported that the taping application significantly impaired vertical and long jump ability and concluded that the taping application significantly reduced performance when plantar flexion of the ankle was required. Paris[18] also found that the vertical jump was significantly affected by prophylactic taping application and braces. Juvenal[16] examined the effects of no tape, an elastic tape application, and linen tape on vertical jump and agreed that linen tape significantly reduced jumping ability of subjects. Mayhew[17] and Paris[18] agreed that taping does not affect motor skills such as balance, speed, and agility. Beriau et al,[15] however, concluded that the semirigid support did reduce the time needed to complete an agility course.

We were not surprised that a reduction in performance was found, because each performance test was administered within about 5 minutes of each prophylactic application. Given such a short time period, there was little time for ankle prophylactics to lose any of their supportive or restrictive properties. Typically, loosening of tape is attributed to a separation or tearing of tape fibers, resulting from mechanical strain and moisture on the skin. Perspiration reduces the adhesive property of the tape.[6] We felt that the restrictive properties of the ankle prophylactics were not particularly compromised during the performance tests because of the limited exposure to mechanical stress and perspiration.

20-Minute Exercise Protocol

Personal effort and perspiration may have been contributing factors to the small reliability coefficients in some cases. The mechanical stress, as a result of running in and out of the coned section of the track, varied with each individual. Changes in effort and speed are likely to have had the greatest influence on the breakdown in support and functional ROM measurements. It could be argued that, during running, plantar flexion is a forceful and repetitive functional motion, one which is likely to be affected by increased speed in running. It may then be expected that greater variation in plantar flexion ROM would be seen after an exercise protocol, which the reliability coefficients may reflect. Also, variation in functional ROM, plantar flexion, and effort may have a combined effect with perspiration production. There is evidence that moisture on the skin in the form of perspiration plays a major role in the breakdown of the supportive properties of tape.[6] We reasoned that each subject perspired differently, resulting in a variation of the supportive properties of the ankle prophylactics, which, in turn, impacted the ankle and subtalar ROM.

We hypothesized that the TwMSR application would significantly restrict plantar flexion and inversion in comparison

Table 2. Means and SD of ROM (degrees) for a 20-Minute Exercise Protocol (ANOVA Main Effect Results for Condition)

ROM	Control/ No Support	B	T	TwMSR
Plantar flexion	42.10 (5.16)	35.47 (3.79)*	36.57 (3.68)	35.58 (3.58)
Dorsiflexion	51.97 (5.07)	43.92 (4.52)*	43.35 (5.05)*	42.25 (5.09)*
Inversion	34.05 (11.48)	27.45 (8.85)*	26.43 (9.94)*	25.80 (7.80)*
Eversion	14.63 (2.15)	13.57 (2.22)	12.20 (1.46)*	11.63 (2.32)*

* $p < .05$. Support condition is significantly different from the control/no-support condition.

with the control/no-support condition. The results of our study confirmed this hypothesis. The TwMSR also significantly restricted dorsiflexion and eversion in comparison with the control/no-support condition. However, the other two prophylactics, T and B, also provided significant support. The B application significantly restricted plantar flexion, inversion, and dorsiflexion, while the T application significantly restricted inversion, dorsiflexion, and eversion in comparison with the control/no-support condition. It is difficult to conjecture how our results translate into the prevention of ankle injury. However, according to Gehlsen et al,[3] when movement around the ankle is restricted, the ligaments surrounding the ankle joint are protected as well.

With regard to the restrictive capabilities of ankle braces, our results are similar to the recent findings of Martin and Harter.[8] Martin and Harter[8] reported that after a 20-minute exercise protocol, the lace-up ankle brace significantly restricted subtalar inversion when compared with the control/no-support condition.

Most recently, Lindley and Kernozek[19] examined the restrictive properties of TwMSR after subjects performed a series of five successful 40-yd sprints. In disagreement with our results, Lindley and Kernozek[19] found that TwMSR application did not significantly reduce plantar flexion after subjects ran a series of 40-yd sprints. Differences in our results in comparison with the results of Lindley and Kernozek[19] could be attributed to the moleskin application technique. The latter study used one single stirrup, whereas we used a split-tail (7.62 cm, 3 inches) technique.

In conclusion, we found that the TwMSR condition significantly restricted all four ROMs (plantar flexion, dorsiflexion, inversion, and eversion) tested, whereas the T and B applications significantly limited only three of four ROMs tested in comparison with the control/no-support condition. Additionally, all three conditions significantly reduced motor performance in comparison with the control/no-support condition. We surmise that the additional restriction in ROM that the TwMSR affords the ankle complex would not necessarily translate to superior ankle protection on the playing field when compared with the T and B conditions. Therefore, we are of the opinion that there would not appear to be any benefit in choosing one prophylactic over the others if near-optimal performance is desired. Other factors, such as comfort, ease of application, and cost should then be considered.

Certainly, the advantage of the brace (approximate cost, $42.00) is that it can be worn throughout the season and can be applied by the individual. In contrast, the T application (approximately $1.80 per application) and the TwMSR application (approximately $2.50 per application) must be applied before each event by a skilled person. Finally, in terms of comfort, Beriau et al[15] reported that the Swede-O brace was just as comfortable as, and was preferred to, two other support braces (Aircast Sports Stirrup and Aircast Training, Aircast, Inc, Summit, NJ) and was more comfortable than, and was preferred to, the DonJoy Ankle Ligament Protector (Smith & Nephew DonJoy, Inc, Carlsbad, CA). Thus, when we consider all the factors, eg, comfort, ease of application, cost, restrictive properties, and influence on performance, the Swede-O brace seems to have a slight edge over the other ankle prophylactic applications.

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Changes in Ankle Joint Proprioception Resulting From Strips of Athletic Tape Applied Over the Skin

Guy G. Simoneau, PhD, ATC, PT; Rebecca M. Degner, PT; Cindi A. Kramper, PT; Kent H. Kittleson, PT

Objective: In part, the believed effectiveness of taping in preventing injuries may be in the increased proprioception that it provides through stimulation of cutaneous mechanoreceptors. The objective of this study was to examine the effectiveness of strips of athletic tape applied over the skin of the ankle in improving ankle joint movement and position perception.

Design and Setting: The study consisted of a single-group, repeated-measures design, where all subjects were tested under all conditions presented in a fully randomized order. Testing was performed in the biomechanics laboratory at Marquette University.

Subjects: Twenty healthy males (mean age = 20.3 ± 1.5 yr) participated in this study.

Measurements: Ankle joint movement and position perception for plantar flexion and dorsiflexion were tested using a specially designed apparatus. Each individual was tested with and without two 12.7-cm (5-inch) strips of tape applied in a distal-proximal direction directly to the skin in front of and behind the subject's talocrural joint.

Results: Data were analyzed with repeated-measures analyses of variance (ANOVA) models. Our results indicate that under the nonweightbearing condition, taping significantly improved ($p < .05$) the ability of the subjects to perceive ankle joint position, especially for a 10° plantar-flexed position. In the weightbearing condition, the use of tape did not significantly alter ($p > .05$) the ability of the subjects to perceive ankle position. Similarly, taping did not alter ankle movement perception in either the weightbearing or nonweightbearing condition ($p > .05$).

Conclusions: We concluded that increased cutaneous sensory feedback provided by strips of athletic tape applied across the ankle joint of healthy individuals can help improve ankle joint position perception in nonweightbearing, especially for a midrange plantar-flexed ankle position.

Key words: external support, kinesthesia, joint position perception, joint movement perception

Athletic trainers, physical therapists, and other rehabilitation professionals stress the importance of proprioceptive reeducation during the rehabilitation process following an injury.[1, 2] It is believed that an injury such as an inversion ankle sprain, for example, results in a reduction of proprioceptive function that may lead to future reinjuries.[3] One suggested palliative method to supplement a deficit in proprioceptive function at the ankle is the use of external support such as taping and braces.[4–7] The tape or brace is believed to provide increased mechanical support as well as increased proprioception.

While a few studies have investigated the effects of taping and bracing on tasks such as maintaining standing balance,[5–8] no study has directly measured the effects of taping on ankle joint position and movement perception. This lack of information is partly due to the current limited ability to directly assess these aspects of proprioception at the ankle joint.

The purpose of this study was to examine the effects of strips of athletic tape, applied over the skin of the ankle, on a person's ability to perceive joint movement and joint position at the ankle. An apparatus specially designed for the purpose of measuring joint position sense and kinesthesia (joint movement perception) at the ankle was used.[9] It was hypothesized that ankle proprioception would be improved with the added cutaneous sensory stimuli provided with the use of athletic tape.

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METHODS

Subjects

Twenty healthy males between the ages of 19 and 25 (mean age = 20.3 ± 1.5 yr) participated in this study. All subjects were free of current or chronic ankle injuries and had normal ligamentous stability of the ankle. The subjects were recruited from the general student population of Marquette University through media frequently read by this group—fliers, advertisement boards, and student newspapers. An informed consent, approved by the Marquette University Institutional Review Board, was obtained from each subject prior to his participation in the study.

Baseline data for basic physical characteristics were collected on each subject. These included age, weight, height, and range of motion at the ankle for plantar flexion and dorsiflexion. Standard clinical stability testing of the ankle ligamentous structures was performed in order to rule out anterior and lateral talocrural joint instability. Subjects were also screened for any significant ankle/foot deformity (such as excessive foot planus and foot cavus), any recent (within 6 months) ankle injuries, any history of chronic ankle sprains, and any history of significant injury at the ankle.

Testing Apparatus

The ankle joint movement and position perception apparatus, which was designed to objectively measure various aspects of ankle proprioception, consisted of two individually movable foot platforms (Fig 1). Each platform was made up of a 12-by-7-inch metal plate, on which the subject placed his foot, and two 9-inch-high side walls. These side walls are used to provide an attachment base for the axes connecting the foot platforms to the supporting uprights. The distance between the axis of rotation of each platform and the surface on which the subject stood was adjustable from 0 to 6 inches. This "depth" adjustment, made by varying the thickness of the floor layers (wood plates) between the foot and the platform itself, was an important feature in properly matching the axis of rotation of the platform with the lateral malleolus (the lateral malleolus corresponds to the approximate location of the axis of rotation of the ankle for plantar flexion and dorsiflexion). An electrically driven electromagnetic actuator was used to move each platform individually at angular velocities varying from 0.1 to 4.0°/sec. Lengthening of the actuator caused an upward tilt of the anterior section of the foot platform, which brought the ankle in dorsiflexion; shortening of the actuator caused a downward tilt of the platform and resulted in ankle plantar flexion. A total amplitude of angular movement of 25° (8° upward and 17° downward) could be achieved with the actuator. An inclinometer, precise to 0.01 degree, was directly mounted on each foot platform to measure the angular position of each ankle. To eliminate lower leg movement, the subject's lower legs were fixed to a shin pad using two VELCRO® pads (Fig 1). A surrounding wood platform was built to make the apparatus more accessible and to allow for testing with the subject sitting. This platform included a surrounding rail that the subject could hold to further stabilize the upper body. This rail, combined with the anatomical placement of the platform's axis of rotation, ensured that the shin pad and VELCRO straps provided similar stability for the sitting and standing testing positions, standardizing the testing procedures across all conditions. Test-retest reliability of this device for the testing of joint movement perception was established at $r = 0.84$.[9] Further description of the device has been published elsewhere.[9]

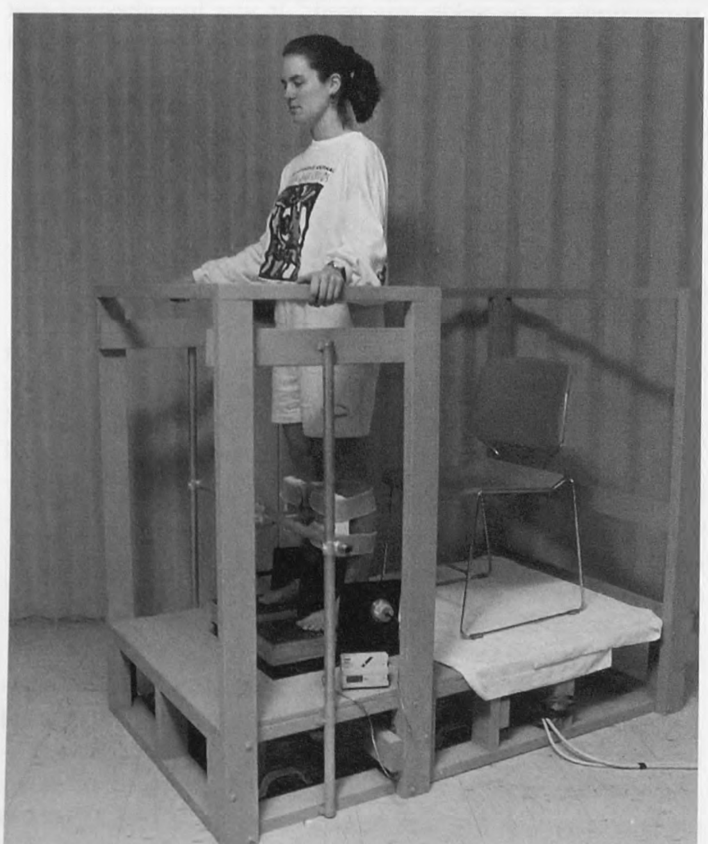

Fig 1. Individual being tested standing on the ankle device.

Testing Protocol for Ankle Proprioception

For each subject, testing was performed on either the right or left ankle. The choice of the ankle to be tested was made by the principal investigator based on the exclusion criteria listed earlier in Methods. In cases where both ankles were suitable for testing, the right ankle was tested. Two aspects of proprioception at the ankle were tested: joint position perception (JPP) and joint movement perception threshold (JMPT). JPP was tested by evaluating the ability of the subject to return the ankle joint to a predetermined angular position. The difference (in degrees) between the predetermined angular position of the ankle and the position to which the subject returned the ankle was considered a measure of ankle JPP. JMPT was tested by evaluating the ability of the subject to perceive angular movement at the ankle. This characteristic was measured by the amount of passive angular movement necessary at the ankle before the subject was able to correctly state the direction of the movement (either plantar flexion or dorsiflexion).

Both JPP and JMPT were measured in a weightbearing, as well as in a relatively nonweightbearing, condition. The weightbearing condition (similar to closed kinetic chain activities) was achieved by having the subject tested while standing on the apparatus (Fig 1). The relatively nonweightbearing condition (similar to open kinetic chain activities) was achieved by having the subject tested while sitting in a chair with both feet resting on the platforms (Fig 2). Although we defined this condition as being nonweightbearing, minimal weight was actually applied under the foot, secondary to the contact with the foot platform.

For all aspects of the study, a balanced, randomized design was used, eliminating testing bias due to systematic testing sequences. To achieve randomization, standard latin square tables were used. Testing was performed on two different days, no more than three days apart. JPP was tested during the first test day; JMPT was tested during the second test day.

JPP Testing

To test JPP, the tester used the linear actuator to passively place the subject's ankle in a predetermined 10° plantar-flexed

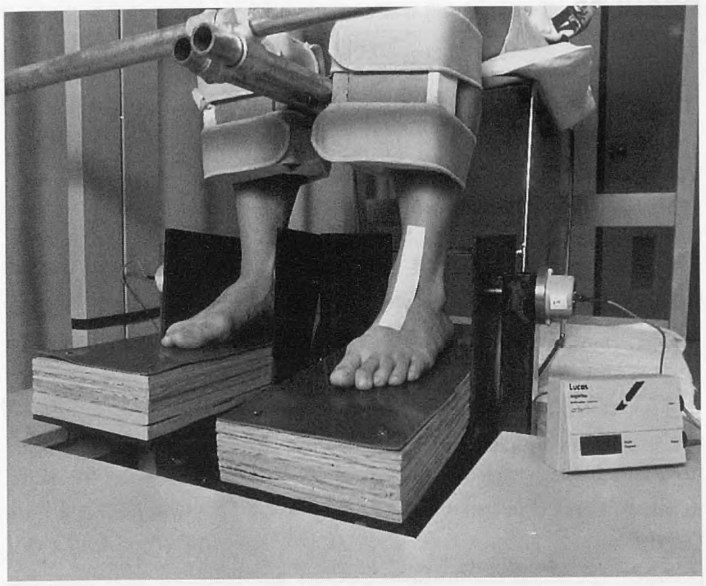

Fig 2. Tape applied to the anterior aspect of the ankle.

or 5° dorsiflexed angular position for 5 seconds. After the subject was told that this was the position he should aim to reproduce, the ankle was returned (by the tester) to a standard neutral position (defined as the foot parallel to the ground while the lower leg was in the vertical plane). After a period of 3 seconds in the neutral position, the subject was asked to provide the necessary instructions to the tester in order to return the ankle to the predetermined position; the tester passively moved the ankle using the actuator. This testing sequence was repeated for each trial. The subject was tested three times in a row for the 10° plantar-flexed position and three times in a row for the 5° dorsiflexed position. The errors made for each of the three trials were averaged for each direction to obtain one error value for the plantar-flexed position and one error value for the dorsiflexed position. The order of presentation of the angles was randomized across subjects. JPP for the ankle was measured for the following conditions: (1) weightbearing without tape, (2) nonweightbearing without tape, (3) weightbearing with tape, and (4) nonweightbearing with tape.

JMPT testing

To test JMPT, the ankle was passively moved from the predefined standard neutral position (defined as the foot parallel to the ground while the lower leg was in the vertical plane) in either dorsiflexion or plantar flexion at an angular velocity of 0.25°/sec. During testing, the subject held a stop button that allowed him to stop the movement of the platform at any time. The task of the subject was to use the stop button to stop the platform as soon as he was able to determine the direction of movement of his ankle.

To eliminate guessing and/or anticipation from the subject, a variable amount of time was used between indicating to the subject the start of the test and initiating movement of the foot platform. In addition, noise coming from the actuator was masked through the use of white noise heard over a set of headphones worn by the subject. Finally, to further eliminate guessing, the subject was instructed that the examiner would from time to time activate the opposite foot platform instead of the platform of the ankle being tested. Between trials, the foot platform was returned to its neutral position, as described earlier. The JMPT was determined by the difference between the angular position when the movement of the platform was initiated and the position of the platform when the platform was stopped by the subject. The sequence of presentation for direction of movement (plantar flexion or dorsiflexion) was randomized.

Testing was performed for dorsiflexion and plantar flexion during weightbearing and nonweightbearing with and without tape. Three trials were performed for each direction for each condition. The results of the three trials were averaged and recorded as the JMPT.

In this study, we used a very slow angular velocity in order to minimize, as a factor in the measurement of JMPT, the reaction time between the perception of movement and the pressing of the stop button by the subject. The angular velocity used for testing was slower than the 0.5°/sec angular velocity used by Lephart et al[10] for testing joint movement perception at the knee, but our earlier work with the ankle apparatus showed that no statistically significant difference existed between testing performed at 0.25°/sec as compared with 0.75°/sec.[9]

Taping

In this experiment, two 12.7-cm-long (5-inch-long) strips of athletic tape were used to add cutaneous sensory stimulus at the ankle. One strip, starting approximately 7.6 cm proximal to the ankle joint line and ending 5.1 cm distal to the ankle joint line, was positioned directly on the skin over the anterior aspect of the ankle joint (Fig 2). A similar strip was used posteriorly over the Achilles tendon and calcaneus (Fig 3). Any hair in the area where the tape was to be applied was shaved prior to the application of the tape.

These strips of tape were used to selectively add cutaneous sensory feedback around the ankle. This model was preferred

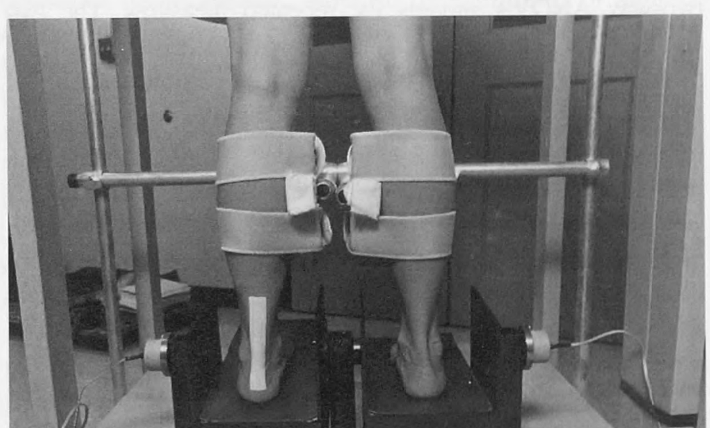

Fig 3. Tape applied to the posterior aspect of the ankle.

to directly taping the ankle because we were interested in specifically examining the role of added cutaneous stimulation of the athletic tape without the added mechanical constriction and pressure associated with the application of ankle taping as used in athletic events. Although this model may not directly answer the question of whether taping increases proprioception at the ankle, it provides a better generalization of our findings in terms of the role of added cutaneous stimulation on joint proprioception.

Subjective Questionnaire

After the JPP testing session, each subject was asked the following three questions regarding his ability to reproduce a given angle: (1) Did the tape help you bring your ankle back to the desired position? (2) Was testing easier while standing (weightbearing) or while sitting (nonweightbearing)? (3) Was testing easier with the foot up (dorsiflexion) or the foot down (plantar flexion)?

After the JMPT testing session, each subject was asked to answer the following three questions regarding his ability to perceive movement at the ankle: (1) Did the tape help you with the perception of movement at the ankle? (2) Was testing easier while standing (weightbearing) or while sitting (nonweightbearing)? (3) Was testing easier with the foot going up (dorsiflexion) or the foot going down (plantar flexion)?

Statistical Analysis

Data analysis was performed with the SPSS statistical software package (SPSS, Inc, Chicago, IL) on Marquette University's mainframe computer. The primary focus of the data analysis was to determine the influence of tape on joint position and joint movement perception. Therefore, separate ANOVA models were used to analyze the weightbearing and nonweightbearing conditions independently.

Data analysis for JPP was performed using two 2×2 two-way ANOVA models for repeated measures. The two factors were external sensory stimulus (tape and no tape) and position of the ankle (10° of plantar flexion and 5° of dorsiflexion). One model was used to analyze the four conditions performed with the subjects standing (weightbearing), and a separate ANOVA was used to analyze the data for the four conditions with the subjects sitting (nonweightbearing). Each ANOVA was followed by a least squares (LS) means post hoc analysis to identify any significant differences among means.

Similar two-way ANOVA models, followed by LS means post hoc analyses, were used to analyze the data on JMPT. For the analysis of JMPT data, the two factors were external sensory stimulus (tape and no tape) and direction of movement of the ankle (plantar flexion and dorsiflexion). Similar to the analysis for joint position perception, the weightbearing and nonweightbearing conditions were analyzed separately.

RESULTS

Descriptive Data

Twenty males between the ages of 19 and 25 participated in the study. The descriptive statistics on the group are provided in Table 1.

Joint Position Perception

The results of the testing for ankle JPP are presented in Tables 2 and 3.

The statistical analysis for JPP in weightbearing indicated that a significant main effect was present for the angular position of the ankle (Table 3). The average error in joint position reproduction was 1.50° ± 0.64° for the 10° plantar-flexed ankle versus 0.94° ± 0.43° for the 5° dorsiflexed position ($p < .01$). Therefore, better accuracy in returning the ankle to the desired position was demonstrated for the dorsiflexed position. The ability to reproduce ankle position with tape versus without tape was 1.13° ± 0.54° and 1.31° ± 0.67°, respectively. This difference was not statistically significant ($p > .05$). No significant interactions existed between the two factors.

For the nonweightbearing conditions, significant main effects were found for both factors in the model: angular position of the ankle and tape ($p < .01$) (Table 3). Post hoc analysis of the data indicated a significant interaction between tape and angular position ($p < .05$), with the use of tape significantly improving the ability of the subjects to perceive ankle joint position only for the plantar-flexed position. For the 10° of plantar flexion position, an average error of 1.53° ± 0.84° was made with the use of tape as compared with a mean error of 2.31° ± 1.22° without the use of tape (Table 2). The same comparison made for the 5° of dorsiflexion position indicated that the average error with tape was 1.08° ± 0.59° as compared with 1.12° ± 0.62° without tape.

The results for JMPT are presented in Tables 4 and 5. The statistical analysis for JMPT in weightbearing indicated that a significant main effect existed for the direction of movement of the ankle ($p < .05$) (Table 5). The mean amount of angular movement necessary before detection of plantar flexion was 0.60° ± 0.47° vs 0.67° ± 0.50° for the detection of movement toward dorsiflexion.

Table 1. Subject Characteristics ($n = 20$)

Variables	Mean ± SD	(Range)
Age (yr)	20.3 ± 1.5	(19.0–25.0)
Height (cm)	179 ± 6	(163–191)
Weight (kg)	74.2 ± 8.3	(58.5–87.1)
Ankle PROM PF (degrees)*	36.9 ± 8.2	(25.0–57.0)
Ankle PROM DF knee bent (degrees)†	17.8 ± 5.4	(6.0–27.0)
Ankle PROM DF knee extended (degrees)‡	9.2 ± 3.1	(5.0–16.0)

* Amount of passive range of motion (PROM) of the ankle for plantar flexion (PF).

† Amount of passive range of motion of the ankle for dorsiflexion (DF) measured with the knee bent at approximately 90° of flexion.

‡ Amount of passive range of motion of the ankle for dorsiflexion measured with the knee fully extended.

Table 2. Ankle joint position perception (in degrees)*

Conditions	Mean ± SD	(Range)
Weightbearing		
No tape/plantar flexion	1.64 ± 0.65	(0.47–3.47)
Tape/plantar flexion	1.36 ± 0.62	(0.21–2.75)
No tape/dorsiflexion	0.98 ± 0.52	(0.37–2.37)
Tape/dorsiflexion	0.90 ± 0.31	(0.42–1.70)
Nonweightbearing		
No tape/plantar flexion	2.31 ± 1.22	(0.53–4.87)
Tape/plantar flexion	1.53 ± 0.84	(0.30–3.22)
No tape/dorsiflexion	1.12 ± 0.62	(0.41–2.27)
Tape/dorsiflexion	1.08 ± 0.59	(0.36–3.15)

* These values represent the amount of error in trying to reproduce a predetermined ankle angular position. Therefore, the closer the value is to 0.00, the better the performance.

Table 3. ANOVA results for ankle joint position perception

Conditions	Mean ± SD (Degrees)	DF*	*F* value	*p*-value
Weightbearing				
Tape	1.13 ± 0.54	1	2.56	0.13
No tape	1.31 ± 0.67			
Dorsiflexion	0.94 ± 0.43	1	36.46	0.00
Plantar flexion	1.50 ± 0.64			
Nonweightbearing				
Tape	1.30 ± 0.76	1	9.08	0.01
No tape	1.72 ± 1.13			
Dorsiflexion	1.10 ± 0.60	1	13.56	0.00
Plantar flexion	1.92 ± 1.11			

* DF, degrees of freedom.

Table 4. Ankle joint movement perception (in degrees)*

Conditions	Mean ± SD	(Range)
Weightbearing		
No tape/plantar flexion	0.56 ± 0.38	(0.20–1.67)
Tape/plantar flexion	0.64 ± 0.55	(0.19–2.64)
No tape/dorsiflexion	0.70 ± 0.60	(0.22–2.91)
Tape/dorsiflexion	0.65 ± 0.39	(0.27–1.92)
Nonweightbearing		
No tape/plantar flexion	0.73 ± 0.57	(0.24–2.36)
Tape/plantar flexion	0.82 ± 0.58	(0.15–2.85)
No tape/dorsiflexion	0.98 ± 0.73	(0.32–2.93)
Tape/dorsiflexion	0.89 ± 0.62	(0.27–3.15)

* These values represent the amount of angular displacement that took place at the ankle before the subject was able to perceive the movement. Therefore, the closer the value is to 0.00, the better the performance.

Under the nonweightbearing conditions, there was also a statistically significant difference in the ability to perceive the direction of movement at the ankle ($p < .05$) (Table 5). The average amount of angular movement necessary before detection of plantar flexion was 0.78° ± 0.57° vs 0.93° ± 0.67° for the detection of movement toward dorsiflexion.

The use of tape did not significantly alter ($p > .05$) the ability of the subjects to perceive movement at the ankle under any of the conditions (Table 5).

Table 5. ANOVA results for ankle joint movement perception

Conditions	Mean ± SD (Degrees)	DF*	*F*-value	*p*-value
Weightbearing				
Tape	0.65 ± 0.47	1	0.00	0.99
No tape	0.63 ± 0.50			
Dorsiflexion	0.67 ± 0.50	1	6.09	0.02
Plantar flexion	0.60 ± 0.47			
Nonweightbearing				
Tape	0.86 ± 0.60	1	0.14	0.72
No tape	0.86 ± 0.66			
Dorsiflexion	0.93 ± 0.67	1	5.21	0.03
Plantar flexion	0.78 ± 0.57			

* DF, degrees of freedom.

Subjective Questionnaire

As seen in Table 6, the above findings were corroborated by the subjective opinion of the subjects. When asked, 16 of 20 subjects stated that the tape helped with position perception, while only 5 of 18 subjects stated that the tape helped with movement perception. Data were available on only 18 of the 20 subjects for joint movement perception because two subjects failed to complete this part of the questionnaire.

DISCUSSION

The ankle is one of the most common sites of injury in sports, with ankle sprains accounting for 85% of all ankle injuries.[11–13] It is estimated that 70% of all high school basketball players have a history of an ankle sprain, with an 80% recurrence rate.[13] The high rate of injury and especially reinjury seen with ankle sprains has challenged the clinical community to provide better rehabilitative as well as prophylactic strategies to reduce the incidence rate. Methods traditionally used to prevent ankle sprains include strengthening programs, proprioceptive training, and the use of external support such as braces and athletic tape.[14–16]

Many clinicians believe that bracing and taping provide increased cutaneous stimuli as well as external support to the joint that they surround. The increased stimulation of the cutaneous proprioceptors, provided through direct or indirect contact between the skin and the brace or tape, would enhance kinesthetic and joint position sense awareness and possibly help prevent injuries. To date, only scarce scientific evidence can be presented to support the fact that proprioceptive feedback at the ankle is improved by the use of bracing or taping.[4,17]

The most common method used to assess the effect of taping or bracing on proprioception at the ankle has been through the evaluation of balance and postural control.[5–8] Overall, these studies have failed to show that athletic tape or ankle braces resulted in better balance or an improved ability to maintain a static posture.[5–8,18,19] In fact, a few of these authors have actually provided evidence that the use of tape or brace may decrease the ability to perform a balance task.[5,7,8] This decreased ability to maintain a static posture was partially attributed to the limitation of joint movement that may occur with the use of external support.[8] Despite the fact that

Table 6. Subjective questionnaire

Variables	Responses		
Joint position perception			
Did the tape help you bring your ankle back to the desired position?	16 (yes)	3 (no)	1 (hindered)
Was testing easier while standing (weightbearing—WB) or while sitting (nonweightbearing—NWB)?	12 (WB)	4 (NWB)	4 (no difference)
Was testing easier with the foot up (dorsiflexion) or the foot down (plantar flexion)?	6 (up)	6 (down)	8 (no difference)
Joint movement perception*			
Did the tape help you with the perception of movement at the ankle?	5 (yes)	13 (no)	
Was testing easier while standing (weightbearing—WB) or while sitting (nonweightbearing—NWB)?	10 (WB)	4 (NWB)	4 (no difference)
Was testing easier with the foot going up (dorsiflexion) or the foot going down (plantar flexion)?	6 (up)	6 (down)	6 (no difference)

* Eighteen of the 20 subjects completed this questionnaire.

maintaining posture is recognized as a task requiring proprioceptive feedback of the ankle, it also involves vestibular and visual sensory function.[20] The degree of redundancy among these systems[20] makes the interpretation of changes in postural control difficult in regard to the effects of taping or bracing on ankle joint proprioception. Therefore, the above studies may not be optimal in establishing the effect of tape on proprioception.

A few authors have specifically investigated the effects of taping or bracing on joint movement or position perception at the ankle. In order to assess the effects of a rigid ankle orthosis on joint position perception at the ankle, Feuerbach et al[17] used a three-dimensional video analysis system. The subjects were asked to reproduce nine predetermined angular positions of the ankle with and without the use of an ankle brace. Using four high-speed video cameras, researchers monitored the subject's ankle position in all three planes of movement. Since the subjects did significantly better when using the ankle brace (as compared with results without the brace), the results of that particular study provided some evidence that a rigid ankle orthosis would help improve this particular aspect of proprioception, at least in a nonweightbearing position. Karlsson and Andreasson,[4] using surface electromyography, investigated the effects of tape on the reaction time of the peroneus longus when the ankle was submitted to a sudden inversion tilt. Their results indicated that the delayed muscular reaction time that was present in patients with chronic ankle instability was markedly improved (although not completely back to normal) with the use of tape. These authors concluded that the increased cutaneous stimulus provided by the tape helped in the earlier recruitment of muscles that could protect against inversion injuries.

The above studies all used ankle taping or bracing as applied to the ankle for sports participation. Because ankle taping also leads to mechanical restriction and mechanical pressure on subcutaneous structures such as tendons and muscles, it is difficult to infer that these results are solely due to increased cutaneous stimuli. The mechanical pressure caused by taping could well influence proprioception and muscular reaction time. In our study, the application of tape to the skin was designed to specifically increase proprioception through cutaneous stimuli without added mechanical stresses on related underlying structures.

The testing apparatus used in our study was initially designed and built by the principal investigator to quantify the loss of proprioception resulting from distal peripheral diabetic sensory neuropathy.[9] In the current study, the device was used to evaluate joint movement and position perception at the ankle in an attempt to provide some support to the belief that an external cutaneous stimulus, such as that provided by tape applied over the skin, may increase joint proprioception.

Our results appear to support the findings of Feuerbach et al,[17] whose work with ankle orthoses showed that the application of an external support to the ankle improves JPP in a nonweightbearing position. However, while the improvement in JPP occurred for both the dorsiflexed and plantar-flexed angles, it is clear from the data in Table 2 that the effect of taping is particularly marked for the plantar-flexed position. Therefore, taping would provide added proprioceptive information that could possibly help in the proper positioning of the ankle just prior to foot contact during running or just prior to landing when coming down from a jump. In our opinion, this is a significant finding since most ankle sprains occur during the weight acceptance phase, which takes place when running and when landing from jumps. Therefore, an increase in ankle JPP could help in properly positioning the foot and ankle and could possibly help in better detecting an uneven ground or object under the foot that could affect proper foot placement.

While both angular positions that we tested should be considered in the midrange of the ankle joint available range of movement, the difference in effectiveness of the strips of tape between the dorsiflexed and plantar-flexed position can possibly be attributed to the fact that 5° of dorsiflexion is closer to end-range than the 10° of plantar-flexion position. The added effectiveness of the strips of tape in the midportion of the range of movement would theoretically be supported by the documented lesser effectiveness of the joint mechanoreceptors to provide joint position sense in midrange as compared with end-range.[21]

Of particular interest is the fact that no increase in position perception was achieved with the strips of tape in the full weightbearing position. These results again support earlier work that has been done with a functional weightbearing task such as maintaining balance.[5–8,18,19] Therefore, for weightbearing tasks such as maintaining standing balance or the stance phase of walking or running, the cutaneous stimulus from strips of tape as used in this experiment does not appear to be of benefit from a proprioception perspective. However, taping may still be of benefit from the mechanical perspective of restricting excessive movement at the ankle.[22,23]

Our study also demonstrated that athletic tape, as used here on healthy subjects, does not provide any advantages for the detection of joint movement in either weightbearing or nonweightbearing situations.

We conclude from this research that increased cutaneous sensory feedback provided by strips of athletic tape applied across the ankle joint of healthy individuals can help improve ankle JPP in nonweightbearing situations, especially for a midrange plantar-flexed ankle position. The effect of similar strips of tape in improving proprioception in individuals with chronic and acute ankle sprains remains to be established.

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The Role of Athletic Trainers in Counseling Collegiate Athletes

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Objective: To assess athletic trainers' perceptions with regard to (a) their role in counseling athletes, (b) how qualified they felt to address counseling issues, and (c) current training room procedures for providing psychological services to athletes.

Design and Setting: A 47-item, open-ended survey was administered to Division I certified athletic trainers who volunteered to participate.

Subjects: Fourteen Division I certified athletic trainers (mean age, 33 yr; range, 24 to 47 yr) volunteered to participate in the survey. They included five head athletic trainers, five assistant athletic trainers, three graduate assistants, and one associate director of athletics and sports medicine.

Measurements: Survey results were tabulated and reported in percentages.

Results: Athletic trainers felt that their roles went beyond the care and prevention of athletic injuries, yet they did not necessarily feel qualified to counsel athletes. Most athletic trainers were familiar with on-campus student support services to which student athletes with personal issues could be referred for assistance, but none had access to a sport psychologist.

Conclusions: It is recommended that the NATA include counseling preparation in curriculums and that continuing education be offered to provide certified athletic trainers with current information and skills for delivering psychological services to athletes.

Key Words: sport psychology, curriculum, continuing education

The role of the athletic trainer in counseling athletes is currently receiving considerable attention.[1] While sport psychologists and others have conducted studies examining the relationship of psychology to injury rehabilitation,[2–4] little research has been conducted to determine the extent to which athletes approach athletic trainers with personal problems and emotional conflicts related to athletic competition. It also has not been determined how prepared athletic trainers feel to address the personal problems of athletes.

Since most universities do not employ a sport psychologist on a full-time basis or as a consultant, the athletic trainer is often required to fulfill this role. The purpose of this study was to survey certified collegiate athletic trainers to determine their perception of athletes' needs in the psychological realm, to examine their preparation for such a role, and to evaluate current training room procedures for providing psychological services to athletes.

Two studies that surveyed athletic trainers provided insight into the role athletic trainers play in counseling athletes. Wiese, Weiss, and Yukelson[5] surveyed the attitudes and beliefs of athletic trainers regarding the psychological strategies used with injured athletes. The results supported the importance of using a variety of psychological skills and strategies to assist athletes in rehabilitation. It was noted that athletic trainers should seek the assistance of a sport psychologist, if available, to promote a team approach to rehabilitation. The need to educate athletic trainers about the use of sport psychology techniques was also identified by Wiese et al.[5] Larson, Starkey, and Zaichkowsky[6] surveyed the perceptions of certified athletic trainers about their attitudes and beliefs and the use of psychological strategies and techniques in working with injured athletes. Most of the athletic trainers thought it was important to treat the psychological aspect of an athletic injury; many had referred athletes for psychological counseling; and about a fourth of the athletic trainers had a sport psychologist as a member of the rehabilitation team.

Because athletic trainers typically spend extended periods of time with athletes under conditions that promote personal interaction and trust, they are professionally in a position to provide counseling on a variety of issues. Recently, the National Athletic Trainers' Association Board of Certification (NATABOC)[7] conducted a role delineation study to identify the competencies that entry-level athletic trainers should possess. Psychological competencies were included in all six of the identified domains of performance.[7] Some of these skills include recognizing the psychological signs and symptoms of athletic injury, practicing effective communication skills in the area of health maintenance, and providing athletes with injury prevention education in relation to athletic injury. Thus, the role of the athletic trainer as defined by the NATABOC encompasses and supports researchers' conclusions that services beyond the prevention and care of athletic injuries are requested and needed by athletes.[8-10]

METHODS

Study participants included eight male and six female Caucasian NATABOC-certified athletic trainers currently employed in Division I universities in a Southern conference. The sample included five head athletic trainers, five assistant athletic trainers, three graduate assistants, and one associate director of athletics and sports medicine, with 12 having a master's degree. Subjects ranged in age from 24 to 47 years with an average age of 33.

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We designed an open-ended questionnaire with 47 items. These items were reviewed for accuracy and language by three certified athletic trainers and one faculty member. Primary suggestions included feedback on additions and deletions of items and comments on the content validity of the instrument. In addition to demographic information, the questionnaire included items assessing the perception of the athletic trainers regarding their role in counseling athletes. Participants were also asked how qualified they felt to counsel athletes on a variety of issues and how athletic trainers could potentially gain the knowledge and skills necessary to feel competent in this area.

The questionnaire was sent to 17 certified athletic trainers in the selected conference, and 14 elected to participate. The participation of the athletic trainers in this study was voluntary, and all potential subjects received a cover letter explaining the purpose of the study and an informed consent form. Those who agreed to participate returned a signed consent form with the completed questionnaire.

RESULTS

Athletic trainers in this study reported that their role went beyond the prevention and care of athletic injuries and included the role of educator and counselor (Table 1). They also reported feeling comfortable discussing student athletes' personal issues but expressed concern about being adequately trained to provide appropriate professional responses.

Athletic trainers responded that athletes disclosed personal issues about themselves as well as problems related to a specific athletic injury. They believed that student athletes felt more at ease disclosing personal issues because of the unique nature of the relationship between the athletic trainers and student athletes. A majority (11, 79%) of athletic trainers surveyed had been in a position where counseling student athletes regarding personal issues was necessary and also a requirement of their position. Most (10, 71%) said they felt this was a satisfying experience, but 12 (86%) indicated they preferred counseling athletes with problems related to injuries obtained in athletics, as opposed to other personal problems. Table 2 identifies the type of personal issues athletes presented to athletic trainers. Survey responses revealed that 12 (86%) of the athletic trainers felt qualified to discuss personal issues when athletes approached them with problems. However, only 5 (36%) felt they received adequate training in counseling techniques to assist athletes with their personal issues.

Table 1. Roles of Athletic Trainers

Roles	Responses	Rank
Educator	13	1
Injury advisor	13	1
Nutritionist	12	2
Counselor	11	3
Problem solver	11	3
Friend	9	4
Academic advisor	8	5
Mentor	6	6
Physical therapist	4	7
Tutor	3	8
Physician	1	9

Table 2. Issues Frequently Expressed to Athletic Trainers By Athletes

Issue	Responses	Rank
Conflicts with coach or players	12	1
Health-related	12	1
Career decisions	11	2
Sexually transmitted diseases	11	2
Injury mechanisms	11	2
Sport enhancement	11	2
Sport demands	10	3
Rehabilitation protocol	10	3
Rehabilitation compliance	9	4
Eating disorders	9	4
Sexuality	9	4
Drug and alcohol	9	4
Academic concerns	9	4
Social pressures	6	5
Family-related issues	4	6

Subjects in the study were asked to identify the skills they perceived to be important in helping athletes deal with sport injuries. The top five skills named were injury recognition, motivation, goal setting, counseling, and stress management. The application of counseling principles and techniques is obviously an important aspect of an athletic trainer's role.

Twelve (86%) of the athletic trainers responded that their athletic training department and staff were aware of on-campus student support services to assist student athletes with personal issues. Typically, from 1 to 6 athletes per semester were referred to support services by 10 (71%) of the athletic trainers. Access to educational information regarding support services was made readily available to athletes through brochures, pamphlets, and orientation classes by 9 (64%) of the athletic trainers. Only a third of the athletic trainers had made off-campus referrals to athletes with personal issues.

Eleven (79%) of the athletic trainers reported that student athletic trainers at their facilities were given instruction regarding the management of confidential issues of athletes. Less than a quarter of the athletic trainers (3, 21%) reported monitoring student athletic trainers while they counseled athletes. The survey revealed that four (29%) of the athletic training programs conducted in-service programs addressing emotional or psychological issues that might be addressed by student athletic trainers. Only one (7%) athletic trainer had counseling courses included in the curriculum as a part of the athletic training program. Overwhelmingly, athletic trainers (11, 79%) expressed a need from the National Athletic Trainers' Association for continuing education credits focusing on counseling techniques.

DISCUSSION

Athletic trainers reported responsibility for a wide range of roles in their jobs. This finding agrees with several studies indicating that the responsibilities of athletic trainers extend well beyond the care and prevention of athletic injuries.[8–12] Counseling, one of the roles identified by the athletic trainers, was identified as a unique facet of the athletic trainer's responsibility.[6] All respondents felt that they were in a unique position to be approached by athletes with issues because of the special relationship that exists between athlete and athletic trainer. The athletic trainers viewed themselves as safe, approachable, care-taking individuals with whom athletes felt comfortable disclosing personal information. The participants (12, 86%) acknowledged a preference for counseling athletes whose psychological and emotional problems were directly related to a sport injury, but felt qualified to discuss personal issues when athletes sought advice.

Several researchers have reported that athletes experience greater psychological crisis than nonathletes but are less likely to seek out professional counseling services.[13,14] In this study, 10 (71%) of the athletic trainers referred 1 to 6 student athletes per semester to professional counseling services, and only one third of the athletic trainers referred athletes to off-campus services. Perhaps the low number of referrals by athletic trainers was the result of viewing counseling as part of their job responsibility. Counseling ranked third in self-perceived roles; therefore, they may have been less likely to send athletes to professional services without first attempting counseling themselves.

Only five (36%) athletic trainers felt adequately trained to counsel athletes, although 10 (71%) said they had a satisfying experience when in a situation where they counseled an athlete. Interestingly, athletic trainers are often placed into situations where they attempt to meet job expectations but struggle with feeling unprepared to adequately fulfill the task of counseling.

None of the athletic trainers had access to a sport psychologist for referring athletes who needed counseling services. Larson et al[6] reported similar findings, whereas several studies indicated that a sport psychologist is an integral part of the sports health care system.[3–5,15,16]

All athletic trainers reported that there is a need for training in the area of counseling, which supports the findings of earlier studies.[5,6] Athletic trainers thought education should focus on curriculum development of current athletic training programs and continuing education programs for certified athletic trainers. Currently, 10 (71%) did no in-service training with student athletic trainers on the psychological and emotional problems of athletes, and 11 (79%) had no policies, guidelines, or instructions designed for student athletic trainers on handling confidential counseling issues. There appears to be a deficiency in how student athletic trainers obtain the appropriate skills needed to deal with counseling issues.

The need for education in counseling for athletic trainers is clear. Adjustments made in current athletic training curriculums and NATA-approved continuing education credits are two approaches to meet the needs of athletic trainers. Preparing athletic trainers to better handle counseling situations involves developing skills in communication (both verbal and nonverbal), crisis identification and crisis intervention, and increasing knowledge of resources and policies on reporting counseling issues.

The education of athletic trainers should be designed to provide the necessary skills to effectively communicate with and evaluate athletes and to promptly refer athletes for counseling when needed. The objective is not to prepare athletic trainers as professional counselors, but to allow them to recognize their counseling boundaries and limitations. Athletic trainers in this study were willing to counsel athletes with emotional problems. In fact, many viewed themselves as the logical choice of athletes needing counseling because of the unique role they play. Although all the athletic trainers stated a need for education in counseling skills, viable concerns were expressed about the lack of adequate training necessary to respond to athletes' personal needs. Given the NATABOC guidelines in the psychological competency area, such skill training should be a mandatory component of the athletic training curriculum. Athletic trainers could then be competent and confident when dealing with the counseling issues of their athletes.

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Cubital Tunnel Syndrome in a Collegiate Wrestler: A Case Report

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Objective: The authors present a case study involving a 21-year-old male collegiate wrestler diagnosed with cubital tunnel syndrome.

Background: Cubital tunnel syndrome is a condition brought on by an increase in the pressure exerted upon the ulnar nerve at the elbow within the cubital tunnel. The wrestler was diagnosed with cubital tunnel syndrome after 6 weeks of increasing disability and dysfunction.

Differential Diagnosis: Ulnar nerve contusion, ulnar nerve neuritis, cubital tunnel syndrome, thoracic outlet syndrome, C8 nerve root entrapment, double-crush syndrome, tumor.

Treatment: The subject was treated conservatively for 3 months without resolution of the symptoms. Surgical treatment then involved a subcutaneous ulnar nerve transposition performed to decompress the cubital tunnel. Following surgery, the athlete participated in an aggressive rehabilitation program to restore function and strength to the elbow and adjacent joints. He was cleared for full unrestricted activity 15 days following surgery and returned to varsity athletic competition in 1 month.

Uniqueness: Our literature review found no reported cases of cubital tunnel syndrome in wrestlers. Cubital tunnel syndrome is usually seen in throwing athletes and results from either acute trauma or repetitive activities.

Conclusion: The athletic trainer should consider cubital tunnel syndrome as a possible pathology for nonthrowing athletes when presented with associated signs and symptoms.

Key Words: ulnar nerve entrapment, neuropathy

Cubital tunnel syndrome is a condition brought on by an increase in the pressure exerted upon the ulnar nerve at the cubital tunnel. Cubital tunnel syndrome is the most common entrapment condition for the ulnar nerve.[1,2] It is second only to carpal tunnel syndrome in compressive neuropathologies of the upper extremities.[1,2] Repetitive overhead activities, such as throwing, are a primary cause of this condition.[2,3] The injury primarily occurs either with excessive or repetitive activity of the elbow or with acute trauma to the ulnar nerve.[2–5] Both situations may be encountered in the sport of wrestling. Besides being compressed within the cubital tunnel, the ulnar nerve may also become entrapped at the arcade of Struthers,[1,5] in the anomalous slip of the triceps at the olecranon,[6] or at the deep floor of the deep flexor pronator aponeurosis[1] (Fig 1). Bednar et al[1] and Folberg et al[5] stated that the symptoms of cubital tunnel syndrome may masquerade as another condition and are similar to those associated with thoracic outlet syndrome, a C8 nerve root entrapment, a double-crush syndrome, or a tumor.

The purpose of this paper is to present a case study of an ulnar nerve lesion at the cubital tunnel of an athlete not engaging in repetitive overhead activities.

THE INJURY

A 21-year-old male varsity collegiate wrestler reported to the training room 3 weeks after the start of the wrestling season with left elbow pain. He also complained of decreased sensation along the medial forearm and decreased motor function in the hand and wrist. The athlete acknowledged a history of these symptoms approximately 1 year earlier but stated that the symptoms had not been as severe. He did not recall a specific mechanism of injury but did acknowledge a partial loss of function following intense activity or after some trauma, such as a direct blow, to the elbow. We observed a decrease in the athlete's ability to function effectively while wrestling. He in turn stated that he did not feel he could compete successfully. The athlete also reported a lack of control of the arm when the symptoms were present.

Our initial evaluation of the athlete found no swelling, discoloration, or deformity. There was point tenderness along the medial midshaft of the humerus, the medial epicondyle, the olecranon process, and in the area of the ulnar nerve and cubital tunnel. Palpation of the ulnar nerve elicited radiating pain and numbness distally from the elbow, which was similar to the symptoms he experienced while wrestling. Active and passive range of motion was bilaterally equal. There was weakness detected through manual muscle testing in elbow flexion, elbow extension, wrist flexion, wrist extension, pronation and supination of the forearm, and grip strength. Reflexes were bilaterally equal. Two-point discrimination was normal. However, the athlete stated that there was a sensory difference on the medial portion of the fourth and fifth digits of the left hand, compared with the right. We took girth measurements every 5.1 cm distal from the olecranon. (The athlete is right hand dominant.) Girth on the affected, left side was decreased from 0.3 cm at 5 cm and 20.3 cm distal to the olecranon and 1.2 cm at 10.2 cm distal to the olecranon. Tests (Yergason's, apprehension, brachial plexus nerve stretch injury, and thoracic outlet syndrome) were all negative.

We failed to see improvement in the athlete's condition after ten days of conservative treatment. A Tinel's sign at the elbow was still positive approximately 2 weeks after the report of the complaint. The athlete was referred to Slippery Rock University's general practitioner team physician at this time for an

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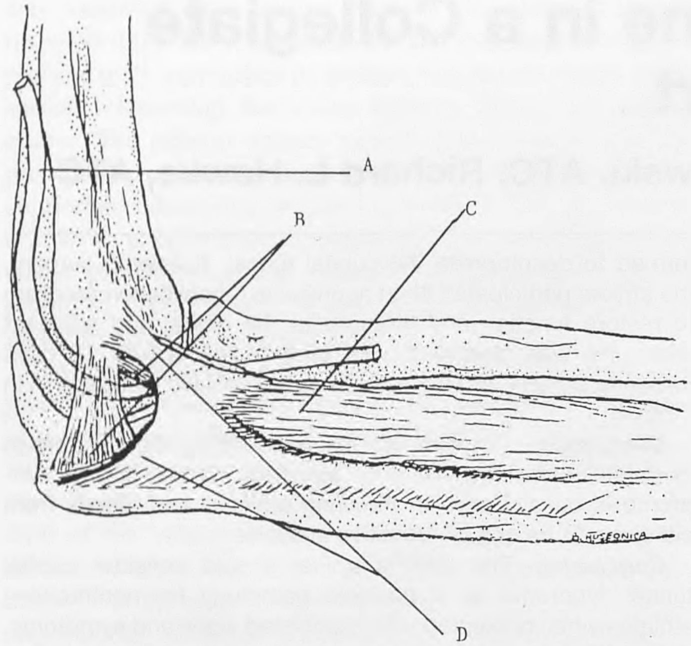

Fig 1. The athlete's arm before surgery. (A) ulnar nerve; (B) ulnar collateral ligament; (C) flexor carpi ulnaris muscle; (D) flexor carpi ulnaris tendon.

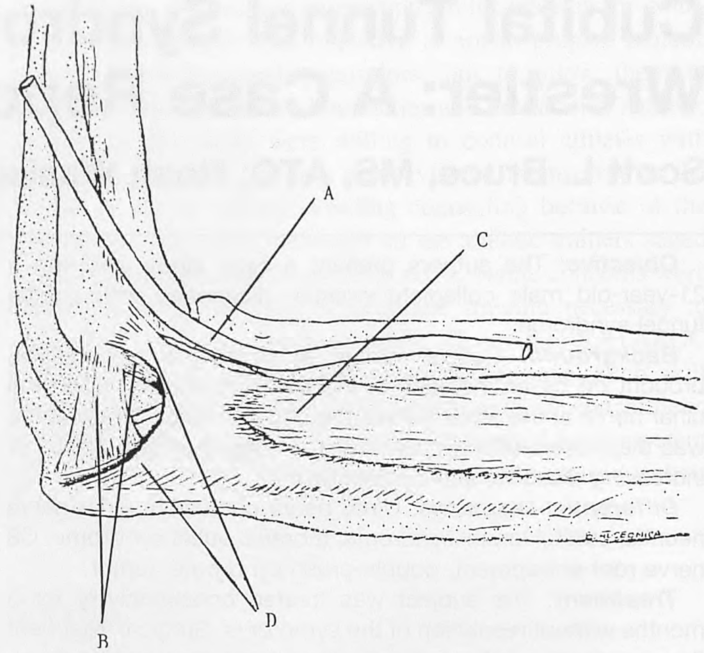

Fig 2. The athlete's arm after surgery. (A) transposed ulnar nerve; (B) ulnar collateral ligament; (C) flexor carpi ulnaris muscle; (D) flexor carpi ulnaris tendon.

evaluation. X-rays of the elbow were also taken at this time and were negative. Our team physician prescribed a nonsteroidal, anti-inflammatory medication and referred him for an orthopedic evaluation. The orthopedic surgeon's diagnosis was a possible cubital tunnel syndrome. The surgeon permitted the athlete to continue with his wrestling activity and suggested we test him with a hand dynamometer before and after activity to objectively evaluate his strength loss. He also ordered electromyography and nerve conduction tests to be done, and they were normal.

The athlete's grip strength in the involved arm, as measured with a hand dynamometer, was decreased 45% prior to practice and 60% after practice, compared bilaterally. This decrease in strength had a significant effect on the athlete's ability to compete and train effectively. These results confirmed for the orthopedic surgeon that a cubital tunnel syndrome was present. The athlete was referred to a neurologist for a second opinion.

The neurologist concurred with the orthopedic surgeon that a cubital tunnel syndrome existed. Although the electromyography and nerve conduction studies were inconclusive, the neurologist reported that the wrestler displayed clinical signs consistent with a cubital tunnel syndrome. Additionally, the neurologist studied the x-rays and noted that the athlete's bony structures created an abnormally narrow cubital tunnel. The result was an increased likelihood that a cubital tunnel syndrome had occurred.

The athlete had surgery 3 months after the first complaint of symptoms. On an outpatient basis, he underwent a subcutaneous anterior transposition of the ulnar nerve. In this procedure, the ulnar nerve was transposed anterior to the medial epicondyle. A pulley, erected to stabilize the ulnar nerve anteriorly, was made between the subcutaneous tissue and the fascia overlying the flexor pronator muscle mass (Fig 2).[2]

The athlete was placed in a sling postsurgery. We were instructed to have the wrestler do the following immediate rehabilitative exercises: active range-of-motion exercises of the elbow joint, isometrics for the elbow flexor and extensor muscles, and hand, wrist, and forearm strengthening as tolerated. At 5 days postsurgery, the athlete had progressed from pain-free active exercises for the elbow to light-weight resistive exercise. Theraband (The Hygenic Corporation, Akron, OH) and free weights of 0.45 to 1.125 kg (1 to 2.5 lb) were used for resistive exercises of the elbow, forearm, hand, and wrist. The athlete maintained his cardiovascular endurance through use of a stationary bike and StairMaster 4000PT (StairMaster Sports/Medical Products, Inc, Kirkland, WA).

One week postsurgery the athlete had obtained full active range of motion of the elbow, forearm, hand, and wrist. He also was able to increase his use of light resistive exercises for the elbow and adjacent joints. Hand dynamometer tests found only a 10% deficiency at this time. The athlete was released for unrestricted strengthening exercises and vigorous noncontact exercises at this time. All strengthening exercises were steadily increased in resistance. We began a series of eccentric curls for the elbow joint and closed kinetic chain and rhythmic-stabilization exercises for the upper extremity. The athlete received a release to return to wrestling activity 2 weeks postsurgery. The athlete's functional rehabilitation progressed from wrestling drills, to wrestling in the down position, and on to full wrestling activity over the next 2 weeks. Four weeks after surgery the athlete received permission from the orthopedic surgeon to return to varsity competition.

DISCUSSION

Cubital tunnel syndrome occurs because of increased pressure upon the ulnar nerve at the cubital tunnel. The ulnar nerve is a branch of the medial brachial plexus and progresses from the upper arm through the cubital tunnel at the elbow and into the forearm.[2,4–7] The cubital tunnel is bordered by the ulnar collateral ligament, the medial edge of the trochlea, and the medial epicondylar groove. The roof of the cubital tunnel is formed by the arcuate ligament.[1,2,4,5,7]

The causes of cubital tunnel syndrome are many. They include mechanical factors (such as stretching of, friction on, or compression of the ulnar nerve), direct trauma or other space-occupying lesion, repetitive elbow flexion/extension, repetitive overhead activities, traction, subluxation of the ulnar nerve from the ulnar groove, metabolic disorders, congenital deformities, synovial cysts, anatomical irregularities, arthritis, joint inflammation, and occupational/athletic factors.[2,4–6,8–10]

The ulnar nerve is vulnerable to trauma in contact sports, such as wrestling, because it lies behind the medial epicondyle and is superficial in the olecranon fossa as it enters the cubital tunnel.[2,4,7] Repetitive elbow flexion causes the ulnar nerve to be stretched, which compresses the nerve within the cubital tunnel.[2,4,5,11] The many compromising positions the elbow is placed in during a wrestling match could easily be defined as excessive or repetitive. However, we were unable to identify any reports of cubital tunnel syndrome involving wrestling.

Cailliet[7] states that cubital tunnel syndrome most often occurs with shoulder external rotation and abduction, forearm pronation, and elbow flexion. This increases the pressure on the ulnar nerve in the cubital tunnel. This sequence of movements occurs in many athletic activities, either singularly or in various combinations. Norkus and Meyers[2] and Wojtys et al[3] identified throwing and repetitive overhead activities specifically as motions that were involved in causing cubital tunnel syndrome.

Folberg et al[5] stated that the symptoms of cubital tunnel syndrome may start "insidiously or acutely." The symptoms of cubital tunnel syndrome may include any of the following: tenderness along the path of the ulnar nerve and along the medial aspect of the elbow; pain with elbow flexion; pain radiating distally along the ulnar side of the forearm; weakness in wrist flexion and finger flexion; decreased sensation in the fourth and fifth digits with intermittent numbness and tingling; palpable ulnar nerve; mild to moderate clumsiness; and muscle atrophy.[2–5,7,11] This athlete displayed signs and symptoms consistent with moderate ulnar nerve involvement at the cubital tunnel.

Upon the first orthopedic assessment, the physician performed the elbow flexion test as outlined by Folberg et al[5] and Norkus and Meyers.[2] In the elbow flexion test the patient flexes the elbow for 1, 3, and 5 minutes. A positive test is confirmed by numbness and tingling, paraesthesia, and pain along the ulnar nerve distribution. The earlier the test becomes positive the greater involvement within the cubital tunnel. This test was positive at the 1-minute interval when performed by our wrestler.

The value of the electromyography and nerve conduction tests is questioned in the literature. Several authors stated that the tests should be done as part of the examination of the patient.[2,4,6,7,11–13] Folberg et al[12] and Uchida and Sugioka[13] stated that electromyography and nerve conduction tests in mild cases are often normal. Several sources cite studies stating that electromyography and nerve conduction tests are not always positive for cubital tunnel syndrome.[4,14–16] Furthermore these sources state that up to 50% of the patients may still require surgery even if they have normal electromyograms.[4,14–16] Bednar et al[1] suggested following the patient for 3 months after the initial set of tests; if no improvement in the patient's condition occurred, the tests should be repeated. Surgery could then be performed depending upon the results of the second set of tests. Although electromyography and nerve conduction tests were negative in this case, the athlete had been symptomatic for 3 months, and his clinical examination was consistent with cubital tunnel syndrome.

There is some controversy over whether conservative treatment of cubital tunnel syndrome is effective. Although Cailliet[7] suggested that conservative treatment is usually effective, Rettig[10] and Folberg et al[5] stated that this condition responds poorly to conservative treatment. Dellon,[14] Folberg et al,[5] and Norkus and Meyers[2] all agreed that in mild cases conservative treatment is successful. Dellon[14] stated, however, that in the moderate or severe cases conservative treatment was unsuccessful.

Conservative treatment may include any of the following: rest,[2–4] immobilization of the elbow to avoid extension and acute elbow flexion,[1–4,7,9,12] avoiding excessive elbow flexion,[7,12] protective padding,[1,7] altering activity,[1,3] avoiding pressure to the cubital tunnel,[7,12] and nonsteroidal anti-inflammatory medications.[1–4] Folberg et al,[12] however, state that "the use of nonsteroidal anti-inflammatory drugs has no documented clinical efficacy in cubital tunnel syndrome." The use of local injectable medications has been shown to be of little assistance in relief of the symptoms of cubital tunnel syndrome.[2,12] The key, according to Norkus and Meyers,[2] is the avoidance of painful activity. Individuals who do not alter their activities will not find positive results with conservative management.[2] In the time between diagnosis and surgery, we found that conservative treatment methods were not successful in our case.

Bednar et al[1] reported that there are few studies written on the use of conservative treatment in cubital tunnel syndrome. Of those written, there appears to be some controversy regarding the role of conservative management in this condition. Bednar et al identified several problems with conservative treatment, including noncompliant patients, improper follow-up of symptoms, and incorrect or late diagnosis.[1]

Surgery is indicated either when conservative treatment has failed to produce the desired results or when the signs and symptoms suggest that the condition is of moderate or severe involvement.[12] Success of the surgical procedure is dependent upon the degree of ulnar nerve involvement[4,12] and the thorough decompression of the cubital tunnel.[12] There are several surgical options available. These include simple decompression,[2,10,12] subcutaneous anterior transposition (or transfer),[2,10,12] submuscular transfer,[10,12] and medial epicondylectomy.[2,10,12] Discussion of the indications for, and the merits of, these surgical procedures is beyond the scope of our report. We will focus on the subcutaneous anterior transposition procedure performed for this wrestler.

In a subcutaneous anterior transposition, the ulnar nerve is transferred to the anterior portion of the medial epicondyle of the humerus. This places the nerve anterior to the axis of the elbow. The net result is a decrease in the forces placed upon the ulnar nerve.[2,12] A sling or pulley is constructed from the subcutaneous tissue and the fascia overlying the flexor pronator muscle mass to hold the ulnar nerve in its new location and protect it from trauma (Fig 2).[2]

Norkus and Meyers[2] state that there are many advantages to using the subcutaneous anterior transposition as opposed to the other previously mentioned procedures: it is a less invasive procedure, detachment of the flexor pronator muscle is avoided, there is decreased risk of secondary scarring and entrapment, there is decreased chance of successive entrapment, further tension on the ulnar nerve during repetitive flexion/extension of the elbow can be prevented, and there is rapid return to activity. Folberg et al[12] add that there is a high success rate and a low recurrence rate with this procedure. Bednar et al[1] state that the primary complications and disadvantages of a subcutaneous anterior transposition include an injury to the medial antebrachial cutaneous nerve, a failure to release all of the points of constriction, tenderness of the ulnar nerve in its new position, and formation of a new point of constriction. Norkus and Meyers[2] also state that complications with the subcutaneous anterior transposition include significant disruption and manipulation of the ulnar nerve, risk of flexor carpi ulnaris denervation, and disruption of ulnar nerve vascularity.

Barker[4] stated that the goals for rehabilitation and the factors that can affect rehabilitation do not differ from those of other postsurgical conditions: encourage strengthening of the uninjured tissues and simultaneously protect the injured areas. In this case we were concerned about both motor and sensory function. Sensory function was near normal in a few days. Our rehabilitation focused primarily on the gross motor movements of the upper extremity. The wrestler regained fine motor coordination relatively quickly through the normal daily activities of a college student. He did not exhibit or indicate any restrictions or problems in his daily activities; therefore, we did not spend a great deal of time on exercises for the fine motor pathways.

It is extremely important not to fatigue the athlete during rehabilitation. Fatigue may lead to complications such as increased pain and inflammation or a loss of function,[4] as well as a breakdown in biomechanics. Throughout the rehabilitation period, a combination of muscular strengthening and muscular endurance exercises concentrating on different joints and structures worked best in our situation. This athlete was able to participate pain free only 4 weeks after surgery was performed and wrestled symptom free the remainder of the season.

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Partial Posterior Cruciate Ligament Tear in a Collegiate Basketball Player: A Case Report

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Objective: To present a case of a collegiate basketball player treated conservatively for an incomplete tear of the posterior cruciate ligament (PCL).

Background: The PCL is the strongest ligament of the knee, but PCL injuries are rare during athletic activity especially when compared with anterior cruciate ligament (ACL) injuries.

Differential Diagnosis: ACL injury, contusion.

Treatment: Treatment options include either conservative management or surgical intervention. Although controversy exists as to which method produces the best results, it appears that good functional outcomes can result from aggressive rehabilitation alone.

Uniqueness: The athlete was reluctant to report the injury because she thought it was only a bruise. Once assessed with a PCL sprain, the athlete adamantly refused to see a physician for a definitive diagnosis. The infrequent occurrence and the apparent lack of knowledge regarding mechanism and clinical presentation of PCL injuries often result in misdiagnosis. Subsequently, patients with unrecognized involvement of the PCL may respond inadequately to rehabilitation measures.

Conclusions: Based on the literature, it appears that athletes who suffer isolated PCL injuries can achieve good functional results when treated conservatively. A vital component to the success of managing PCL injuries is the athletic trainer's being well versed in the recognition of signs, symptoms, and mechanisms of injury, as well as being knowledgeable in evaluation techniques that lead to assessment of this infrequent injury.

Key Words: basketball injuries, female basketball injuries, knee injuries, knee evaluation, conservative knee rehabilitation

The knee is a very complex joint and is often injured as a result of athletic activity. However, athletic-related injuries isolated to the posterior cruciate ligament (PCL) are rare and their subsequent treatment is controversial.[1–5] In most cases, the PCL is injured during motor vehicle accidents when the tibia strikes the dashboard and is forced posteriorly.[1,6] In addition, some authors argue that PCL injuries probably do occur more frequently in athletes than statistics indicate but are often misdiagnosed during initial examinations.[1,7–9] Surprisingly, most athletes who sustain acute PCL sprains are unaware they may have suffered a significant knee injury.[9]

The PCL plays a significant role in knee joint stability and might be the most important ligament of the knee.[3,10,11] The literature is lacking articles solely devoted to the PCL when compared with the anterior cruciate ligament (ACL).[9] As a result, the athletic trainer may not be well prepared to evaluate and treat such an uncommon injury.

CLINICAL PRESENTATION

Near the end of the season, a 21-year-old, Caucasian, female collegiate basketball player (170 cm, 63 kg) reported to the training room with a slight limp complaining of a left knee injury that had occurred during the early portion of practice the previous day. While sprinting during a full-court dribbling drill, she tripped herself and fell down, but only on the left knee. She reported landing on the anterior aspect of her left knee with her ankle in plantar flexion as if she were kneeling down, but she got up immediately and finished the drill. She related feeling embarrassed, and she stated the initial pain quickly subsided to vague, general soreness about the knee. She was able to finish practice with some discomfort and stiffness, especially during flexion. She also admitted her reluctance to seek out the athletic training staff because she thought it was "just a bruise." The athlete denied any previous history of knee injuries or of left hip or left ankle involvement.

Physical examination revealed mild-to-moderate general joint effusion with limited active and passive knee flexion to approximately 110°. Full extension range of motion (ROM) was achieved both actively and passively with pain present only during active range. Localized swelling and tenderness with palpation was noted over the tibial tuberosity. In addition, she complained of vague soreness posteriorly and paresthesia in the popliteal fossa. Manual muscle tests compared bilaterally revealed knee extension strength within normal limits, but flexion was painful and graded 4 out of 5. Lachman's test, anterior drawer test, McMurray's test, and valgus and varus stress tests at 0° and at 30° were all negative. The posterior sag sign was positive, and the posterior drawer test was also positive for pain and mild-to-moderate laxity, but a firm end point was evident, indicating a stable joint. Based on these findings she was conservatively assessed with a grade II PCL sprain.

We discussed referring her to our orthopaedic team physician for a definitive diagnosis. Following a summary of the anatomy involved, the athlete was advised of the significance of this type of injury; however, she refused to see a physician for reasons she chose not to disclose. We respected her

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decision and accepted her choice to begin a conservative treatment regimen.

For the first 3 days postinjury, treatment consisted of rest, ice, elastic wrap for compression, elevation, and over-the-counter nonsteroidal anti-inflammatory medication. She was also instructed to perform 100 quadriceps sets and 50 straight-leg raises per day, adding resistance as strength improved. Stationary bicycle, light jogging, and shooting drills were added and performed on days 5 and 6 without a significant increase in pain and swelling. Physical examination (which was performed daily) revealed on day 7 mild-to-no effusion, full ROM and strength as compared bilaterally, and normal gait. She complained of vague soreness in the popliteal space, but she downplayed its significance. Subsequently, she was able to resume full practice status. Prepractice treatment for the remaining 3 weeks of the season included moist heat and ultrasound for the posterior tenderness, progressive resistance knee-extension exercises, and quadriceps and hamstring stretching. At various times during these last weeks, she reported increased soreness, mild weakness, and mild effusion. Therefore, she continued to ice, not only postpractice, but also several times during the evening. She also continued the use of nonsteroidal anti-inflammatory medication.

Upon completion of the season, she discontinued all running activities for 5 weeks, and we focused her activities on more advanced quadriceps-strengthening exercises that included mini-squats, slideboard, stair stepper, closed chain terminal knee extension, leg press, wall sits, and mini-trampoline. Rehabilitation sessions were performed 30 to 60 minutes daily, five times per week. Following this concentrated rehabilitation period, she complained of a vague soreness in the knee and that it still didn't feel right. Once again, we discussed the importance of seeing a physician and at this point she agreed. At approximately 9 weeks postinjury she saw the team physician. A magnetic resonance imaging (MRI) examination was ordered that revealed an incomplete midsubstance PCL tear with no ACL or meniscal involvement (Fig 1). We continued intense quadriceps-strengthening exercises for another month, at which time she reported no soreness or functional difficulties. She participated in competitive basketball during the summer and played her entire senior season without any functional impairment. She reported almost 2 years postinjury her participation in a full schedule of competitive athletic activities without any recurrence of symptoms.

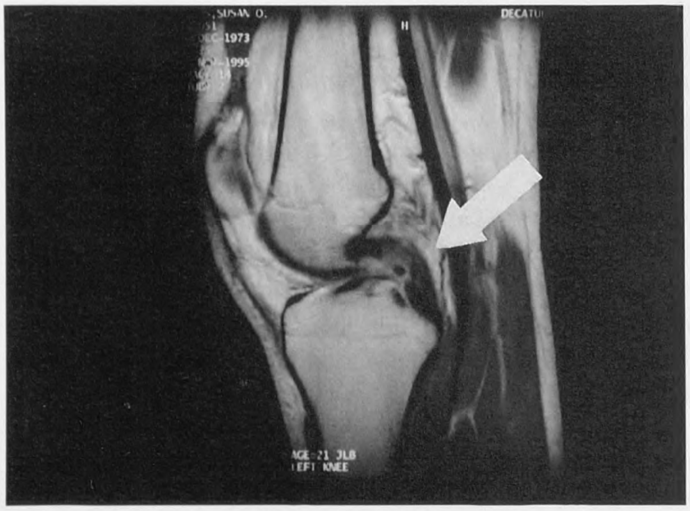

Fig 1. Magnetic resonance imaging (MRI) scan revealing an incomplete tear of the PCL (arrow).

DISCUSSION

The PCL is almost two times stronger,[12] is thicker, and is shorter than the ACL.[3] Contributing to the strength of the PCL are its unique attachments to the femur and tibia. Its fibers attach to the femur in an anterior to posterior direction while the tibial attachment is in a medial to lateral direction.[13] Although the PCL is a single structure, it has two distinctive bundles, each very important in providing knee stability. The thicker anterolateral fibers are taut in flexion and lax in extension, while the thinner posteromedial fibers are taut in extension and lax in flexion.[14,15] The screw-home mechanism of the knee is partially attributed to portions of these bundles being continually taut throughout the full ROM.[16] The primary function of the PCL is to prevent posterior displacement of the tibia on the femur, especially in flexion.[3,17] For example, at 90° flexion, the PCL provides 95% of the total restraint to posterior tibial translation while no other single structure provides more than two percent.[18]

The mechanisms of injury and clinical presentation of PCL injuries are usually very consistent. There exist at least three common mechanisms of injury resulting in PCL sprains: 1) hyperextension of the knee,[1,3,6,13,19] 2) hyperflexion of the knee,[13,20] and 3) posterior displacement of the tibia on the femur while the knee is flexed.[3,6,13] Some authors[19,21–23] also include with the last mechanism the position of the ankle in plantar flexion, and Starkey[23] notes a magnified load on the PCL with this ankle position. If the ankle is plantar flexed, it appears that a force delivered to the anterior tibia may result in possible PCL injury, whereas if the ankle is dorsiflexed, the force is absorbed by the patella. However, Fowler and Messieh[20] reported a PCL injury in a patient with the ankle in dorsiflexion. Additionally, this mechanism typically presents with evidence of anterior tibial swelling, abrasions or lacerations, and pain with knee flexion.[9] Garrick and Webb[1] believe that the most consistent symptom of PCL injuries is posterior knee pain. Our athlete's mechanism of injury, signs, and symptoms are very consistent with the literature. The athletic trainer should suspect and thoroughly investigate PCL involvement in all cases where these mechanisms and clinical entities are identified.

The athletic trainer can use many special tests to evaluate the integrity of the PCL. Perhaps the most important test and the one that should be performed first is the posterior sag sign or gravity drawer test.[24,25] In this test, the patient lies supine, knees at 90° flexion, hips at 45° flexion, and the feet flat on the table in neutral position. The athletic trainer views the tibial plateaus from the side looking for posterior sagging or a dropped-back appearance indicating disruption of the PCL (Fig 2). The most recognized and utilized test to detect PCL injuries is the posterior drawer test.[6,9] For this test, the patient lies in the same position as for the posterior sag test. The athletic

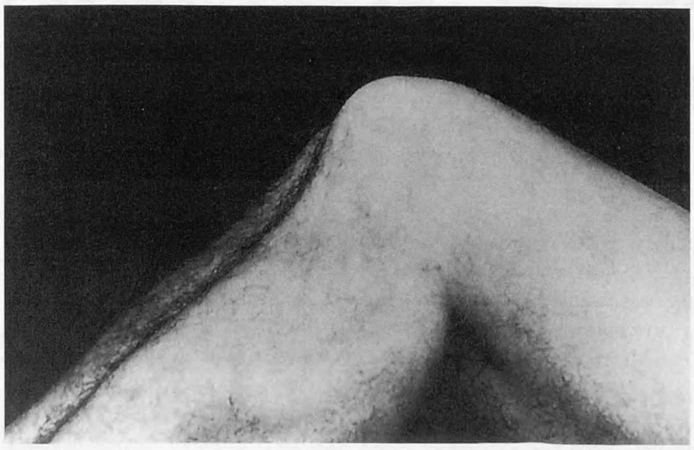

Fig 2. Positive posterior sag sign. Note the dropped back appearance of the left tibia.[23] (published courtesy of F. A. Davis Company)

trainer grasps the proximal lower leg and attempts to displace the tibia posteriorly by pushing it backward,[21,23] with a positive test denoted by pain and/or laxity.

Incorrect results may occur if the athletic trainer performs the posterior drawer test before checking for the posterior sag sign.[1,8,19,24,25] For instance, if the posterior sag sign is positive and the athletic trainer performs a posterior drawer test with the tibia already in a sagging position, the tibia will not move any further posteriorly, producing a false-negative result.[1,24] Conversely, if the anterior drawer test is performed from the dropped-back position, it will appear to show excessive anterior laxity, producing a false-positive result.[8,18,19,24,25] It is essential for the athletic trainer to determine the starting position of the tibia in order to avoid false interpretations of these tests. Additional tests that might be helpful to the athletic trainer in evaluating PCL injuries are the quadriceps active test,[8] Godfrey's test,[23] the reverse Lachman test,[25] and the valgus stress test at full extension.[10,21] Hughston[10] reported that a positive valgus stress test in full extension is a critical finding in the assessment of acute PCL ruptures. Although PCL injuries are uncommon, it is crucial for the athletic trainer to understand and perform all special tests necessary to detect them.

There is considerable controversy in the treatment of PCL injuries because the natural history of these injuries is still unknown. Some authors advocate surgical repair or reconstruction,[3,6,11,22] while others prefer conservative management through rigorous rehabilitation.[1,4,5,7,15,26,27] However, most authors agree that PCL injuries occurring in combination with other significant ligamentous injuries need surgical intervention to achieve good results,[7,9,11,20,26–28] whereas the conservative nonoperative approach appears to be the treatment of choice for incomplete, isolated PCL sprains.[1,20,21,27] Fowler and Messieh[20] reported that all of their patients who suffered partial PCL tears did well functionally and subjectively without surgery and with thorough rehabilitation. In another study, a followup of 25 PCL-deficient patients showed that 80% were satisfied with their knee stability and 84% returned to their sports without functional disability.[4] Regardless of which option the physician and/or athlete chooses, the athletic trainer should promote an aggressive rehabilitation program to prevent further disability and achieve preinjury functional status.

The primary focus of an aggressive rehabilitation program is regaining significant quadriceps strength.[1,4,7,9,20] The importance of quadriceps strength is noted by Parolie and Bergfeld,[4] who recommend achieving and maintaining at least 100% quadriceps strength when compared bilaterally, and by Garrick and Webb,[1] who describe it as acquiring "supranormal" quadriceps strength. Increased quadriceps strength is very important in decreasing the incidence of patellofemoral irritation[7] and keeping the tibia in an anterior position by overpowering the ability of the hamstrings to pull the tibia into a subluxed posterior position.[1] Tibone et al[29] observed biomechanical gait abnormalities in both PCL-deficient patients and postreconstruction patients and, thus, advocate additional rehabilitative focus on the gastrocnemius-soleus complex to correct these anomalies. However, the conservative approach has shown some possible long-term complications. Increasing disability and functional losses, including degenerative joint changes and arthritis, are likely.[7,15,22,30] In a study of 116 PCL ruptures treated both conservatively and surgically, Cross and Powell[7] concluded that patients can have good or excellent results with extensive quadriceps strengthening, but degenerative changes are highly likely to develop. Keller et al[30] reviewed 40 patients treated nonoperatively an average of 6 years post-PCL injury, and the results indicated significant symptoms and degenerative changes to be more evident with increasing time intervals from injury.

The PCL is a critical structure of the knee but is often less considered than its ACL counterpart. Even though PCL injuries are uncommon in athletics, they should not be disregarded as a potential cause of pain and disability. Therefore, the athletic trainer must remain familiar with their mechanisms, signs, symptoms, and evaluation techniques to avoid overlooking this obscure injury. With the correct mode of treatment, the vast majority of athletes can attain preinjury levels of activity.

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Fracture of the First Cervical Vertebra in a High School Football Player: A Case Report

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Objective: To present the case of a high school football player with a burst fracture of the ring of C1 resulting from a "spearing" tackle.

Background: Cervical spine fractures are rare in collision sports, but their potentially grave consequences mean that they must be given special attention. Spearing was banned by the National Collegiate Athletic Association and the National Federation of High School Athletic Associations in 1976, and the number of cervical spine fractures in high school and college football players has fallen dramatically. However, cervical spine fractures do still occur, and they present a diagnostic challenge to sports medicine professionals.

Differential Diagnosis: Cervical sprain.

Treatment: Treatment consists of halo-vest immobilization. Surgical fusion may be necessary for unstable C1-C2 fractures, although initial halo-vest treatment is usually attempted.

Uniqueness: A 17-year-old defensive back attempted to make a tackle with his head lowered. He was struck on the superolateral aspect of the helmet by the opposing running back. He remained in the game for another play, but then left the field under his own power, complaining of neck stiffness and headache. Physical examination revealed upper trapezius and occiput tenderness, bilateral cervical muscle spasm, and pain at all extremes of voluntary cervical movement. He was alert and oriented, with a normal neurologic examination. Treatment with ice was attempted but was discontinued due to increased pain and stiffness. Heat resulted in decreased pain and stiffness, but his symptoms persisted, and he was transported to the emergency room. Plain radiographs were read as negative, but a CT scan demonstrated a burst fracture of C1. He was treated with halo-vest immobilization for 8 weeks and a rigid cervical collar for 8 additional weeks. Physical therapy was then initiated, and normal cervical range of motion and strength were restored within 6 weeks. The athlete competed in track 6 months after the injury and continues to play recreational sports without difficulty. At clinical follow-up 8 months after injury, he had full, painless cervical range of motion and a normal neurologic examination.

Conclusions: A potentially devastating cervical spine injury can present insidiously, without dramatic signs or symptoms. Therefore, sports medicine professionals must retain a high index of suspicion when evaluating athletes with cervical spine complaints.

Key Words: Jefferson fracture, C1, atlas, athletic injury

Cervical spine fractures are rare in collision sports, but the potentially grave complications associated with these injuries demand that they be given special attention. Fractures of the C1 vertebra (atlas) were first described by Cooper in 1822.[1] Jefferson[2] proposed a mechanism of injury in 1920, and the burst-type fracture has since borne his eponym. In 1976, Han et al[3] attributed an increase in the observed incidence of Jefferson fractures to a more informed medical community and to the routine use of the open-mouth radiographic view. Fractures of the first cervical vertebra are usually the result of falls or motor-vehicle accidents. Torg et al[4] presented evidence that spearing with the helmet in high school football placed the player at increased risk for serious cervical injury, including C1 fractures. Their research ultimately led in 1976 to implementation by the NCAA and the NFHSAA (National Federation of High School Athletic Associations) of rules banning spearing.[5] Since the adoption of these rules, a dramatic decline in the incidence of cervical spine fractures has been noted in high school and college football.[4,6] Fractures of the first cervical vertebra still present a diagnostic challenge, owing to the paucity of symptoms and findings. We present a case that illustrates some of the difficulties and pitfalls encountered by the medical staff when presented with such an injury.

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CASE REPORT

During the third quarter of a high school football game, a 17-year-old male defensive back attempted to make a tackle with his head lowered. He was struck on the superolateral aspect of the helmet by the opposing running back. He remained in the game for another play before leaving under his own power. On the sidelines he complained of neck stiffness and headache. He denied paresthesias in the upper or lower extremities. At the time of initial evaluation, examination revealed tenderness over the upper trapezius and the occiput. Moderate bilateral cervical muscle spasm was palpable. Voluntary cervical flexion was 40°, extension 15°, side bending symmetrical 20° to the left and right, and axial rotation symmetrical 40° to the left and right. Pain was reported at all extremes of voluntary cervical movement. Shoulder range of motion was normal bilaterally. He was able to exert normal isometric force with his neck musculature when tested manually in all directions but stated that this was painful. He was alert and oriented, and his neurologic examination was normal. Ice was applied but was removed after 10 minutes due to exacerbation of pain and stiffness. Heat was then applied resulting in a decrease in subjective stiffness and pain. After approximately 90 minutes' observation, during which complaints of neck stiffness, headache, and cervical pain persisted, he was transported to the emergency room. Cervical plane radiographs were read as negative (Fig 1). Because cervical muscle spasm had increased by this point, making it difficult for the technician to obtain adequate views of the cervical spine, a CT scan of the cervical spine was obtained, which demonstrated a burst fracture of C1 (Fig 2). He was admitted and treated with halo-vest immobilization. The halo was removed at 8 weeks, and he wore a rigid cervical collar for 8 additional weeks. Physical therapy was initiated 4 months after the injury, and, after 6 weeks of biweekly treatments, normal cervical motion and strength had been restored. This athlete did very well, competing in track 6 months after the injury. He graduated that year, and a recent phone follow-up revealed that he continues to play recreational basketball, football, and baseball with no cervical pain. He works at a video rental store and is taking community college courses. At the last clinical follow-up visit 8 months postinjury, he was found to have full, painless cervical range of motion and a normal neurologic examination. Although a follow-up CT scan was never obtained, flexion/extension radiographs obtained 4 months postinjury showed no evidence of instability.

DISCUSSION

The first cervical vertebra derives its name from Atlas, the Greek titan condemned by Zeus to support the weight of the heavens on his shoulders. Similarly, C1 supports and balances the cranium. The atlas is ring shaped, with an anterior arch, posterior arch, and two lateral masses to which are attached the transverse processes and the superior and inferior articular surfaces (Fig 3). The superior articular surfaces are concave and articulate with the occipital condyles of the skull. The inferior articular surfaces are nearly flat and articulate with the superior zygapophyses of C2. C1 is unique in that it has neither a vertebral body nor a spinous process like the other vertebrae. The anterior arch forms about one fifth of the ring. The posterior arch is concave and marked by a smooth, oval inner facet for articulation with the odontoid process of the axis (C2). The upper ends of the longus colli muscles attach to an anterior tubercle on the outer surface of the anterior arch. The posterior arch constitutes much more of the ring, with a posterior tubercle in place of a spinous process. The transverse processes are larger and thicker than those of the lower cervical vertebrae, but each still contains a foramen (tunnel) through which the vertebral arteries course. [7]

Jefferson[2] reported in 1920 on a series of atlas fractures, including 4 of his own experience and a review of 21 other reported cases. He proposed a classification system for atlas fractures including burst fractures, posterior arch fractures, anterior arch fractures, and lateral mass and transverse process fractures,[2] yet his name is traditionally ascribed only to the burst pattern of fracture. Segal et al[8] used CT scanning to identify the comminuted subtype, with ipsilateral fracture lines anterior and posterior to the lateral mass. The comminuted pattern was found to be common and associated with a high incidence of nonunions and poor subjective outcomes. Levine and Edwards[9] provided a seventh subtype, the inferior tubercle avulsion fracture, which is stable and does not require rigid immobilization. Burst fractures are the most common and the least likely to cause neurologic injury. This is thought to be due to the large space available for the spinal cord at this level. Steel[10] noted that the distance between the anterior and

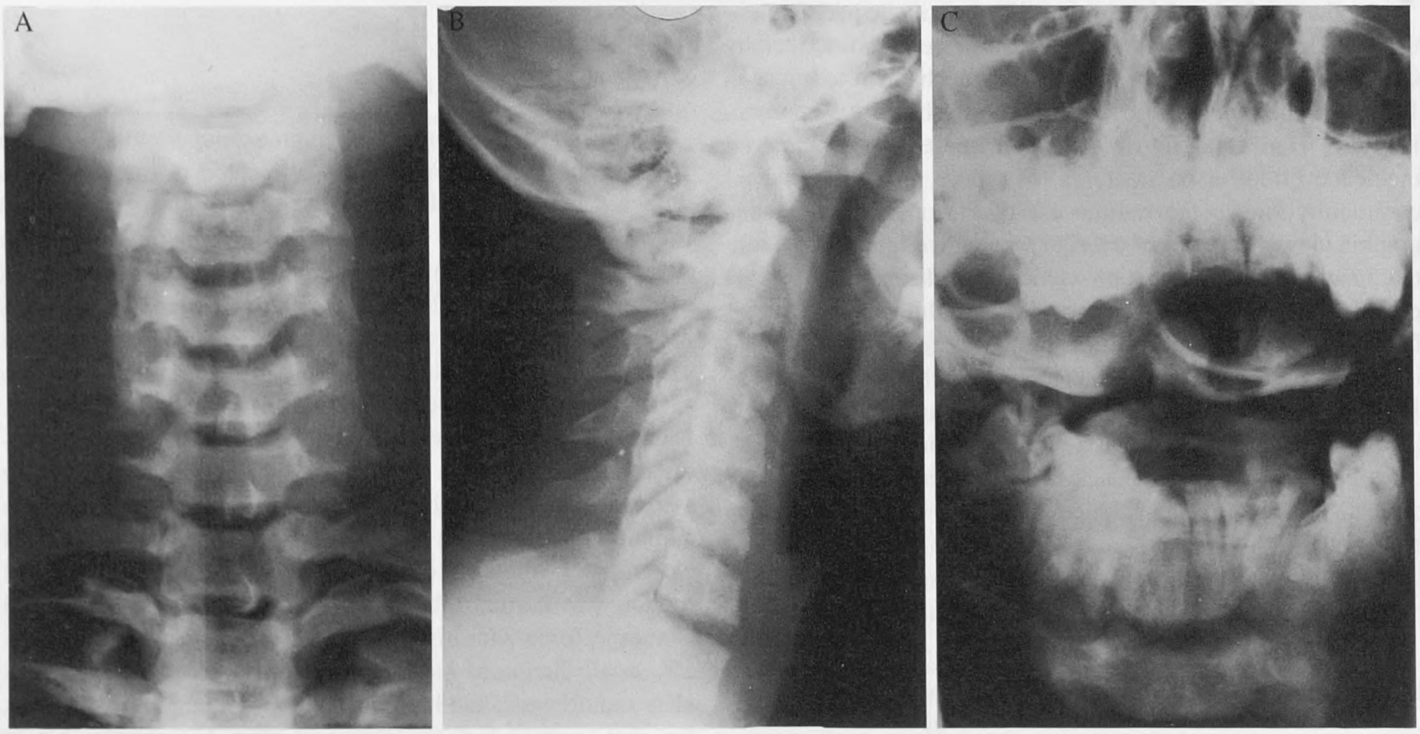

Fig 1. Standard radiographs of the cervical spine on the day of injury. (A) Anteroposterior projection. (B) Lateral projection. (C) Open-mouth projection. The open-mouth view is suboptimal, with the odontoid not centered between the occipital condyles. The technician was unable to obtain a better view due to muscular spasm. These films failed to reveal the fracture of C1.

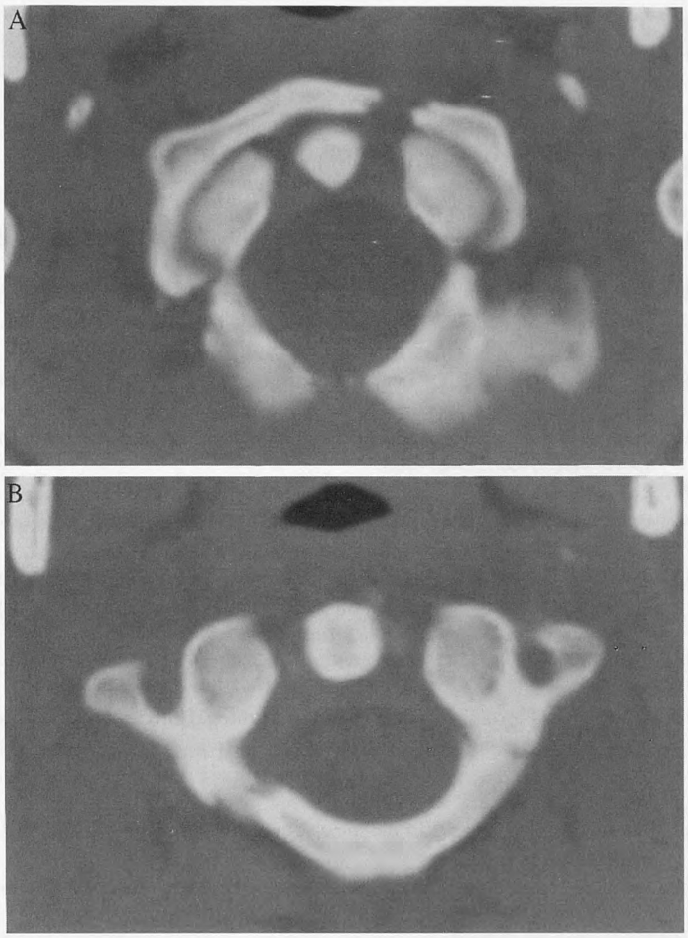

Fig 2. Representative CT scan cuts through the C1 vertebra. Three fracture lines are seen through the ring of C1. (A) A mildly displaced fracture through the left anterior arch of C1 is best appreciated on this cut. (B) Minimally displaced fractures through the posterior arch of C1 are seen on this cut, one adjacent to the left lateral mass and the second involving the right posterior arch.

posterior arches of C1 is divided roughly into thirds, with one third occupied by the dens, one third by the spinal cord, and the last third by space. Additionally, the mechanism of injury (axial impact loading of the cervical spine) tends to spread the resulting fragments away from the cord due to the orientation of the articular processes with the occiput. Spence et al[11] has subdivided the burst fracture into stable and unstable types depending upon the integrity of the transverse ligament, as determined by the radiographic atlantoaxial offset measured on the open-mouth view. The fracture is considered unstable when the total atlantoaxial offset is $\geq$7 mm. Offset is determined by totaling the horizontal displacements between the medial facet joints of C1 and C2 on the right and left sides. Posterior arch fractures are more commonly associated with fractures of the dens or avulsion of the transverse ligament, which can lead to neurologic deficit. Other associated injuries can include traction injuries of the suboccipital and greater occipital nerves, palsies of the lower six cranial nerves, and injuries to the vertebral arteries or veins. These can lead to paresthesias in the posterior scalp, various cranial nerve abnormalities (most commonly involving alterations of phonation or taste), and symptoms of basilar artery insufficiency (vertigo, blurred vision), respectively.[12]

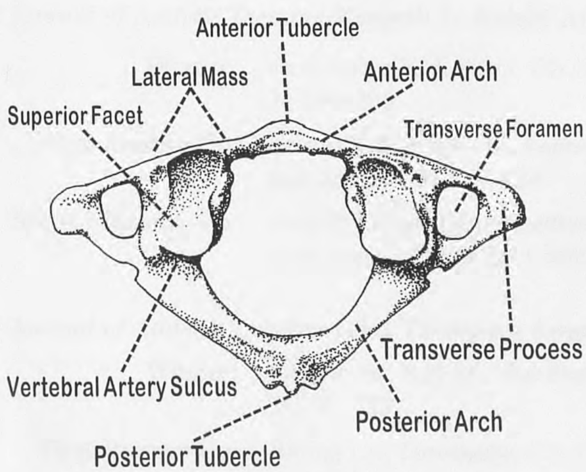

Fig 3. Relevant bony anatomy of the first cervical vertebra (superior view).

Fortunately, neurologic deficits are rare with C1 fractures, but the symptoms can be so insidious that a high index of suspicion is needed to make the appropriate diagnosis. Often, the only clinical findings will be cervical pain, muscle spasm, and decreased neck mobility.[12] Even Jefferson's first referenced case was not radiographed for two days after a high-speed airplane collision because the symptoms appeared so benign.[2] For this reason, all complaints of cervical pain after injury should be thoroughly evaluated by the athletic trainer. If pain and stiffness do not resolve within 5 minutes, the athlete should be kept from further participation until being examined by a physician. If necessary, transport should be done with a hard cervical collar or more rigid immobilization in place.

As our case illustrates, plane radiographs are sometimes insufficient to demonstrate a minimally displaced fracture of C1. With "normal" cervical x-rays and no neurologic deficits on examination, it would have been easy, and perhaps even defensible, for the ER physician to have diagnosed this injury as a cervical sprain. The athlete might have been discharged with nothing more than a soft cervical collar. Fortunately, the physician had an appropriately high index of suspicion and ordered the definitive test. Greenan[13] recommended CT scanning to further evaluate cervical spine fractures and MRI scanning if cervical spinal stenosis or spondylosis is suspected.

Most isolated atlas fractures are treated nonoperatively with halo-vest immobilization. The isolated inferior tubercle avulsion subtype can be treated with a rigid cervical collar. Initial halo traction is sometimes required for unstable burst fractures, and surgical fusion may be necessary for fractures with C1-C2 instability, although initial halo-vest treatment is usually attempted.

CONCLUSIONS

C1 fractures are uncommon in sports, but the potential for serious sequelae mandates that all health care professionals who cover athletic events maintain a high index of suspicion when an athlete presents with complaints of neck pain or stiffness following an injury, no matter how seemingly trivial. Since the mechanism of injury for most cervical fractures involves axial loading, it is not surprising that those sports with a higher risk of cranial impact (football, rugby, diving, gymnastics, swimming, hockey, and trampolining) have a higher incidence of cervical spine fractures.[4,6,14–20] The initial signs and symptoms of a C1 fracture may be subtle. The athlete presented in this report initially appeared to have sustained nothing more serious than a cervical sprain, and the medical team could easily have dismissed it as such. We were, in fact, quite surprised at the radiographic results. We were fortunate that the injury did not occur at the end of the game; because the athlete's initial symptoms were so mild, he might have left without seeking the attention of the athletic trainer or physician. Since this injury, the rigid cervical collar has become an integral part of our sideline athletic trainers' kit, easily and rapidly applied to any athlete with neck complaints before transfer to a medical center.

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■ 20th Annual NATA Student Writing Contest ■

In an effort to promote scholarship among young athletic trainers, the National Athletic Trainers' Association, Inc sponsors an annual writing contest.

1. The contest is open to all undergraduate members of the NATA.
2. Papers must be on a topic germane to the profession of athletic training and can be case reports, literature reviews, original research articles, analyses of training room techniques, etc.
3. Entries must not have been published, nor be under consideration for publication, by any journal.
4. The winning entrant will receive a cash award, and the paper will be published in the *Journal of Athletic Training* with recognition as the winning entry in the Annual NATA Student Writing Contest. One or more other entries may be given honorable mention status.
5. Entries must be written in journal manuscript form and adhere to all regulations set forth in the Authors' Guide of the *Journal of Athletic Training*. We suggest that authors, before starting, read: Knight KL, Ingersoll CD. Structure of a scholarly manuscript: 66 tips for what goes where. *J Athl Train.* 1996;31:201–206 and Knight KL, Ingersoll CD. Optimizing scholarly communications: 30 tips for writing clearly. *J Athl Train.* 1996;31:209–213.
6. Entries must be received by March 1, 1998. Announcement of the winner will be made at the Annual Meeting and Clinical Symposia in June.
7. The Writing Contest Committee reserves the right to make no awards if, in its opinion, none of the entries is of sufficient quality to merit recognition.
8. An original and two copies of the paper must be received at the following address by March 1, 1998.

NATA Student Writing Contest
Deloss Brubaker, EdD, ATC
Life College
1269 Barclay Circle
Marietta, GA 30060

1996 Outstanding Manuscript Awards

Congratulations to the winners and the runners-up of the 1996 Outstanding Manuscript Awards, as determined by the Editorial Board and the Associate Editors of the *Journal of Athletic Training*.

1996 *Journal of Athletic Training* Kenneth L. Knight Award for the Outstanding Research Manuscript

Winner: Guskiewicz KM, Perrin DH, Gansneder BM. Effect of mild head injury on postural stability in athletes. 31:300–306.

First Runner-Up: Swanik CB, Henry TJ, Lephart SM. Chronic brachial plexopathies and upper extremity proprioception and strength. 31:119–124.

Second Runner-Up: Rose S, Draper DO, Schulthies SS, Durrant E. The stretching window part two: rate of thermal decay in deep muscle following 1-MHz ultrasound. 31:139–143.

1996 *Journal of Athletic Training* Clint Thompson Award for the Outstanding Nonresearch Manuscript

Winner: Loudon JK, Bell SL. The foot and ankle: an overview of arthrokinematics and selected joint techniques. 31:173–178.

First Runner-Up: Bitting LA, Trowbridge CA, Costello LE. A model for a policy on HIV-AIDS and athletics. 31:356–357.

Second Runner-Up: Whitehill WR, Norton P, Wright KE. Navigating the library maze: introductory research and the athletic trainer. 31:50–52.

NATA Research & Education Foundation
CALL FOR ABSTRACTS

1998 National Athletic Trainers' Association — Annual Meeting & Clinical Symposium
Baltimore, Maryland • June 17-20, 1998
DEADLINE FOR ABSTRACT SUBMISSION: JANUARY 5, 1998

Instructions for Submission of Abstracts and Process for Review of All Submissions

Please read all instructions before preparing the abstract. Individuals may submit only one abstract or clinical case report as primary (presenting) author, but may submit unlimited abstracts or clinical case reports as a coauthor. All abstracts will undergo blind review.

FREE COMMUNICATIONS ABSTRACTS

Specific Content Requirements

Abstracts in this category must include the purpose of the study or hypothesis, a description of the subjects, the experimental methods and materials, the type(s) of data analysis, the results of the study, and the conclusion(s). Authors are asked to indicate a preference for oral or poster presentation of their abstracts. Authors of free communications are required to categorize their abstracts in one of the five specific areas of research funded by the NATA Research and Education Foundation:

• **Basic Science** — includes controlled laboratory studies in the subdisciplines of exercise physiology, biomechanics, and motor behavior, among others, which relate to athletic training and sports medicine.
• **Clinical Studies** — includes assessment of the validity, reliability, and efficacy of clinical procedures, rehabilitation protocols, injury prevention programs, surgical techniques, and so on.
• **Educational Research** — a broad category ranging from basic surveys to detailed athletic training/sports medicine curricular development. An abstract in this category will generally include assessment of student learning, teaching effectiveness (didactic or clinical), educational materials and curricular development.
• **Sports Injury Epidemiology** — includes studies of injury patterns among athletes. These studies will generally encompass large-scale data collection and analysis. Surveys and questionnaires may be classified in this category but are more likely to come under the Observation/Informational Studies category.
• **Observation/Informational Studies** — includes studies involving surveys, questionnaires, and descriptive programs, among others, which relate to athletic training and sports medicine.

Instructions for Preparing the Abstract

1. Provide all information requested on the Abstract Author Information Form. Abstracts should be typed or word processed using a **letter-quality** printer with no smaller than elite (12 cpi) or 10-point typeface. Do not use a dot matrix printer.
2. Top, bottom, right, and left margins should be set at 1.5" using a standard 8.5" x 11" sheet of paper. Type the title of the paper or project in all **CAPITAL** letters on the left margin.
3. On the next line, indent 3 spaces and type the names of all authors, with the author who will make the presentation listed first. Type the last name, then initials (without periods), followed by a comma; continue with the other authors (if any), ending with a colon.
4. Indicate the institution where the research or case report was conducted on the same line following the author(s)' names.
5. Double space and begin typing the text of the abstract flush left in a single paragraph with no indentions. Do not justify the right margin.
6. The abstract must not exceed 400 words.

CLINICAL CASE REPORTS

Specific Content Requirements

This category of abstracts involves the presentation of unique individual athletic injury cases of general interest to our membership. This year, no form is provided so that authors may use their own word-processing software to format and submit the following information using a two-page format. Abstracts in this category must include the following information. A maximum of one paragraph should be presented for each of the following required content area headings:

1) Personal data
2) Physical signs and symptoms
3) Differential diagnosis
4) Results of diagnostic imaging/laboratory tests
5) Clinical course
6) Deviation from the expected

Instructions for Preparing the Abstract

1. An individual may submit only one clinical case report abstract as primary (presenting) author; however, there is no limit to the number of abstracts (free communications or case reports) listing an individual as coauthor.
2. Clinical case report abstracts are to be word processed or typed using a **letter-quality** printer with no smaller than elite (12 cpi) or 10-point typeface. Do not use a dot matrix printer.
3. Top, bottom, right, and left margins should be set at 1.5" using a standard 8.5" x 11" sheet of paper. Type the title of the paper or project in all **CAPITAL** letters on the left margin.
4. Provide all information requested on the information form on the next page. Please note that the institution where the clinical case occurred should be cited, not the author(s)' current address, if different.

5. The title of the clinical case report should not contain information that may reveal the identity of the individual nor the specific nature of the medical problem to the reader. An example of a proper title for a clinical case report is "Chronic Shoulder Pain in a Collegiate Wrestler."
6. Complete the six different categories of information as required for a clinical case report abstract. These categories are:
   a. Personal Data/Pertinent Medical history (age, sex, sport/occupation of individual, primary complaint, and pertinent aspects of their medical history)
   b. Physical Signs and Symptoms (a brief summary of the physical findings)
   c. Differential Diagnosis (array of possible injuries/conditions)
   d. Results of Diagnostic Imaging/Laboratory Tests
   e. Clinical Course (eg, diagnosis, treatment, surgical technique, rehabilitation program, final outcome)
   f. Deviation From the Expected (a brief description of what makes this case unique)

NATA Research & Education Foundation Call for Reviewers

The NATA Research & Education Foundation sponsors the Free Communication Sessions at the NATA Annual Meeting & Clinical Symposium. These events offer NATA members the opportunity to present and learn about the latest developments in athletic training.

The Foundation is currently recruiting individuals interested in reviewing the abstracts submitted for inclusion in these oral and poster research presentations. The abstracts fall under the following categories: basic science, clinical studies, educational research, observational studies, sports injury epidemiology, and clinical case reports (unique injury cases).

Abstracts are due January 5 of each year. During the month of February, reviewers are asked to submit written evaluations of blind abstracts within their interest or expertise area.

Those interested in volunteering to become an abstract reviewer should send a curriculum vitae or resume, your preferred review category, and a short description of why you would make a good abstract evaluator to:

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Complete the form and mail it, the original abstract, two photocopies of the original abstract, six (6) blind copies (showing no information about the authors or institution) of the abstract and a labeled 3.5" DISKETTE copy (preferably in WordPerfect or ASCII format; if you must send it in Macintosh format, please use a high-density diskette) of your abstract to:

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ABSTRACTS POSTMARKED AFTER JANUARY 5, 1998 WILL NOT BE ACCEPTED.

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Abstracts

Clint Thompson, MS, ATC

Lintner SA, Levy A, Kenter K, Speer KP. Glenohumeral translation in the asymptomatic athlete's shoulder and its relationship to other clinically measurable anthropometric variables. *Am J Sports Med.* 1996;24:716–720.

To determine the degree of shoulder translation in uninjured athletes, we examined 76 Division I collegiate athletes (44 women and 32 men) for passive range of motion in both shoulders and for knee and elbow hyperextension. Translation was based on a scale of 0 to 3+. Shoulders with symptoms of pain or a history of instability or dislocation were excluded from this study. Forty-six shoulders had 0 anterior translation, 75 had 1+, and 31 had 2+. Thirteen shoulders had 0 posterior translation, 56 had 1 +, and 83 had 2+. Thirty-eight shoulders had 0 inferior translation, 105 had 1+, and 9 had 2+. No shoulder had translation of 3+ in any direction. Twenty-four athletes, 12 men and 12 women, had translational asymmetry of a minimum of one grade in at least one direction. No shoulder was asymmetric in all three directions. There was a significant correlation between dominant hand and increased translation; 19 of 24 athletes with asymmetric shoulders had greater translation in the nondominant extremity. There was no relationship between translation and range of motion, knee or elbow hyperextension, thumb-to-forearm distance, or years spent in sports participation. Asymmetry of shoulder translation may exist in the normal shoulder. This review shows that up to 2+ translation in any direction cannot be considered abnormal.

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Liu SH, Henry MH, Nuccion SL. A prospective evaluation of a new physical examination in predicting glenoid labral tears. *Am J Sports Med.* 1996; 24:721–725.

We studied 62 patients (40 men and 22 women) with an average age of 28 years over a 28-month period who presented with shoulder pain that was refractory to 3 months of conservative management. Patients with a prior glenohumeral dislocation or a rotator cuff tear were excluded. The "crank" test was performed with the arm elevated 160° in the scapular plane of the body, loaded axially along the humerus, and with maximal internal and external rotation. Although similar tests have been described, the crank test is a new examination previously unreported. Half of the patients (31) had a positive crank test. Arthroscopy performed on all 62 patients revealed glenoid labral tears in 32 patients. Two patients who had positive crank tests did not have labral tears but had partial-thickness, articular-side rotator cuff tears. The sensitivity of the crank test was 91%, the specificity was 93%, the positive predictive value was 94%, and the negative predictive value was 90%. With these data, the crank test fulfills the criteria as a single physical examination test that is highly accurate for the preoperative diagnosis of glenoid labral tears. Accordingly, expensive imaging modalities currently used in this patient population may be employed less in the future.

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Hewett TE, Stroupe AL, Nance NA, Noyes FR. Plyometric training in female athletes: decreased impact forces and increased hamstring torques. *Am J Sports Med.* 1996;24:765–773.

The purpose of this study was to test the effect of a jump-training program on landing mechanics and lower extremity strength in female athletes involved in jumping sports. These parameters were compared before and after training with those of male athletes. The program was designed to decrease landing forces by teaching neuromuscular control of the lower limb during landing and to increase vertical jump height. After training, peak landing forces from a volleyball block jump decreased 22%, and knee adduction and abduction moments (medially and laterally directed torques) decreased approximately 50%. Multiple regression analysis revealed that these moments were significant predictors of peak landing forces. Female athletes demonstrated lower landing forces than male athletes and lower adduction and abduction moments after training. External knee extension moments (hamstring muscle-dominant) of male athletes were threefold higher than those of female athletes. Hamstring-to-quadriceps muscle-peak-torque ratios increased 26% on the nondominant side and 13% on the dominant side, correcting side-to-side imbalances. Hamstring power increased 44% with training on the dominant side and 21% on the nondominant. Peak torques of male athletes were significantly greater than those of untrained female athletes but were similar to those of trained females. Mean vertical jump height increased approximately 10%. This training may have a significant effect on knee stabilization and prevention of serious knee injury among female athletes.

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Garth WP, Pomphrey M, Merrill K. Functional treatment of patellar dislocation in an athletic population. *Am J Sports Med.* 1996;24:785–791.

Fifty-eight athletically active study participants with 69 knees that had experienced patellar dislocations were available for followup after being selected for a functional rehabilitation program without antecedent immobilization. Follow-up evaluation was at a minimum of 24 months after onset of treatment and averaged 46.2 months. Good or excellent results occurred in 39 (66%) knees treated after an initial patellar dislocation and in 15 (50%) knees with a chronic history of patellar instability. Twenty-six percent of the 69 knees had experienced recurrent patellar instability at followup. Overall, 42 patients (73%) were satisfied with their knees after this nonsurgical management. Anatomic predisposition and onset of bilateral instability at an early age were found to be significant factors associated with a less favorable outcome.

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Ashton-Miller JA, Ottaviani RA, Hutchinson C, Wojtys EM. What best protects the inverted weight-bearing ankle against further inversion? *Am J Sports Med.* 1996;24:800–809.

We measured the maximal isometric eversion moment developed under full weight bearing in 20 healthy adult men (age 24.4 ± 3.4 yr; mean ± SD) with their ankles in 15° of inversion. Tests were performed at both 0° and 32° of ankle plantar flexion in low- and in three-quarter-top shoes with and without adhesive athletic tape or one of three proprietary ankle orthoses. At 0° of ankle plantar flexion, the mean maximal voluntary resistance of the unprotected ankle to an inversion moment was 50 + 8 N-m; this increased by an average of 12% (or 6 N-m) when the subject wore a three-quarter-top basketball shoe. The maximal voluntary resistances to inversion moments developed with the ankles further protected by athletic tape or any of three orthoses were not significantly different. Biomechanical calculations suggest that at 15° of inversion the fully active ankle evertor muscles isometrically developed a moment up to six times larger than that developed when an athlete wears a three-quarter-top shoe alone and more than three times larger than that developed passively when the athlete has tape or an orthosis worn inside a three-quarter-top shoe. We conclude that fully activated and strong ankle evertor muscles are the best protection for a near-maximally inverted ankle at footstrike.

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Bennell K, Malcom SA, Thoms SA, Reid SJ, Brukner PD, Ebling PR, Wark JD. Risk factors for stress fractures in track and field athletes. *Am J Sports Med.* 1996;24:810–818.

The aim of this 12-month prospective study was to investigate risk factors for stress fractures in a cohort of 53 female and 58 male track and field athletes, aged 17 to 26 years. Total bone mineral content, regional bone density, and soft tissue composition were measured using dual-energy x-ray absorptiometry and anthropometric techniques. Menstrual characteristics, current dietary intake, and training were assessed using questionnaires. A clinical biomechanical assessment was performed by a physical therapist. The incidence of stress fractures during the study was 21.1%, with most injuries located in the tibia. Of the risk factors evaluated, none was able to predict the occurrence of stress fractures in men. However, in female athletes, significant risk factors included lower bone density, a history of menstrual disturbance, less lean mass in the lower limb, a discrepancy in leg length, and a lower fat diet. Multiple logistic regression revealed that age of menarche and calf girth were the best independent predictors of stress fractures in women. This bivariate model correctly assigned 80% of the female athletes into their respective stress fracture or nonstress fracture groups. These results suggest that it may by possible to identify female athletes most at risk for this overuse bone injury.

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Heidt RS, Dormer SG, Cawley PW, Scranton PE, Losse G, Howard M. Differences in friction and torsional resistance in athletic shoe-turf surface interfaces. *Am J Sports Med.* 1996;24: 834–842.

This study evaluated the shoe-surface interaction of 15 football shoes made by 3 manufacturers in both anterior translation and rotation using a specially designed pneumatic testing system. The shoes included traditional cleated football shoes, "court" shoes (basketball-style shoes), molded-cleat shoes, and turf shoes. Under an 11.35-kg (25-pound) axial load, all shoes were tested on synthetic turf under wet and dry conditions and on natural stadium grass. Test-retest reliability, as calculated using the Pearson Product-Moment Correlation test, was 0.85 for force of translation and 0.55 for the moment of rotation. The wet versus dry surface values on translation were significantly different for rotation about the tibial axis. Spatting, which is protective taping of the ankle and heel applied on the outside of the shoe, resulted in a reduction of forces generated in both translation and rotation. No overall difference between shoes on grass versus AstroTurf was noted. However, there were significant differences for cleated and turf shoes. Shoes tested in conditions for which they were not designed exhibited reproducible excessive or extreme minimal friction characteristics that may have safety implications. On the basis of this study, we urge shoe manufacturers to display suggested indications and playing surface conditions for which their shoes are recommended.

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Muellner T, Weinstabl R, Schabus R, Vecsei V, Kainberger F. The diagnosis of meniscal tears in athletes. *Am J Sports Med.* 1997;25:7–12.

This study evaluated the predictability of clinical examination alone in comparison with magnetic resonance imaging in the diagnosis of meniscal tears in competitive athletes. Ninety-three competitive athletes were prospectively investigated between 1992 and 1995. A total of 57 athletes were operated on based on clinical examination alone, and the 36 remaining athletes had magnetic resonance imaging before surgery. The correct diagnosis of a meniscal lesion was made on clinical examination alone in 83 athletes (89%) and on magnetic resonance imaging the correct diagnosis was also made in 89% of 36 athletes. The overall values for the clinical investigation of the medial and lateral menisci combined were 94.5%, 91.5%, 99%, 96.5%, and 87% for accuracy, positive predictive value, negative predictive value, sensitivity, and specificity, respectively. The overall values for magnetic resonance imaging of the medial and lateral menisci combined were 95.5%, 96.5%, 91.5%, 98%, and 85.5% for accuracy, positive predictive value, negative predictive value, sensitivity, and specificity, respectively.

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Deutsch A, Altchek DW, Veltri DM, Potter HG, Warren RF. Traumatic tears of the subscapularis tendon. ***Am J Sports Med.*** **1997;25:13–22.**

The study population consisted of 14 shoulders in 13 consecutive patients with surgically confirmed isolated subscapularis tendon tears. In all but three patients, the mechanism of injury was traumatic hyperextension or external rotation of the abducted arm. All patients reported pain and weakness in the affected shoulder. Physical findings revealed limited passive range of motion at maximal internal and external rotation due to pain, weakness of internal rotation of the shoulder, and tenderness in the region of the intertubercular groove. However, these findings did not conclusively point to the subscapularis tendon as the site of injury. Preoperative interpretation of magnetic resonance imaging studies was used to diagnose tears of the subscapularis tendon in 14 shoulders and biceps tendon subluxation or dislocation in 6 shoulders. On arthroscopic examination, one patient was found to have a partial-thickness tear that was treated with arthroscopic debridement. Six shoulders had full-thickness tears of the subscapularis tendon, and seven shoulders had full-thickness tears associated with concomitant biceps tendon pathologic conditions, including subluxation, dislocation, or rupture. The full-thickness subscapularis tendon tears were repaired via an open anterior approach to the shoulder through the deltopectoral groove. Associated biceps tendon injuries were treated with tenodesis of the tendon to the intertubercular groove. Our early followup results have shown that, with proper diagnoses and surgical treatments, patients have greatly decreased pain and marked improvement in shoulder function.

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Shelbourne KD, Trumpter RV. Preventing anterior knee pain after anterior cruciate ligament reconstruction. ***Am J Sports Med.*** **1997;25:41–47.**

We studied a group of 602 patients who had anterior cruciate ligament reconstructions between 1987 and 1992. An autogenous patellar tendon graft was used, regardless of preexisting patellofemoral pain or chondromalacia. The surgeon and rehabilitation protocol were the same for all patients, with emphasis on obtaining full knee hyperextension postoperatively. All patients were evaluated by a questionnaire designed to determine the incidence and severity of anterior knee pain as it relates to sporting or daily living activities, prolonged sitting, stair climbing, and kneeling. Range of motion for the study group was recorded during physical examination. We compared the findings with those from a control group of 122 patients who had no previous knee injury. The study group reported a mean score of 89.5 ± 12.5, compared with 90.2 ± 12.3 in the control group. Both the operative and control groups reported little or no symptoms during sporting activities (94% and 92%, respectively). No differences were noted with respect to the other activities surveyed. These results demonstrate that anterior knee pain after anterior cruciate ligament reconstruction is not an inherent complication associated with patellar tendon harvesting. We suggest that the increased incidence of anterior knee pain with an autogenous patellar tendon graft can be prevented by obtaining full knee hyperextension postoperatively. This goal can be achieved through preoperative rehabilitation and a postoperative protocol emphasizing early restoration of full knee hyperextension.

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Konradsen L, Voigt M, Hojsgaard C. Ankle inversion injuries: the role of the dynamic defense mechanism. ***Am J Sports Med.*** **1997;25:54–58.**

We investigated the role of a muscular defense in the stabilization and protection of the ankle joint against sudden forced inversion. Ten volunteers with mechanically stable ankles were tested in different standing and walking situations using a trap door model and lower extremity electromyography and electrogoniometers. Peroneal electromyographic activity was observed 54 milliseconds after the detection of ankle inversion. This latency was shorter when the ankle was already in inversion and longer with the ankle in eversion. Quadriceps and hamstring muscle electromyographic activity occurred 68 milliseconds after the ankle inversion stimulus. Evidence of active eversion was seen 176 milliseconds after sudden inversion. Active changes in knee and hip joint angles occurred even later. In contrast, the trap door rotated 30° in approximately 80 milliseconds. We conclude that the reflex reaction to sudden inversion is initiated at a peripheral level by the inversion motion followed by a reaction pattern mediated by spinal or cortical motor centers. Both peripheral and central reactions, however, seem too slow to protect the ankle in case of sudden inversion occurring at the time of heel contact.

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Sirota SC, Malanga GA, Eischen JJ, Laskowski ER. An eccentric and concentric strength profile of shoulder external and internal rotator muscles in professional baseball pitchers. ***Am J Sports Med.*** **1997;25:59–64.**

The purpose of this study was to establish a database on the isokinetic eccentric muscular performance characteristics of external and internal rotator muscles in the shoulders of professional baseball pitchers. Concentric data is also included and compared with previously published concentric studies. Twenty-five professional baseball pitchers were evaluated with a Kin-Com isokinetic dynamometer. The subjects tested had a mean age of 23.5 years and a mean body weight of 199 pounds. Eccentric and concentric isokinetic tests were performed at 60 and 120 deg/sec. The testing protocol was standardized for each subject. Test results indicated no statistically significant difference in mean torque between throwing and nonthrowing shoulders for either external or internal rotator muscle groups. Eccentric strength was significantly greater than concentric strength for all muscle groups tested. The external-to-internal rotator muscle strength ratios were well above those previously published for high school through professional pitchers. Mean torque-to-lean body weight ratios were also included to establish a database. This study establishes one of the first databases for eccentric isokinetic muscle strength of shoulder rotator muscles in professional baseball pitchers. The data may help clinicians prevent and rehabilitate shoulder injuries in professional throwing athletes.

Perlmutter GS, Leffert RD, Zarins B. Direct injury to the axillary nerve in athletes playing contact sports. *Am J Sports Med.* 1997;25:65–68.

We performed long-term followup (31 to 276 months) of 11 contact athletes who had sustained isolated injuries to their axillary nerves during athletic competition. There were no known shoulder dislocations. Electromyographs were taken of 10 patients, and all patients had confirmation of clinically defined injuries that were confined to their axillary nerves. Nine injuries were sustained while tackling opposing players in football; two were sustained in hockey collisions. In seven athletes, the mechanism of injury was a direct blow to the anterior lateral deltoid muscle. In four athletes, there were simultaneous contralateral neck flexion and ipsilateral shoulder depression. At followup, all patients had residual deficits of axillary sensory and motor nerve function. There had been no deltoid muscle improvement in three patients, moderate improvement in two patients, and major improvement in six patients. However, shoulder function remained excellent, with all athletes maintaining full range of motion and good-to-excellent motor strength. Axillary nerve exploration and neurolysis in four patients did not significantly affect the outcomes. Although no patient had full recovery of axillary nerve function, 10 of 11 athletes returned to their preinjury levels of sports activities, including professional athletics.

Levitz CL, Reilly PJ, Torg JS. The pathomechanics of chronic, recurrent cervical nerve root neurapraxia. *Am J Sports Med.* 1997;25:73–76.

This study defined chronic recurrent cervical nerve root neurapraxia, the chronic burner syndrome, characterized the clinical findings, and described the responsible pathomechanics. We studied a subset of 55 athletes (mean age, 22 yr) for evaluation of recurrent burners. Eleven subjects were professional athletes. The mechanism of injury was extension combined with ipsilateral-lateral deviation in 46 patients (83%). Spurling's sign was positive in 39 patients (70%). Twenty-nine patients (53%) had developmentally narrowed cervical canals, and 48 patients (87%) had evidence of disk disease by magnetic resonance imaging. The disk disease was in the form of a disk bulge, disk protrusion, or a frank disk herniation deforming the cord. Fifty-one patients (93%) had disk disease or narrowing of the intervertebral foramina secondary to degenerative disk disease. Although burners may be the result of a brachial plexus stretch injury in high school and collegiate football players seen with acute symptoms, nerve root compression in the intervertebral foramina secondary to disk disease is a more common cause in collegiate and professional players who have recurrent or chronic burner syndromes. There is a high incidence of cervical canal stenosis in football players with recurrent burner syndrome. The combination of disk disease and cervical spinal canal stenosis may lead to an alteration in normal cervical spine mechanics that may make these athletes more prone to chronic burner syndromes.

Orchard J, Marsden J, Lord S, Garlick D. Preseason hamstring muscle weakness associated with hamstring muscle injury in Australian footballers. *Am J Sports Med.* 1997;25:81–85.

Hamstring muscle strain is the most prevalent injury in Australian Rules Football, accounting for 16% of playing time missed as a result of injury. Thirty-seven professional footballers from an Australian Football League team had preseason measurements of hamstring and quadriceps muscle concentric peak torque at 60, 180, and 300 deg/sec measured on a Cybex 340 dynamometer. Players were studied prospectively throughout the 1995 season. During that time, six players sustained clinically diagnosed hamstring muscle injuries that caused them to miss match-playing time. The injured hamstring muscles were all weaker than in the opposite leg in absolute values and hamstring-to-quadriceps muscle ratios. According to our *t* test results, hamstring muscle injury was significantly associated with a low hamstring-to-quadriceps muscle peak torque ratio at 60 deg/sec on the injured side and a low hamstring muscle side-to-side peak torque ratio at 60 deg/sec. Flexibility (as measured by the sit-and-reach test) did not correlate with injury. Discriminant-function analysis using the two significant ratio variables resulted in a canonical correlation with injury of 0.4594 and correctly classified legs into injury groups with 77.4% success. These results indicate that preseason isokinetic testing of professional Australian Rules footballers can identify players at risk of developing hamstring muscle strains.

Bengal S, Lowe J, Mann G, Finsterbush A, Matan Y. The role of the knee

brace in the prevention of anterior knee pain syndrome. ***Am J Sports Med.*** **1997;25:118–125.**

Our prospective study evaluates the use of a knee brace with a silicon patellar support ring as a method of preventing anterior knee pain from developing in young persons undergoing strenuous physical exercise. We studied 60 young athletes who qualified for a strenuous physical training course and who had not suffered from anterior knee pain previously. Twenty-seven subjects were in the brace group and 33 were in the nonbrace control group. The incidence of anterior knee pain syndrome increased with the intensity of exertion as the study progressed; i.e., subjects ran 6 km in the 1st week, gradually increasing each week up to 42 km/week at the 8th week. Yet, there was a significant reduction in the incidence of the syndrome at the end of the study in male athletes who had applied the braces before exercise sessions and in the brace group as a whole, compared with the control group. Prophylactic use of the brace, as described, did not reduce the ability of the athletes who wore braces to improve their physical fitness parameters in response to exercise. These data indicate that the use of a brace may be an effective way to prevent the development of anterior knee pain syndromes in persons participating in strenuous and intensive physical exercise.

Lephart SM, Pincivero DM, Giraldo JL, Fu FH. The role of proprioception in the management and rehabilitation of athletic injuries. ***Am J Sports Med.*** **1997;25:130–137.**

Rehabilitation continues to evolve with the increased emphasis on patient management and proprioceptive training. Proprioception can be defined as a specialized variation of the sensory modality of touch that encompasses the sensation of joint movement (kinesthesia) and joint position (joint position sense). Numerous investigators have observed that afferent feedback to the brain and spinal pathways is mediated by skin, articular, and muscle mechanoreceptors. Examining the effects of ligamentous injury, surgical intervention, and proprioceptively mediated activities in the rehabilitation program provides an understanding of the complexity of this system responsible for motor control. It appears that this neuromuscular feedback mechanism becomes interrupted with injury and abnormalities and approaches restoration after surgical intervention and rehabilitation. Rehabilitation programs should be designed to include a proprioceptive component that addresses the following three levels of motor control: spinal reflexes, cognitive programming, and brainstem activity. Such a program is highly recommended to promote dynamic joint and functional stability. Thus far, current knowledge regarding the basic science and clinical application of proprioception has led the profession of sports medicine one step closer to its ultimate goal of restoring function.

Hodges PW, Richardson CA. Contraction of the abdominal muscles associated with movement of the lower limb. ***Phys Ther.*** **1997;77:132–144.**

Background and Purpose: Activity of the trunk muscles is essential for maintaining stability of the lumbar spine because of the unstable structure of that portion of the spine. A model involving evaluation of the response of the lumbar multifidus and abdominal muscles to leg movement was developed to evaluate this function. Subjects: To examine this function in healthy persons, nine male and six female subjects (mean age = 20.6 yr, SD = 2.3) with no history of low back pain were studied. Methods: Fine wire and surface electromyography electrodes were used to record the activity of selected trunk muscles and the prime movers for hip flexion, abduction, and extension during hip movements in each of those directions. Results: Trunk muscle activity occurring prior to activity of the prime mover of the limb was associated with hip movement in each direction. The transversus abdominis (TrA) muscle was invariably the first muscle that was active. Although reaction time for the TrA and oblique abdominal muscles was consistent across movement directions, reaction time for the rectus abdominis and multifidus muscles varied with the direction of limb movement. Conclusion and Discussion: Results suggest that the central nervous system deals with stabilization of the spine by contraction of the abdominal and multifidus muscles in anticipation of reactive forces produced by limb movement. The TrA and oblique abdominal muscles appear to contribute to a function not related to the direction of these forces.

Miller JP, Sedory D, Croce RV. Vastus medialis obliquus and vastus lateralis activity in patients with and without patellofemoral pain syndrome. ***J Sport Rehabil.*** **1997;6:1–10.**

The purpose of this study was to examine the efficacy of closed kinetic chain exercises in preferentially recruiting the oblique fibers of the vastus medialis obliquus (VMO). Fifteen athletically active females, 6 with patellofemoral pain syndrome (PFPS) and 9 without PFPS, performed two isometric and two dynamic closed kinetic chain exercises. The isometric exercises were a static lunge with 30° of knee flexion (SL@30°) and with 70° of knee flexion (SL@70°). The dynamic exercises were a step-up/step-down exercise (SUSD) and a modified wall slide (MWS). Selective recruitment of the VMO occurred during the MWS ($p < .05$) and the SUSD in the subjects without PFPS ($p < .05$). For the SL@70° ($p < .01$), the MWS ($p < .01$), and the SUSD ($p < .05$), subjects with PFPS had greater activity of the vastus lateralis (VL), resulting in a lower VMO:VL ratio for those exercises ($p < .05$). It was concluded that the closed kinetic chain exercises examined in this study do not preferentially recruit the VMO in individuals with PFPS. In addition, individuals with PFPS have a lower VMO:VL ratio during these exercises compared with individuals without PFPS.

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Beim G, Giraldo JL, Pincivero DM, Borror MJ, Fu FH. Abdominal strengthening exercises: a comparative EMG study. *J Sport Rehabil.* 1997; 6:11–20.

The purpose of this study was to compare electromyographic (EMG) activity of the abdominal muscles between the crunch exercise and five other popular abdominal exercises. Surface EMG recordings of four muscles (upper rectus, lower rectus, external oblique, and internal oblique) of the anterior abdominal wall were collected and analyzed on 20 healthy, male volunteers. EMG activity was recorded during execution of the abdominal crunch, the sit-up, and exercises performed with the Abflex machine, the AbRoller, the Nordic Track Ab Works, and the Nautilus crunch machine. The results indicate that the crunch exercise is comparable to the five other abdominal exercises with respect to muscle activation of the internal and external abdominal oblique muscles. Activation of the upper rectus abdominal muscles appears to be best achieved with the Abflex machine, whereas the crunch exercise is superior to the sit-up for activation of the upper and lower rectus abdominal muscles.

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McKnight CM, Armstrong CW. The role of ankle strength in functional ankle instability. *J Sport Rehabil.* 1997;6:21–29.

The purpose of this study was to determine whether there were any differences in ankle range of motion, strength, or work between persons with normal ankles (Normal, $n = 14$), those with functional ankle instability (FAI, $n = 15$), and those with a history of FAI who have been through formal proprioceptive rehabilitation (Rehab, $n = 14$). A second purpose was to determine normative values for ankle strength and work measurements using the Biodex isokinetic system. There were no significant differences between groups for ankle range of motion or for any strength or work measurements. The overall strength/work averages were 11.75/3.42 for plantar flexion, 3.39/1.48 for dorsiflexion, 3.10/2.40 for inversion, and 2.62/1.79 for eversion. Dorsiflexion torque overall was 31.43% of plantar flexion, and the evertors produced 75.42% of the torque produced by the inverters. It is recommended that clinicians continue to rehabilitate ankles with strength and proprioceptive exercises but not rely on ankle strength/work testing as the only criteria for determining an athlete's readiness to return to full activity.

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Klucinec B, Denegar C, Mahmood R. The transducer pressure variable: its influence on acoustic energy transmission. *J Sport Rehabil.* 1997;6:47–53.

During the administration of therapeutic ultrasound, the amount of pressure at the sound head-tissue interface may affect the physiologic response to, and the outcome of, treatment. Speed of sonification; size of the treatment area; frequency, intensity, and type of wave; and coupling media are important parameters in providing the patient with an appropriate ultrasound treatment. Pressure variations affect ultrasound transmissivity, yet pressure differences have been virtually unexplored. The purpose of this study was to assess the effects of sound head pressure on acoustic transmissivity. Three trials were conducted whereby pig tissue was subjected to increased sound head pressures using manufactured weights. The weights were added in 100-g increments, starting with 200 g and finishing with 1,400 g. Increased pressure on the transmitting transducer did affect acoustic transmissivity; acoustic energy transmission was increased from 200 g (0.44 lb) up to and optimally at 600 g (1.32 lb). However, there was decreased transmissivity from 700 to 1,400 g (1.54 to 3.00 lb).

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Webborn ADJ, Carbon RJ, Miller BP. Injury rehabilitation programs: "What are we talking about?" *J Sport Rehabil.* 1997;6:54–61.

The concept that exercise therapy is an important and integral part of rehabilitation following injury seems to be universally accepted. However, there is little information on athletes' perceptions of understanding their instructions as they relate to the rehabilitation program. A questionnaire study, involving athletes attending a number of multidisciplinary sports injury clinics over a 6-month period, was performed to examine their understanding of the rehabilitation program relating to site, frequency, and repetitions of exercises, as well as reason for exercise. Although exercise prescription for injury was assumed to be commonplace, over 150 consultations were observed and only 22 athletes were prescribed rehabilitation exercises (a total of 56 exercises). Seventy-eight percent of these athletes misunderstood some aspect of their programs, although they did not perceive a problem with their instructions. Written instructions were used infrequently (14%), but, when used, they significantly improved the athletes' understanding. Since rehabilitation adherence is a problem, athletes should receive adequate explanation and written instructions to ensure that the program is followed correctly. Factors affecting treatment adherence are also discussed.

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Fabrizio PA, Schmidt JA, Clemente FR, Lankiewicz LA, Levine ZA. Acute effects of therapeutic ultrasound delivered at varying parameters on the blood flow velocity in a muscular distribution artery. *J Orthop Sports Phys Ther.* 1996;24:294–302.

Therapeutic modalities that alter hemodynamic parameters may have a dramatic impact on the viability of living tissues. The purpose of the current study was to investigate the response of blood flow velocity to various treatment parameters of therapeutic ultrasound. Twenty healthy volunteers attended six randomly selected, 15-minute treatment sessions of the following parameters: Tx-1 = 1.0 MHz at 1.5 W/cm^2, Tx-2 = 1.0 MHz at 1.0 W/cm^2; Tx-3 = 3.0 MHz at 1.2 W/cm^2; Tx-4 = 3.0 MHz at 1.0 W/cm^2, Tx-5 = sham; and Tx-6 = control. Ultrasound was applied to a circular area over the triceps surae muscle mass. Blood flow velocity in the popliteal artery was assessed after 5, 10, and 15 minutes of ultrasound and at two post-treatment intervals via a dual-frequency, bidirectional ultrasound Doppler. A two-factor analysis of variance (ANOVA) ($p \leq .05$) with repeated measures for treatment and time was performed on the data. Groups Tx-1 and Tx-2 showed significant increases in blood flow velocity when compared with the control and all other groups. The sham group showed significant increases in blood flow velocity when compared with the control group. Groups Tx-3 and Tx-4 showed no significant change when compared with the sham condition. The results of the current study indicate that 1.0 MHz ultrasound delivered at 1.0 and 1.5 W/cm^2 to the triceps surae musculature as described in our study can increase the blood flow velocity in the popliteal artery.

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Tyler T, Zook L, Brittis D, Gleim G. A new pelvic tilt detection device: roentgenographic validation and application to assessment of hip motion in professional ice hockey players. *J Orthop Sports Phys Ther.* 1996;24:303–308.

Professional ice hockey players often sustain hip and low-back strains. We hypothesized that playing the sport of ice hockey may result in the shortening of the iliopsoas muscles, increasing the likelihood of lumbosacral strains and hip injuries. The purpose of this study was to identify whether ice hockey players demonstrate a decrease in hip extension range of motion when compared with age-matched controls. Objective data were obtained using the Thomas test with an electrical circuit device to determine pelvic tilt motion. The device was validated by obtaining x-rays in six subjects during the Thomas test. The study then examined 25 professional hockey players and 25 age-matched controls. A two-way analysis of variance (ANOVA) was applied for statistical analysis to examine the effect of sport and side. The results demonstrated that ice hockey players have a reduced mean hip extension range of motion ($p < .0001$) by comparison with age-matched controls. There was no difference between right and left sides, nor was there any interaction of the sport with the side of the body. Therefore, hockey players demonstrated a decreased extensibility of the iliopsoas muscles. Future research may be directed toward establishing a link between prophylactic stretching and injury rate in professional ice hockey players.

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Ellenbecker TS, Roetert EP, Piorkowski PA, Schulz DA. Glenohumeral joint internal and external rotation range of motion in elite junior tennis players. *J Orthop Sports Phys Ther.* 1996;24:336–341.

Objective measurement of range of motion of the glenohumeral joint is important for the rehabilitation and prevention of shoulder injury. The primary purpose of this study was to determine whether significant differences exist between the dominant (tennis-playing) and nondominant extremity in active internal and external rotation range of motion in elite junior tennis players 11 to 17 years of age. Two hundred three elite junior tennis players (113 males, 90 females) were bilaterally measured for internal and external rotation at 90° of abduction in a supine position with a specific methodology attempting to isolate glenohumeral motion, while minimizing or negating scapulothoracic motion. A standard universal goniometer was utilized to measure active range of motion (AROM). Dependent *t* tests were used to compare differences between extremities. No significant difference was found for males or females between the dominant and nondominant arm in external rotation. Analysis of internal rotation (AROM) differences showed significantly less ($p < .001$) internal rotation (AROM) on the dominant arm for both males and females. Significantly less ($p < .001$) dominant arm total rotational range of motion was also found in both males and females. The loss of dominant arm internal rotation (AROM) has clinical application for both the development of rehabilitation and preventive flexibility/range of motion programs.

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Maffey-Ward L, Jull G, Wellington L. Toward a clinical test of lumbar spine kinesthesia. *J Orthop Sports Phys Ther.* 1996;24:354–358.

Poor lumbar spine kinesthetic awareness is often observed in low back pain patients and is usually evaluated qualitatively in the clinical situation. The purpose of this study was to investigate a simple, kinesthetic test for the lumbar spine. The experimental protocol utilized a 3Space Fastrak to determine the error, within and between days, of 10 healthy subjects in reproducing a neutral lumbopelvic (T10-S2) position following movement into flexion. The mean value of the repositioning error for the sagittal plane movement (flexion/extension) over the three repetitions within day 1 was 2.6 ± 1.2 inches and for day 2 was 2.6 ± 1.70 inches. No statistically significant difference existed between days. These repositioning errors were well within the ranges described by other authors for various asymptomatic joint complexes. These results provide a basis for further evaluation of this test on patients with low-back pain to investigate its ability to detect any kinesthetic deficit.

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Sullivan MS, Kues JM, Mayhew TP. Treatment categories for low back pain: a methodological approach. *J Orthop Sports Phys Ther.* 1996;24:359–364.

Studies that evaluate effectiveness of physical therapy can be problematic because frequently several treatment techniques are used during an episode of care. Methods that categorize treatment techniques into discrete categories may be useful in studying treatment outcomes. The purpose of this study was to describe a method to create treatment categories used for patients with low-back pain. We surveyed physical therapists in Virginia to identify frequently used treatments for patients with low-back pain. One hundred fifty-five surveys were completed. Twenty-eight treatments, used frequently or very frequently by 50% or more of the respondents, were retained for analysis. Factor analysis was used to identify treatment categories. Seven categories were identified: McKenzie approach, manual therapy, exercise with equipment, active and stretching exercise, physical agents, aerobic exercise and walking, and ergonomic activities. Indices for the categories were created. Confirmatory factor analyses should be performed on a different sample to validate these findings.

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Nyland JA, Shapiro R, Caborn DBM, Nitz A, Malone TR. The effect of quadriceps femoris, hamstring, and placebo eccentric fatigue on knee and ankle dynamics during crossover cutting. *J Orthop Sports Phys Ther.* 1997; 25:171–184.

This study attempted to determine the effect of eccentric quadriceps femoris, hamstring, and placebo fatigue on stance limb dynamics during the plant-and-cut phase of a crossover cut. Twenty female college students (task-trained) were tested. Hamstring fatigue resulted in decreased peak impact knee flexion moments ($p \leq .07$), increased internal tibial rotation at peak knee flexion ($p \leq .05$), and decreased peak ankle dorsiflexion ($p \leq .05$). Quadriceps fatigue resulted in increased peak ankle dorsiflexion moments ($p < .01$), decreased peak posterior braking forces ($p \leq .01$), decreased peak knee extension moments ($p \leq .01$), delayed peak knee flexion ($p \leq .01$), delayed peak propulsive forces ($p < .01$), and delayed subtalar peak inversion moments ($p \leq .05$). Fatigue of either muscle group produced earlier peak ankle plantar flexion moments ($p \leq .05$) and decreased peak propulsive knee flexion moments ($p \leq .05$). Variables requiring further study ($p \leq .1$) provide discussion data. Soleus, gastrocnemius, tibialis anterior, and deep posterior compartment calf muscles serve as dynamic impact force attenuators, compensating for fatigued proximal muscles.

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Klingman RE, Liaos SM, Hardin KM. The effect of subtalar joint posting on patellar glide position in subjects with excessive rearfoot pronation. *J Orthop Sports Phys Ther.* 1997;25:185–191.

It has been postulated that patellar position is influenced by subtalar joint mechanics. The purpose of this study was to compare the patellar alignment observed by radiographic analysis in subjects with excessive rearfoot pronation, both pre- and postplacement semirigid rearfoot posting. Sixteen asymptomatic patellofemoral joints were contributed from 12 female subjects (four bilaterally). The amount of subtalar joint posting each subject received was related to the amount of rearfoot pronation present. The subjects' patellofemoral joints were radiographed in full weight-bearing, tangential view, both pre- (resting calcaneal stance position) and post- (neutral calcaneal stance position) placement of the posting material. The paired *t* test revealed a statistically significant change in patellar positioning (medial glide) after placement of semirigid posting ($p \leq .05$). This finding has structural implications for utilization of orthotics in the treatment of patients with patellofemoral pain syndrome with requisite excessive rearfoot pronation.

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Book Reviews

Science of Flexibility
Michael J. Alter
Human Kinetics, Champaign, IL
1996
2nd edition
373 pages
ISBN: 0–87322-977–0
Price: $53.95

The text, *Science of Flexibility*, 2nd edition, was written to provide readers with an up-to-date survey of knowledge on flexibility. The book greatly surpasses the typical discourse one might find in other texts about this subject, discussing neurophysiological concepts related to flexibility and then concluding with a presentation of sample stretching exercises. In *Science of Flexibility*, Michael J. Alter takes into consideration these topics, in addition to presenting the reader with food for thought regarding relatively new issues that typically are not discussed alongside flexibility. For example, the subject of stretching (including mental, emotional, and social aspects) for special populations, including senior citizens, pregnant women, and people who are physically challenged, is investigated. Moreover, the appropriate title of the text fully implies the comprehensiveness and scientific approach of Alter's discourse.

The book consists of twenty chapters, all wonderfully illustrated with ample photographs, anatomical drawings, figures, and tables. Chapter 1 gives some excellent background information that even includes a historical overview of flexibility. Chapters 2 to 9 enlighten the reader with the many anatomical and physiologic concepts that relate either directly or indirectly to flexibility. For example, teaching or clinical professionals in any of the exercise/sport sciences, the health sciences, and biological sciences would find these chapters particularly useful as excellent resource and/or supplemental materials. Specifically, the discussion of muscle and neural physiology, how the different types of connective tissue can limit flexibility, the mechanical and dynamic properties of soft tissues, the etiology and consequences of muscular soreness, and the management of hypermobility are all superbly presented and tied in to the overriding theme of the *Science of Flexibility*.

The remaining chapters of the text discuss how these limiting factors can be modified to enhance joint range of motion, in addition to presenting a variety of techniques one can utilize to enhance flexibility throughout the body. The uniqueness at this point in the text is that the anatomy and flexibility of the lower extremity and pelvic girdle, the anatomy and flexibility of the vertebral column, and the anatomy and flexibility of the upper extremity are presented in separate chapters, all supported with excellent illustrations. Furthermore, a visual demonstration of actual stretching exercises (60 to be exact) is given in the form of a pseudo-appendix section at the back of the text.

The *Science of Flexibility* is a superb reference for athletic trainers, exercise scientists, physical therapists, health and fitness professionals, and other interested parties. Even though I do not see this as a stand-alone text for a course, I do envision this text's having tremendous utility in athletic training, physical therapy, exercise sciences, and anatomy and physiology curricula. Most likely, the text would better serve the upper-division undergraduate or graduate student enrolled in one or more of the following courses: athletic injury assessment, therapeutic rehabilitation/exercise, anatomy, physiology, exercise prescription, biomechanics, or any of the other exercise science courses.

Finally, this book is a must-read for extremely serious and well-versed athletic trainers, physical therapists, exercise scientists, and health and fitness professionals. This text is not recommended for individuals without previous educational training in anatomy and physiology.

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Ethical Decisions in Sport: Interscholastic, Intercollegiate, Olympic, and Professional
Edward J. Shea, PhD
Charles C. Thomas, Springfield, IL
1996
223 pages
ISBN: 0–398-06599–3
Price: $39.95 cloth, $24.95 paper

Ethical Decisions in Sport: Interscholastic, Intercollegiate, Olympic, and Professional presents the author's views on the moral and ethical aspects of competitive sports and a specific method for determining appropriate action when dealing with the ethical dilemmas of competitive sports. The author's presentation of a decision-making model for identifying appropriate action when dealing with ethical or unethical conduct in competitive sports is the distinguishing characteristic of the book and a unique feature of the text. The author emphasizes that the decision-making model presented is applicable to the four major categories of competitive sports (interscholastic, intercollegiate, Olympic, and professional).

The author presents a contemporary view of competitive sports, suggesting that the primary focus of many sports participants is associated with the desire for financial gain rather than personal satisfaction. The author discusses the significance of this cultural change to human behavior in sports competition and expresses the need for a method or model for ethical judgment. A substantial number of ethical incidents taken from the news media, educational journals, and published reports of athletic and educational associations are included throughout the book and at the end of each chapter. The text is amply supplemented with action photos that demonstrate ethical or unethical actions of players, coaches, officials, and fans. The ethical incidents and photo illustrations are an important contribution to the text.

The book is a valuable addition to the literature for all persons involved in sports at all levels. Undergraduate and graduate students enrolled in sports-related educational programs should be encouraged to include the book as a part of their supplemental reading assignments. The fact that the book is available in both cloth and paper is an asset, making it more accessible and affordable to all potential readers.

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Therapeutic Exercise: Foundations and Techniques
Carolyn Kisner and Lynn Allen Colby
F. A. Davis Company, Philadelphia, PA
1996
3rd edition
761 pages
ISBN: 0-8036-0038-0
Price: $46.95

Based on recent advances in rehabilitation, this book was written with the intent to expand and update current therapeutic exercise theory and technique from the second edition of *Therapeutic Exercise: Foundations and Techniques*. The authors have recognized the rapid changes in rehabilitation in the past few years and have systematically incorporated these trends into their latest edition. This text still, however, maintains the same basic structure of previous editions, with greater organization and presentation of contemporary rehabilitation theory.

The layout of the book consists of three parts. Part I (chapters 1 to 6) essentially presents the necessary theory and model for each domain of therapeutic exercise, with fantastic illustrations of each technique and its relevant areas of the body. Each chapter ends with a plethora of current, pertinent references that enable the reader to become familiar with the research performed in each domain. Part II (chapters 7 to 16) of this text begins with the principles of treating soft-tissue injury (chapter 7). Within this chapter, the inflammatory process is examined along with the stages of tissue healing. The rest of these chapters address each region of the body, including specific pathologies that may result, along with the appropriate management plan. Part III (chapters 17 to 21) of the book presents some special areas of therapeutic exercise as they apply to unique populations.

Immediate differences in the latest edition of this text are readily visible in the first chapter, where the authors stress the importance of documenting functional limitation, disability, or handicap during the patient evaluation. The authors have moved the chapter on aerobic exercise from part III to part I of the text, signifying the importance of cardiovascular conditioning to overall functional capacity and the general rehabilitation framework. Perhaps the most significant contribution of material added to this book reflects one of the more popular topics in rehabilitation, functional exercise. The authors have expanded on the concepts of open- and closed-chain exercise, plyometrics, and stabilization training as they relate to functional activity. In part II of the book ("Application of Therapeutic Exercise Techniques to Regions of the Body") each chapter has been reorganized such that it begins with reviews of the structural and functional anatomy of each region, followed by discussion of common pathologies and their respective conservative and postoperative management guidelines. Furthermore, each of these chapters presents an abundance of well-illustrated exercise techniques, with progressions that can be used in a goal-oriented therapeutic exercise plan. Finally, the chapters devoted to the spine have been restructured into three chapters. The first of these chapters (chapter 14) presents the structural and functional anatomy of the spine, followed by guidelines for treating acute symptoms and various acute soft-tissue pathologies along with their respective exercise regimens. The second chapter (chapter 15) discusses conditions, postural problems, and treatment of the spine as they relate to the subacute and chronic stages of healing. The last chapter devoted to the spine (chapter 16) presents a thorough overview of the effects, indications, limitations, contraindications, and necessary precautions of traction techniques in treating spinal injury.

This well-designed, comprehensive text has been prepared for any student, on any level, pursuing a career in the allied health professions where the knowledge of therapeutic exercise is necessary. This text continues to provide useful and up-to-date material concerning advances in therapeutic exercise theory and application. What differentiates this book from others is its approach in presenting the necessary information from which any therapeutic exercise plan can be formulated. I highly recommend the use of this book as a complete reference source for the practicing clinician as well as a foundation text for an aspiring allied health professions student.

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Treat Your Own Strains, Sprains, and Bruises
R. Lindsay, G. Watson, D. Hickmott, A. Broadfoot, and L. Bruynel
Spinal Publications, LTD; distributed by Orthopedic Physical Therapy Products, Minneapolis, MN
1994
153 pages
ISBN: 0959-804943
Price: $15.95

This text, as its name states, is intended as a home self-treatment text for the layperson. The text is divided into separate sections on the soft tissues of the body, types of injuries, basic treatment principles, and types of pain. There are also separate sections on injuries by region of the body, such as ankle injuries and elbow injuries. The information is presented in a straightforward manner, using comprehensive treatment approaches.

The text may be appropriate as a supplement for the beginning athletic training student but would not be appropriate for the advanced student or the certified athletic trainer due to its format. The text is well illustrated throughout, and the photographs used are clear and are presented in the appropriate sections. This text seeks to fill a niche in the publishing market for self-treatment, similar to those texts published by McKenzie, Saunders, and others on the spine. It does this job well but presents the danger of providing patients or athletes with just enough education to be dangerous to themselves. The authors have attempted to prevent this by providing sections entitled "Serious Injury" with each body region. These sections describe signs and symptoms that would require further medical attention by health care professionals.

Overall, the text is well written for the purpose it seeks to serve. However, I do not feel the text, due to its format, adds much to the field of athletic training, except possibly as an introductory resource for the beginning student.

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Biochemistry Primer for Exercise Science
Michael E. Houston
Human Kinetics, Champaign, IL
1995
136 pages
ISBN:0-87322-577-5
Price: $22.00, paperback

The preface of this text describes the changing curricula of numerous groups, pointing toward the inclusion of a basic biochemistry course in those offerings. This text is focused on the biochemistry of humans related to physical activity and nutrition. The author, believing that the majority of biochemistry texts do not address humans and exercise in a very usable fashion, has developed this text to fill the void.

The text is divided into three sections. Part one consists of three chapters involving what the author calls the "major players." Proteins, amino acids, peptides, enzymes, DNA, and RNA are presented in a concise and understandable pattern. Each chapter has a brief summary that should be helpful for the student. Part two consists of two chapters related to basic molecular biology (transcription and protein synthesis). Part three is related to metabolism and includes eight chapters. These chapters would be among the most interesting for the clinician because they speak to the different forms of substrate utilization (phosphates, glucose, lipids, etc).

Although the writing is clear and concise, this topic is not one generally taught by a clinician. The usability of the text will depend on the ability of the instructor (very likely to be a biochemist) to use meaningful examples to better engage the learner because the text is rather chemistry focused. The author has kept true to his task; the text is an attempt to bridge the gaps between exercise physiology, biochemistry, and kinesiology. However, because the text is designed to be a part of the total process, its isolated use may be somewhat limited. Also, although the author states that a limited chemistry background is needed to use the text, a stronger chemistry background would probably enhance the appreciation and use of the text. Still, many readers would find the style very friendly and would enjoy particularly the chapter summaries.

As for consideration of this text for clinicians, most would probably prefer a stronger example-based approach; this text is somewhat "matter-of-fact based" and is therefore not as easily absorbed as the more traditional exercise physiology or kinesiology texts. Overall, the text will probably not be widely used in existing athletic training curricula and will probably be of limited use by clinicians. If the author wishes to see greater use of this text in athletic training curricula, the addition of clinical examples in each applicable chapter and an increased review of basic chemistry would be helpful for both students and clinicians.

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Travel Fitness
Rebecca Johnson and Bill Tulin
Human Kinetics, Champaign, IL
1995
200 pages
ISBN: 0-87322-655-0
Price: $14.95

I enjoyed *Travel Fitness* and think it has many useful tips for athletic trainers who work with athletes or patients who spend time traveling. The book is not complicated reading and has a format that is easy to follow.

As our profession continues to grow, I would consider this book a supplement to any athletic training curriculum or plan of work. The topic itself does not demand a dedicated course; rather it can be easily incorporated into a general athletic training course for students beyond the introductory level. Also, it could be used in an independent study setting for individual learning. The material is easily understood and is not scientifically complex.

Travel Fitness covers typical travel concerns, such as jet lag, sleep debt, and in-flight hydration, as well as many other areas. The authors strongly reiterate the need to maintain fitness and diet plans while traveling away from home. There are many points concerning exercise and diet that are easy to recall, such as an exercise regimen in a hotel room and how to avoid late-night snacking. Also the authors address issues, such as emotional stress, that are associated with being away from home.

Each of the eight chapters is set up in the same format. The information flows easily throughout the text. The authors also utilize "expert" testimonials throughout each chapter, which gives a sense of practical application to the theory that is presented. At the conclusion of each chapter there is a checklist that summarizes the chapter's primary points. Illustrations and tables supplement the text quite well. An example of this is the basic in-room exercise workout that is sketched out.

Travel Fitness is reasonably priced and easy to comprehend. It is a minimal investment of resources and time. It would be a good resource for athletic trainers who work with traveling athletes and for clinicians whose clients are business travelers rather than competitive athletes.

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Athletic Taping and Bracing
David Perrin, PhD, ATC
Human Kinetics, Champaign, IL
1995
120 pages
ISBN: 0-87322-502-3
Price: $25.00

The author's purpose in writing this text was to provide a guide for teaching the art of athletic taping and bracing to athletic training students. Correctly stated by the author, this is an arduous task that requires the synthesis of anatomical principles and taping and bracing techniques. Herein is the major strength of the text and the contribution of the author to athletic training pedagogy: a text that amalgamates the essence of the constituent components of athletic taping and bracing in a concise and highly informative manner.

The illustrations within the text are outstanding and in many ways are the pinnacle of the text. The anatomical illustrations (eg, bone, ligament, and muscle) are to the level expected in human anatomy and physiology texts. The taping illustrations have been painstakingly created with clarity of progressive sequencing. The illustrations are presented with a high level of detail, are clearly identified, and are appropriately accompanied with straightforward written descriptions. The manner in which the illustrations are presented and the quality of presentation allow for direct referencing in the classroom setting, facilitating the teaching and learning process.

The text is well organized and, although not exhaustive in breadth and depth of athletic taping techniques, includes the essence of what can be considered the foundation of this important facet of athletic training. The introductory sections of the text provide for a thorough understanding of the background information that is needed to effectively learn the art of athletic taping. The athletic taping and bracing techniques for each major joint and body region are presented in separate chapters, allowing for organization of information.

The shortcoming of the text is that it is too inclusive with regard to bracing and rehabilitative exercise. Although the author's argument for inclusion of these two topics in a text on athletic injury prophylaxis is defensible, the outcome does not result in the same level of advancement in information and knowledge as is accomplished with the aforementioned sections. The current plethora of type, application, and clinical and functional efficacies of bracing warrants expansion in the appropriate format to be informative to the level needed to advance clinical knowledge and practice. The exercise information in the text, albeit correctly stated as being an important component in injury prevention and rehabilitation, is limited to basic exercises and principles, resulting in limited application in clinical practice.

The text is highly recommended for any student who is in an athletic training taping course. It is unparalleled in quality of illustrations and written descriptions and sets a new standard by which future texts on athletic taping and bracing will be judged.

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Neuromechanical Basis of Kinesiology
Roger M. Enoka
Human Kinetics, Champaign, IL
1994
466 pages
ISBN: 0-87322-665-8
Price: $52.00

Neuromechanical Basis of Kinesiology is probably one of the most extensive texts on human movement available. As its name suggests, this text integrates the physiological and mechanical aspects of movement with an emphasis on the neurological component. The text is divided into three separate sections. The first focuses on the force-motion relationship and contains material found in the typical biomechanics text. It describes how motion is described (kinematics) as well as how motion is produced (kinetics). Included in this section are specific discussions of gait and throwing. This section also describes techniques, such as dynamic analysis and inverse dynamics analysis, used by biomechanists to study movement. The second section discusses the single joint system. The content of this section includes anatomy of the bone, synovial joint, muscle, nerve, and sensory receptors. Additionally, it includes the physiology of membranes, the motor unit, excitation-contraction coupling, and sensory feedback. It concludes by discussing the neural and muscular factors that are responsible for producing movement. The third section of the book is the most clinically applicable to the athletic trainer. Its initial focus is on the overall motor system, with specific discussion of movement strategies and systems organization. This is followed by chapters on acute and chronic adaptations of the neuromuscular system. These last two chapters cover the benefits of warm-up, stretching, and strength training. They also cover muscle fatigue, muscle soreness and injury, and muscle potentiation. Finally, adaptations to reduced use, recovery from muscle and nerve injury, and adaptations with age are discussed.

In general this text manages to fill a niche in the kinesiology literature that has largely been ignored. Most texts in the kinesiology/exercise science discipline have focused solely on the mechanical, physiologic, or motor basis of movement. This text focuses on the integration between skeletal mechanics and neuromuscular physiology. Based on the content of the text and the author's extensive use of examples from the research literature, this text is best suited for an upper-level undergraduate or an introductory graduate level course in kinesiology. Due to the breadth of the text, it is best suited as a primary text that can be easily supplemented with original research articles.

This text has many strengths and few weaknesses. One of the strengths of this text is its use of extensive references to the scientific literature. The author has made it very easy for the reader to find the original materials. The author also has borrowed many illustrations from original research papers. This makes it easier to understand the connections between the concepts and the research. A strength for the student and educator is a set of questions and problems at the end of each chapter. The answers for the odd questions are provided in the back of the text. One of the weaknesses of the text is inadequate illustration captions. Frequently, there is not enough description in the captions to understand the basic elements of the illustration. Thus, the reader is forced to shift between the text description and the figure to obtain a basic understanding of the illustration.

For the athletic trainer, this book initially appears to have no direct clinical value. However, the critical reader will recognize that much of the material provides the scientific foundation for the rehabilitation of musculoskeletal injuries. Thus, for the clinician this text is an excellent reference, and for the athletic training educator it is an excellent supplement to clinical courses. Based on the cost and the amount of information provided on a variety of topics, this text is a good value for the student, clinician, and educator.

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Strength Training for Women
James A. Peterson, Cedric X. Bryant, and Susan L. Peterson
Human Kinetics, Champaign, IL
1995
155 pages
ISBN: 0–87322-752–2
Price: $15.95

Strength Training for Women is a well-written and organized text, produced by very knowledgeable persons within the field of strength training. All the authors have worked at the US Military Academy (West Point) and are now employed in the corporate world. This book is designed for the individual woman interested in starting or improving a training program. Both the novice and the elite athlete can find informative programs within. This work would also be a great addition to the library of anyone who is involved in the training and conditioning of women.

The design of the text is excellent. It is readable, with very little jargon associated with weight lifting. It is based upon sound, proven principles. Part I emphasizes why muscle strength and endurance are important. It addresses many of the concerns women have about strength training and dispels the myths that surround the activity. Part II shows one how to design a training program that is specific for each individual and that maximizes both efficiency and safety. Part III provides information on all types of equipment with which to work and places at which to train. It helps readers decide what is best for their individual needs. The illustrations complement the exceptionally clear descriptions of the specific exercises. There is little chance of misinterpreting what is being described. The format of the book is understandable for the reader—from why one should strength train, through the rationale behind different methods, to how to set up one's own program.

A note of interest: on page 24 there is an error. The sentence reads, "The exception is your quadriceps and hamstrings, which should be 3:2 (your quadriceps should be about 150% stronger than your hamstrings)." It should read ". . . the strength of your quadriceps should be about 150% of the strength of your hamstrings. . ." or ". . . your quadriceps should be about 50% stronger than your hamstrings."

This book is a must for any woman wanting to start or improve a weight training program. Its price is not prohibitive and is definitely less than a membership in a health club. Enjoy reading about how to improve your life.

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Video Reviews

NFL Players Head Concussion Brain Injury Seminar

Hosted by Leigh Steinberg and the Brain Injury Association, Inc

Live-Performance Productions, Orange, CA

1995

120 minutes (two videotapes)

UPC: 794950950224

Price: $99.95

This live production of a seminar hosted by Leigh Steinberg and the Brain Injury Association, Inc included presentations by several renowned experts in the area of concussion and brain injury. The speakers, all physicians or neuropsychologists, offered a comprehensive review of the anatomy, biomechanics, pathophysiology, and epidemiology associated with concussion. Much of the discussion centered around the lack of a consistent definition and grading scale for concussions. Two of the speakers discussed ongoing research projects, one involving neuropsychological assessment of professional football players and the other involving laboratory testing of football helmets.

The moderators stated at the outset that the purpose of the seminar was to bring together a group of experts to determine (1) what happens during a concussion, anatomically, (2) the long-term impact, (3) the involved risks, and (4) how to manage the risks. Additionally, they called for a set of specific recommendations for equipment changes, rule changes, and an accepted medical regimen that might help to improve the existing situation in professional football.

The participants succeeded in addressing some of the issues but clearly did not reach a consensus on many of the more controversial issues surrounding concussion in sport. The biomechanics and pathophysiology section was very informative and offered viewers a detailed and comprehensive anatomical description of concussion. An extensive overview of postconcussion syndrome and second-impact syndrome was presented. There was a lot of overlap on topics such as defining and grading concussion, associated signs and symptoms, and incidence of injury. Several of the speakers presented the inconsistencies and confusion surrounding grading of concussion, while others discussed the lack of return-to-play guidelines following concussion. Unfortunately, few recommendations were offered for the establishment of a more widely accepted medical regimen.

This was a good presentation with valuable material but not an effective video production of the presentation. Although the presentation was probably much more effective for the audience who attended the seminar, the visuals (slides) used by the speakers did not transmit very well on videotape. Therefore, many of the graphics that the speakers made reference to in their presentations were difficult to view on the video. Once viewers accept the poor quality of the production, they should find that much of its content is valuable. The material presented in the video would be most beneficial to clinicians and/or researchers who have specific interests in the pathophysiology of mild head injury. It could serve as a supplement for a graduate class studying mild head injury. While the medical research presented in the video is important, much of it is not clinically applicable to the average clinician. The information on neuropsychological assessment was interesting, but would have been more valuable to clinicians if the actual tests had been explained and demonstrated.

This video is timely because concussion in sport is a popular topic. The media's coverage of concussion in professional sports has forced the sports medicine community to take a stand on how concussions should be managed. Clinicians and researchers need to focus their attention on how to more accurately assess mild head-injured athletes so they can be safely returned to participation. The information presented in this video addresses some of these issues and should contribute to the body of knowledge on mild head injury. At the very least, it hopefully will lead to more clinically applicable research in the area.

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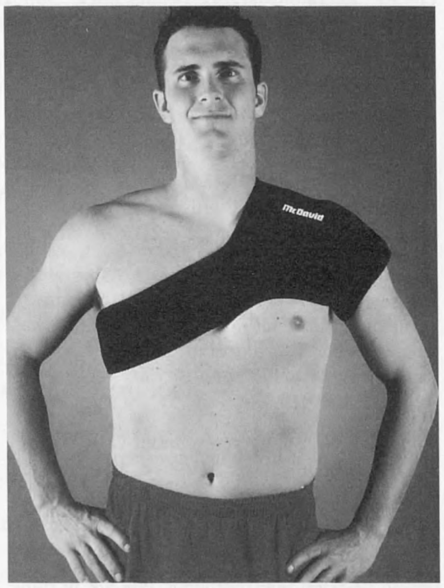
New Products

McDavid Hot and Cold Thermal Wrap Series

McDavid Sports Medical Products has introduced an expanded series of hot and cold thermal wraps for the ankle, knee, back, and shoulder. These thermal wraps offer a convenient application of hot or cold therapy to provide safe and effective treatment of injuries. Each thermal wrap comes with a gel pack that may be microwaved or frozen.

The products consist of a black neoprene wrap with VELCRO® closures and a terrycloth-lined pouch that firmly holds the hot/cold gel pack in place.



For more information call 1-800-237-8245.

Cold Therapy and Sequential Compression

Bio Compression Systems is pleased to introduce Coldflo. Coldflo is a new device that combines two modalities (cold therapy and sequential compression) into one easy-to-use system. Coldflo consists of three components: a compressor pump, a cold fluid reservoir, and an easy zip-on biocomfort sleeve appliance that provides sequential cold therapy to any extremity. Portable, versatile, and easy to operate, Coldflo is designed for private practice as well as clinical use.

For more information call 1-888-COLDFLO (1-888-265-3356).

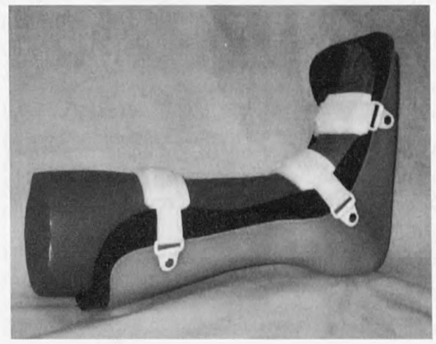
Combo Pads for Protection of Bruising

McDavid Sports Medical Products has introduced Combo Pads, hand-moldable pads used for protection of bruises. The pads are ideal for on-field use because they conform to the body without the use of heat and are held in place with a neoprene wrap. They are ideal for use on the shoulder, hip, thigh, and upper arm. Combo Pads are available in two sizes and with or without a neoprene wrap. The pads are constructed of more than half-inch thick, closed-cell foam in the shape of a donut with a rigid, moldable top layer covered with neoprene.

For more information call 1-800-237-8254.

Biodex Night Splint

Biodex Medical Systems has just released their new Night Splint, which has gained popularity in controlling plantar fasciitis pain. The foot plate of the Night Splint is set in 5° dorsiflexion. This fixed position eliminates stretching, muscle tightening, and contractures that occur while sleeping, greatly reducing pain. The splint features comfortable, padded straps to protect the leg and instep from pressure while ensuring that the foot sits in alignment with the splint.



For more information call 1-800-224-6339.

Garner Industries presents the Healthy Back System™

The Healthy Back System™ is a unique piece of patented therapeutic fitness equipment that combines key back therapies into a single, simultaneous system of exercises. Because the Healthy Back System systematically applies stretching, strengthening, and extension of the back, it is as convenient to use as it is comprehensive. It also delivers a relaxing massage to soothe muscles and ease stress. Using the Healthy Back System is easy and takes just a few minutes. You begin by sitting on the seat and reclining on adjustable foam rollers. They adjust three ways for greater comfort and to help focus the therapy where it is needed most. As you slowly push with your legs or pull with your arms, your back moves in a natural arching motion, delivering active exercise while the rollers massage in a smooth, gentle motion.

For more information call 1-888-311-BACK (1-888-311-2225).

Current Literature

Clint Thompson, MS, ATC

ANKLE

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(Revised February 1997)

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    1. Fischer DH, Jones RT. *Growing Old in America.* New York, NY: Oxford University Press Inc; 1977:210–216.
    2. Spencer JT, Brown QC. Immunology of influenza. In: Kilbourne ED, Gray JB, eds. *The Influenza Viruses and Influenza.* 3rd ed. Orlando, FL: Academic Press Inc; 1975:373–393.

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    1. Stone JA. Swiss ball rehabilitation exercises. Presented at the 47th Annual Meeting and Clinical Symposia of the National Athletic Trainers' Association; June 12, 1996; Orlando, FL.
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23. All black and white line art should be submitted in camera-ready form. Line art should be of good quality; should be clearly presented on white paper with black ink, sans serif typeface, and no box; and should be printed on a laser printer—no dot matrix. Figures that require reduction for publication must remain readable at their final size (either one column or two columns wide). Photographs should be glossy black and white prints. Do not use paper clips, write on photographs, or attach photographs to sheets of paper. On the reverse of each figure attach a write-on label with the figure number, name of the author, and an arrow indicating the top. (Note: Prepare the label before affixing it to the figure.) Authors should submit one original of each figure and five copies for review.
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Journal of Athletic Training CEU Quiz Has Moved to the NATA News

Beginning with the March 1997 issue (Volume 32, No. 1), the CEU quizzes for the *Journal of Athletic Training* moved to the *NATA News*. Please follow this schedule:

Articles in this issue of *Journal of Athletic Training*	**Quiz in this issue of *NATA News***
March (Vol. 32, No. 1)	**April 1997**
June (Vol. 32, No. 2)	**June 1997**
September (Vol. 32, No. 3)	**October 1997**
December (Vol. 32, No. 4)	**January 1998**

Details about the new procedures for the CEU quiz can be found on pages 35 to 37 of the April 1997 issue of the *NATA News*.

The CEU Quiz is also posted on NATA's Fax-On-Demand Service. To access Fax-On-Demand, just dial toll-free 1-888-ASK-NATA or 214-353-6130 from a touch-tone phone. Follow the automated instructions and ask for Document #112.

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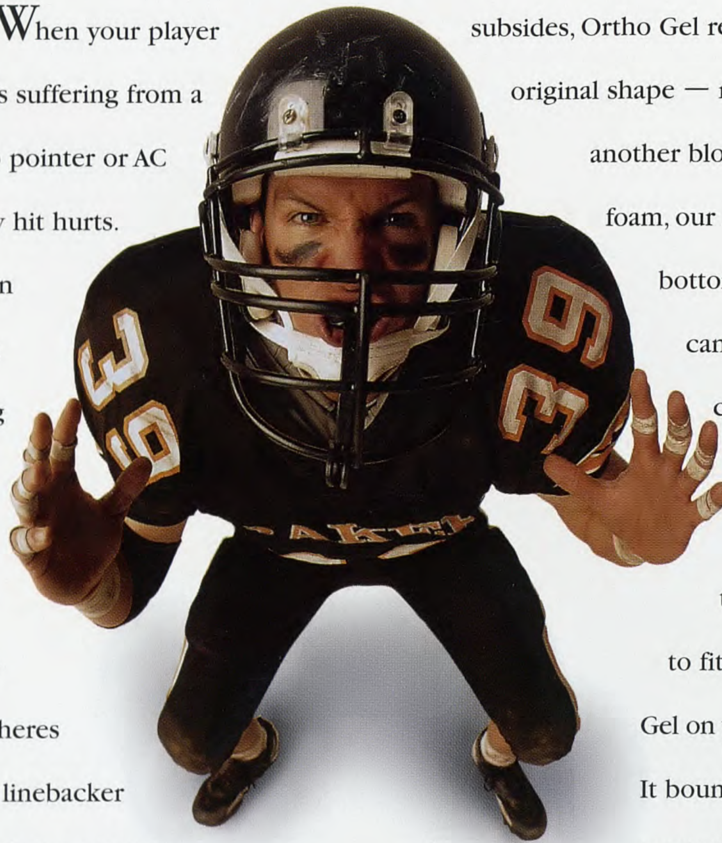

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