

# JOURNAL OF ATHLETIC TRAINING

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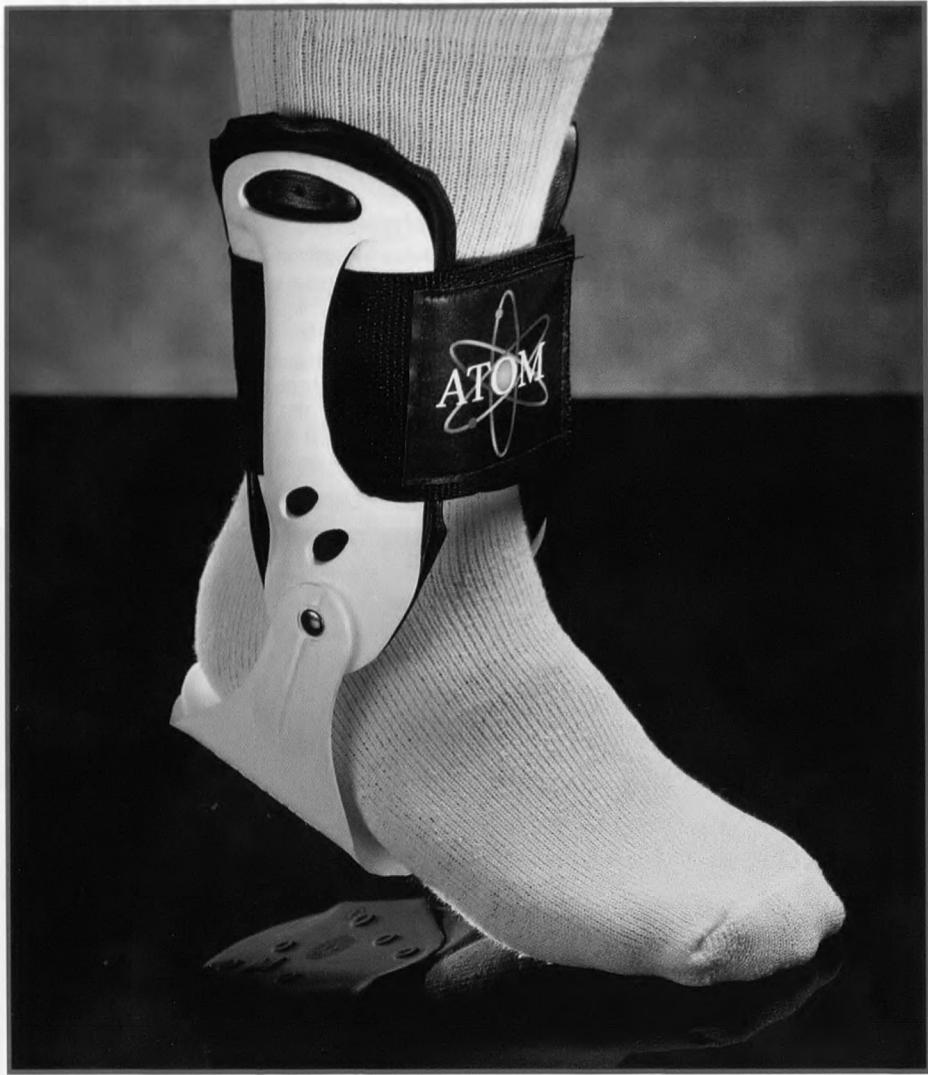
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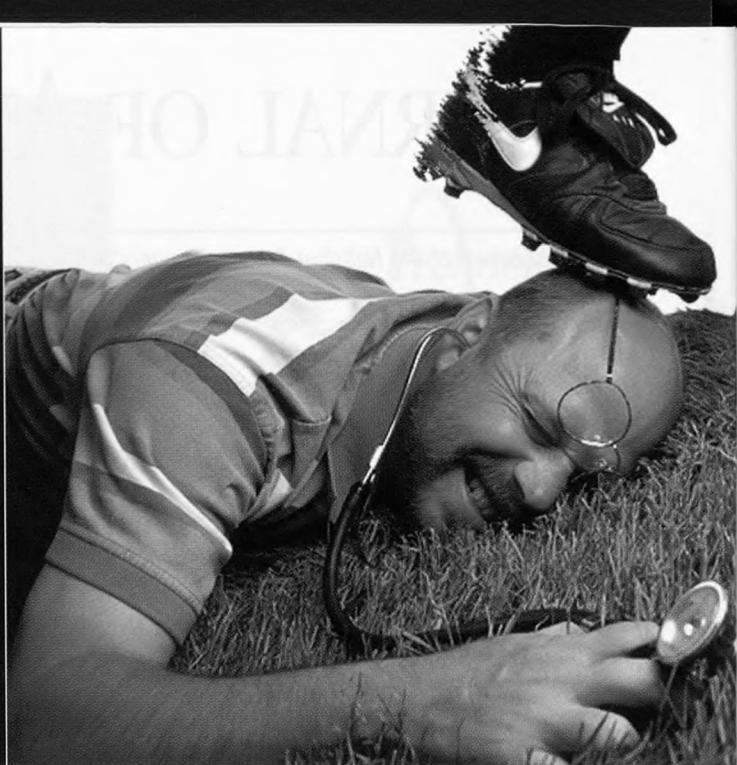
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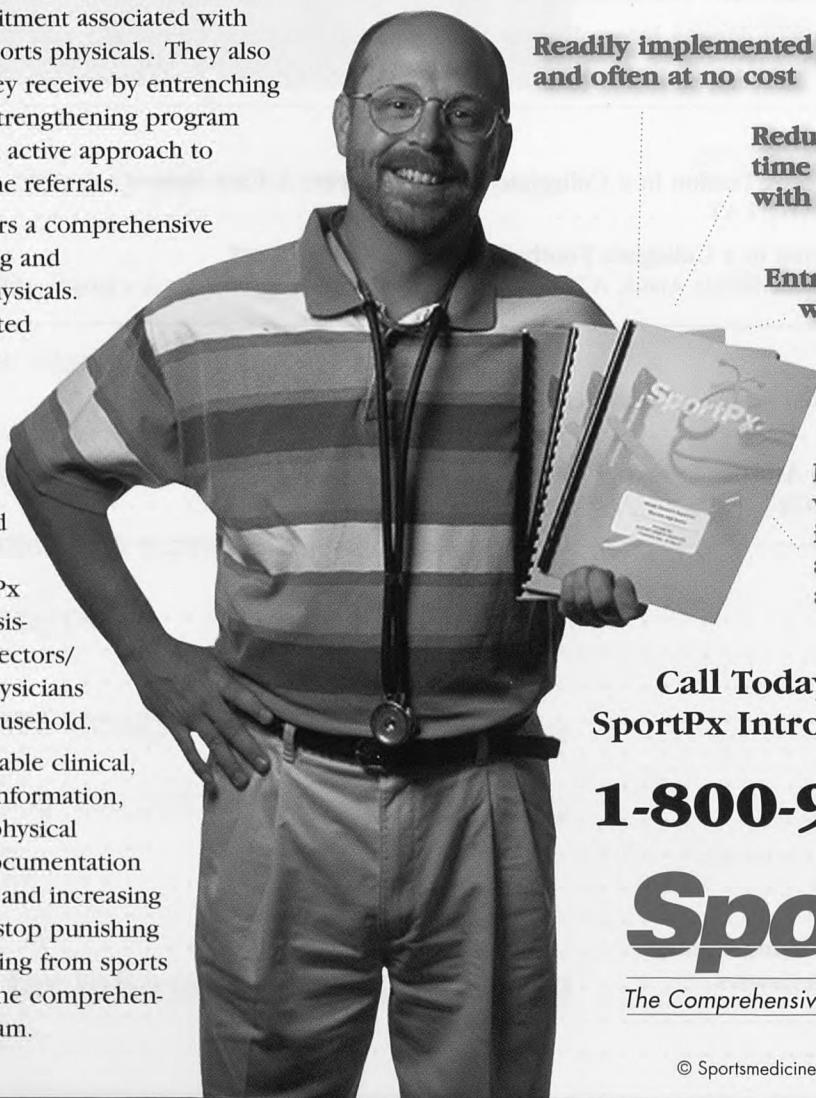


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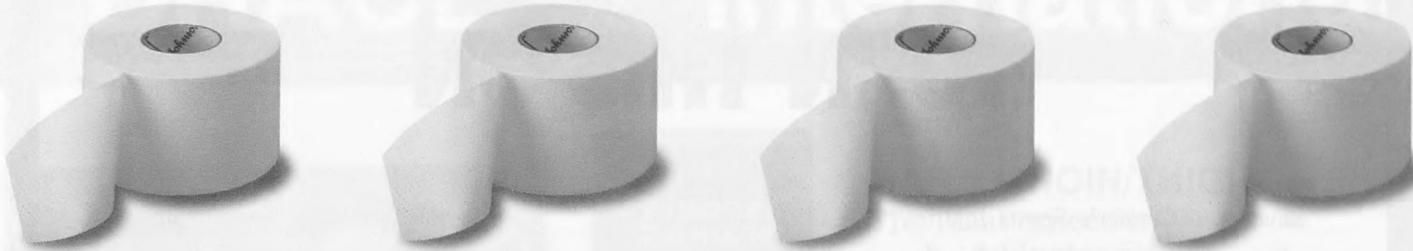
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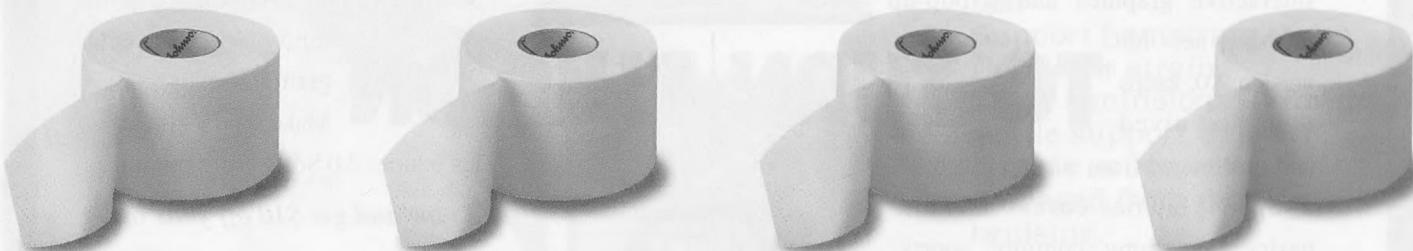
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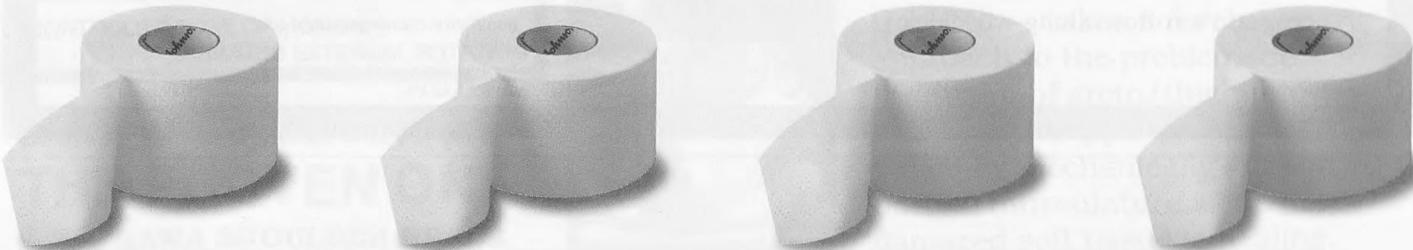
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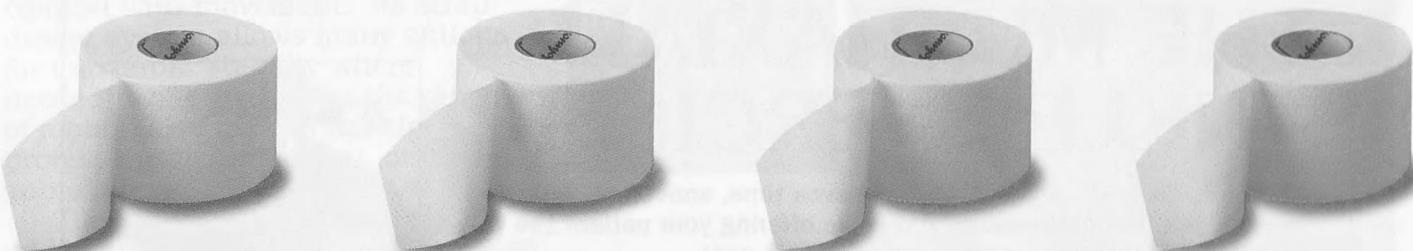
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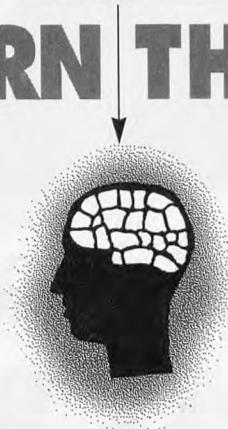
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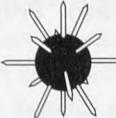
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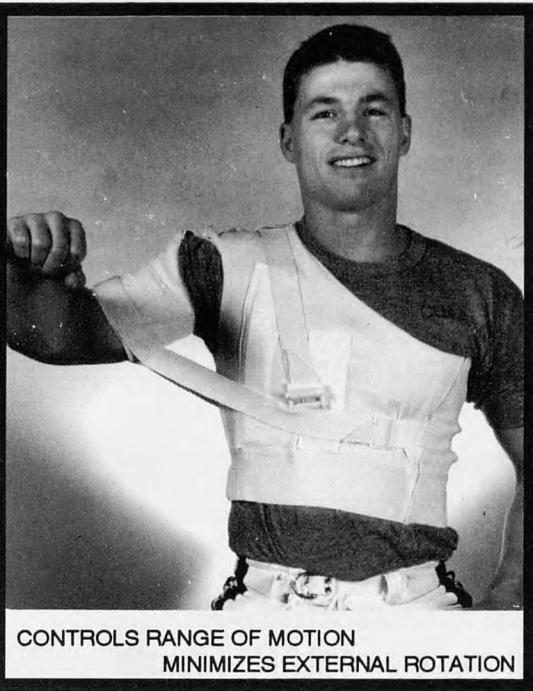
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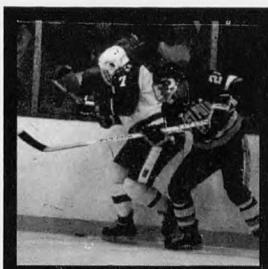
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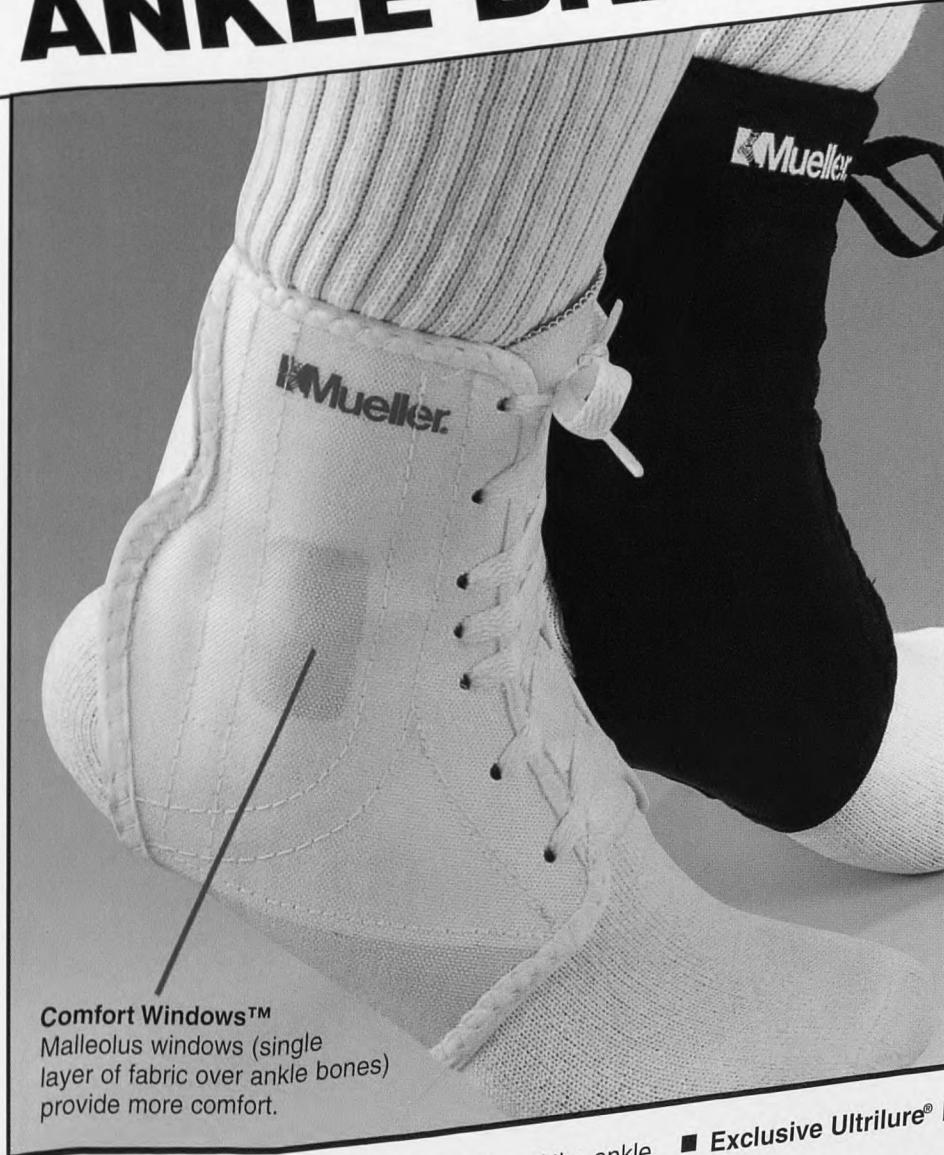
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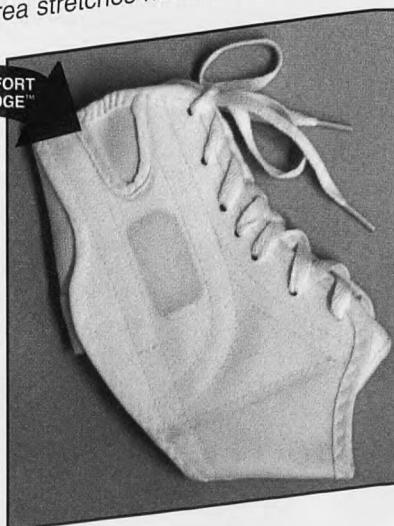
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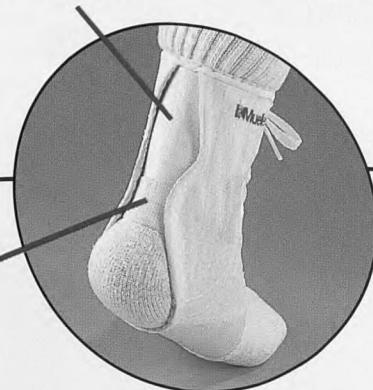
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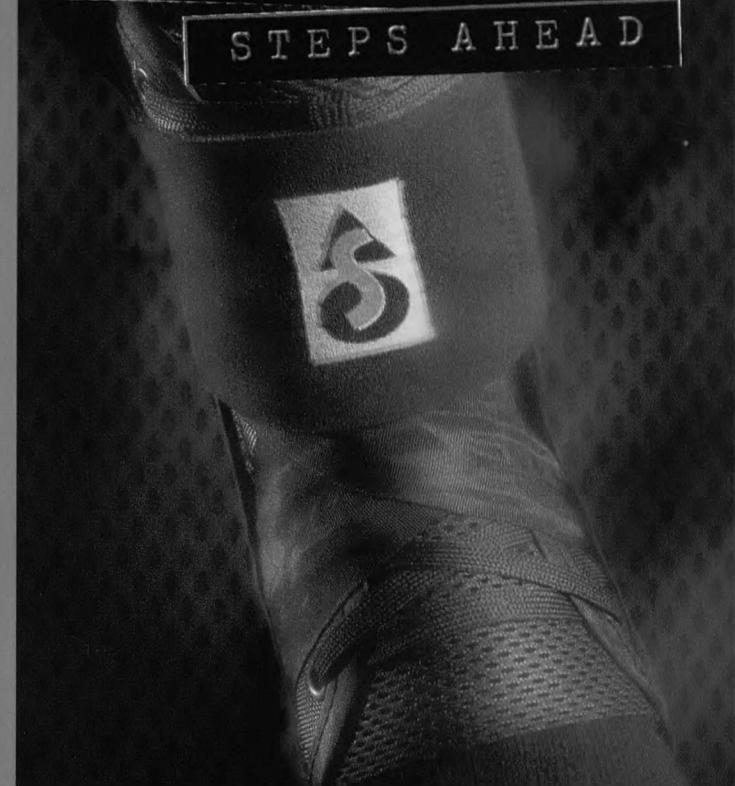
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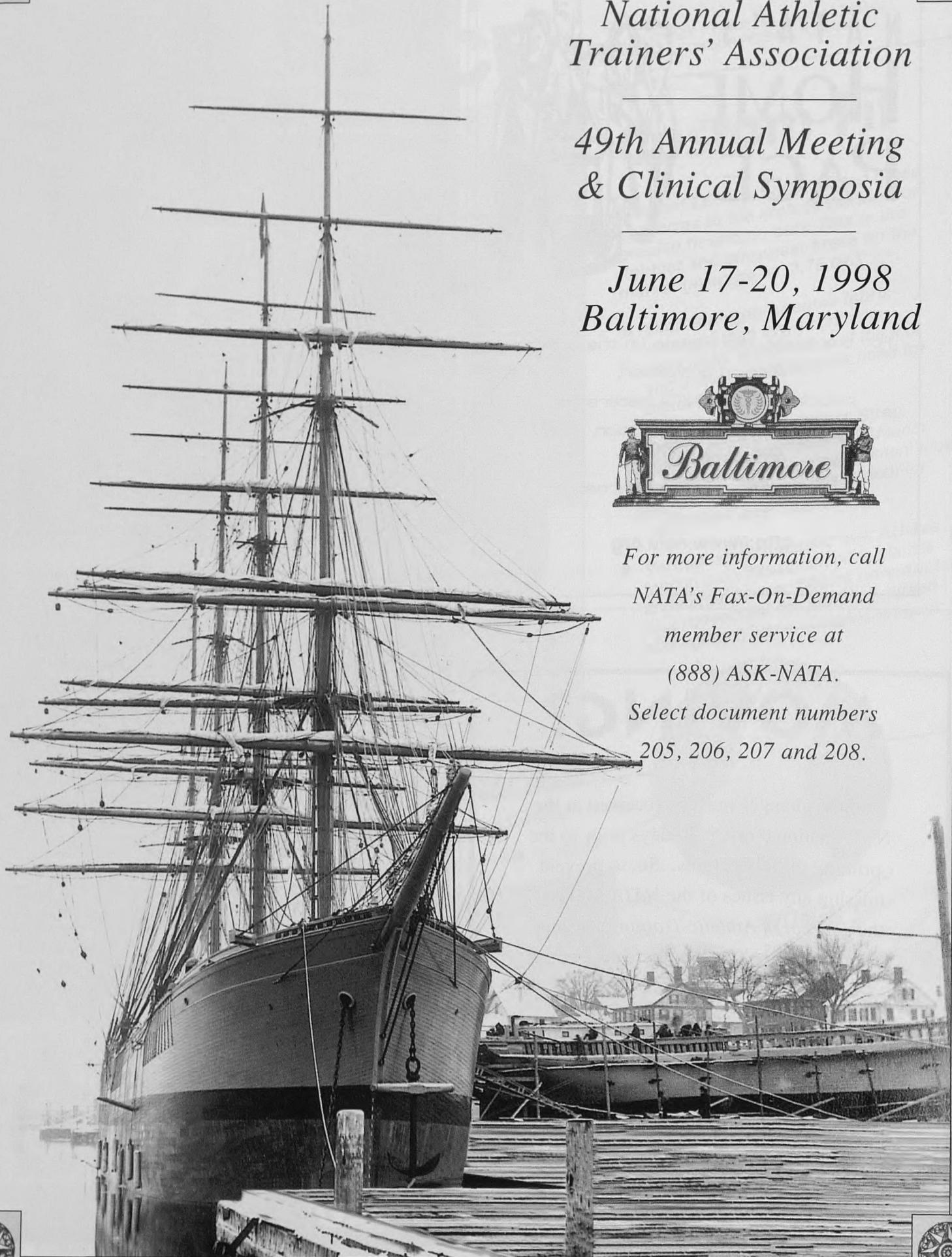
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# E ditorial

## Redefining Our Actions To Better Reflect Our Profession

**Peggy A. Hougum, MS, PT, ATC  
Associate Editor**

Athletic training has advanced to a medical profession and is now so recognized by the American Medical Association. As medical professionals, we certified athletic trainers should reassess what it is we actually do. This does not mean changing the skills, knowledge, and jobs we perform as much as it means changing the attitudes and beliefs we commonly hold, especially the outdated and potentially harmful ones.

Many certified athletic trainers continue to work long and hard more than 40 (and often more than 60) hours a week. Some of us offer our services for free to individuals and organizations, far beyond what is normal, prudent, or expected of other medical professionals. Extended hours at work, either in employment or other circumstances, are frequently at the sacrifice of our families, our own health, and our social lives. We continue to be asked to give this time, which is above and beyond the call of most medical professions, more because we haven't learned to say no than because we are really needed. As long as we say yes, we will be asked over and over again to put in that extra effort.

Volunteering time and effort is not necessarily bad, but it becomes so when we indiscriminately, to individuals, organizations, and events, give services and time 1) that are not professionally beneficial, 2) for which these clients would be able to hire other personnel, or 3) that these clients expect certified athletic trainers to provide because "that's the way it's always been done."

This indiscriminate volunteering is not only unfair to ourselves, our families, and our friends, but it is also unfair to our students, the future certified athletic trainers of the profession. By working long hours, we do our students a severe injustice on two fronts. One is by cutting them out of the job market. How many new jobs would become available if we all stopped working more than 55 hours a week? How many students now struggling to find jobs would be offered employment if we stopped feeling so insecure about our own positions and demanded a fair work week from our employers? How much less would curriculum program directors have to struggle to place their graduates if we pushed our administrators to find the extra money within their budgets to fund additional positions?

On the second front, we are doing our students a dreadful disservice by sending them a very strong subliminal message that, in order to be successful certified athletic trainers, they must work as many hours as we do. After all, isn't that what we learned from our mentors? And don't we measure how well we do our jobs, at least in part, by how willing we are to sacrifice time, family, and quality of life? We send a very strong, unspoken message to our students by being at work and putting in all that "unselfish" and "dedicated" effort each day. Our predecessors taught us these unwritten rules in an earlier time when situations were different, demands were fewer, and opportunities were less plentiful.

Situations are not the same as they were even 10 years ago. Today, rather than take the first position we see because it's in our field, regardless of what it has to offer, we should teach ourselves and our students to evaluate the position for its professional quality and for the quality of life it can offer. Some employers insult us with a salary that is far below the starting salary of other comparable medical professions, yet many certified athletic trainers are routinely willing to accept low salaries and long hours. Employers are eager to hire employees who acquiesce to low salaries. Other medical professionals, however, are unwilling to even consider these less-than-professional standards. If we continue to accept substandard conditions, we will lack the strength to improve our position in the medical arena. Recognizing our true worth in the medical world must begin with a new and yet honest vision of ourselves, our values, and our worth to the medical community and to those who hire us as medical professionals.

How many other medical occupations expect their professionals to spend most of their waking day working, and then provide them with the limited salary compensation that some certified athletic trainers receive? Sure, an orthopaedic surgeon may spend many waking hours working, but the surgeon's salary reflects it, too. I am not advocating that we all demand a surgeon's salary, but I am recommending that we take a long, hard, and honest view of our worth, and then ask ourselves if our value matches our compensation and if we are experiencing our desired quality of life.

How can we expect other medical professions to respect us when we are so often willing to give our services away? If we take what we do so casually, how can we expect others to value what we do? An athletic trainer may feel that he or she isn't in athletic training for the money; however, the reality is that the quality of a profession's service is judged, in part, by the salary of its members. The old adage "You get what you pay for" rings strong and true in the attitudes of both medical professionals and the

people who receive medical services.

I am not advocating that all underpaid certified athletic trainers quit their jobs, and I certainly do not wish to instigate a revolt at institutions across the country. However, it is time to begin a reevaluation process. If we want to be recognized as a respected medical profession and as respected medical professionals, we must first respect ourselves. Then we need to teach our students the value of self-respect, the pride of professionalism, and the importance of not selling ourselves short to others. Only then can we demand respect from other professionals and our administrators.

We must teach our students that, to be recognized as professionals, we must demonstrate quality in our performance, using a sound foundation of knowledge, skill, ethics, and responsibility. This means having a high regard for ourselves, for the athletes we treat, and for the profession we represent. It also means learning to balance work with family and friends, to maintain an appropriate perspective on what is important in life, and to preserve a healthy relationship between compromise and standing up for one's beliefs. We must teach our students that quantity does not assure quality, that quality is a professional's performance goal, and that performance should not be compromised. We should teach our students through demonstration that pride in ourselves and in what we do is important, that being a renaissance individual who can balance work and home life is vital to the quality of life, and that others will treat us with respect when we show that we respect ourselves.

#### **Editor's Note**

**David H. Perrin, PhD, ATC**

You will find several changes in this first issue of Volume 33 of the *Journal of Athletic Training*. First, the mission statement of the *Journal* is now "to enhance communication among professionals interested in the quality of health care for the physically active through education and research in prevention, evaluation, management, and rehabilitation of injuries." This new statement is consistent with the mission of the National Athletic Trainers' Association and reflects an expanding interest in the *Journal* among health care professionals. You will also find a new section of the *Journal* entitled "Communications." We will publish three categories of manuscript in this section: official Position Statements and Policy Statements from the NATA's Pronouncements Committee; Technical Notes on such topics as research design and statistics; and articles on other professional issues of interest to the readership. We have also increased the number of pages devoted to publication of original research, literature reviews, case reports, and clinical techniques. This has been accomplished by moving the New Products to the *NATA News* and by reducing the space devoted to Abstracts and Current Literature. The title page of each manuscript now contains a bibliographic citation and authors are identified by institutional affiliations under their names.

Regarding the use of human and animal subjects, the *Journal of Athletic Training* endorses the principles outlined in the Declaration of Helsinki. Accordingly, we have now solidified a heretofore implicit requirement that all human subjects provide informed consent to participate in any research published in *JAT* and that all studies either be formally approved by institutional review boards or conform with the Declaration of Helsinki (see the Authors' Guide).

In addition to the thanks offered to our Guest Reviewers elsewhere in this issue, the Associate Editors and I extend our appreciation to outgoing Editorial Board members Michael Harland, Rod Harter, Phillip Mateja, James Rankin, Michael Voight, Kenneth Wright, and Donald-Ray Zylks and welcome incoming members Brent Arnold, David Draper, Zeevi Dvir, Christian Fink, Danny Foster, Kevin Guskiewicz, Gary Harrelson, Mary Johnson, David Kahler, Marjorie King, Douglas Kleiner, Scott Lephart, Malissa Martin, Brent Rich, James Vailas, and Ted Worrell. We look forward to working with our Guest Reviewers and our Editorial Board in 1998 to continue to improve *JAT*.

You will find a subscription card in this and upcoming issues of *JAT*. Pass this card along to your team physician and other medical specialists with whom you work and encourage them to subscribe to the *Journal*. I invite you to visit the *JAT* web page at <http://www.nata.org/jat>, and, as always, I welcome your comments and suggestions related to the *Journal of Athletic Training*.

# L etters to the Editor

## Comment on Richard Ray's Editorial

I agree with Dr. Richard Ray's position that it is a sad fact that a large number of student-athletes nationwide are being rehabilitated from injury and surgery at "sports medicine" clinics (*J Athl Train*, 1997;32:205). I also acknowledge that many ATCs willingly refer athletes to these clinics for a variety of reasons. I interpret Dr. Ray's [editorial] as somewhat of a reprimand (probably well deserved) and a plea to all ATCs to take action in the one area we can most readily make changes—our own training rooms.

On the other side of this issue are the high school and college ATCs struggling to keep student-athletes "in house" for postsurgical rehabilitation, as well as rehabilitation for "less severe" injuries. As Dr. Ray stated, many people still believe that the best care is the most expensive care. Likewise, it is generally believed that rehabilitation using the "biggest" and most expensive equipment is going to be similar to that of nearby major college or professional athletes.

Adding to the migration of student-athletes toward clinic rehabilitation is active recruitment of student-athletes for their business due to a clinic's need for either self-promotion or financial survival. This is especially true in suburbs and smaller communities, where available medical services overwhelm the demand. The result is competition among clinics (and among physicians associated with clinics) for the student-athlete reha-

bilitation dollar. Such competition in turn creates competition between clinic ATCs and ATCs in the traditional setting.

I applaud Dr. Ray for urging us to maintain and use our rehabilitative knowledge and skills. We must, however, continue to educate athletes, parents, and physicians as to the advantages of having a rehabilitation specialist on site and available to student-athletes on a daily basis.

John K. Schroder, MS, ATC  
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## Another Comment

Hats off to Richard Ray for his "Use It or Lose It" editorial in the July-September 1997 *Journal of Athletic Training*. The education of the certified athletic trainer should include experience in diverse "cost-effective rehabilitation" of the injured and postsurgical athlete in the school/college training room setting. When working around their peers and teammates, for most athletes the care given is more frequent, more convenient, and psychologically more positive.

Many of us in the "over-the-hill" gang of athletic training have discussed the many changes occurring in the upgrading (?) of our lifelong profession. As members of the developing "sports medicine team," are certified athletic trainers now being directed and controlled by too many other medical specialties? Is the certified athletic trainer allowed to make

a decision regarding the injury or illness status of an athlete? Can the certified athletic trainer make such a decision, or does every injured athlete have to be referred to a physician? If so, then the certified athletic trainer is only a glorified first aider or EMT with additional taping or wrapping skills.

Informed decision-making is the key element in the education of the student athletic trainer. The "teachable moment" opportunities are many. The student must be taught to observe, to listen, to use the hands when examining, while at the same time asking questions and calming the injured athlete. Permissive supervision is a must, but with a loose rein. There must be an understandable, mutual ethical-medical relationship among members of the sports medicine team. The beneficiary of such a positive relationship is the athlete.

Much knowledge is expected of candidates for the certification exam. Is it the same knowledge they will use in their employment? As Richard Ray stated, we must "use it or lose it."

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**Editor's Note:** The *Journal of Athletic Training* welcomes letters to the Editor. Please send them to the *Journal of Athletic Training*, Hughston Sports Medicine Foundation, Inc., 6262 Veterans Parkway, P.O. Box 9517, Columbus, GA 31908-9517.

# Effect of Patellar Taping and Bracing on Patellar Position as Determined by MRI in Patients with Patellofemoral Pain

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**Objective:** To determine the effects of patellar taping, bracing, and not taping on patellar position.

**Design and Setting:** An experimental design was used to compare patellar taping, bracing, and not taping on patellar position as determined by magnetic resonance imaging (MRI).

**Subjects:** Twelve subjects with a diagnosis of patellofemoral pain participated in this study.

**Measurements:** Static MRI images were taken at 8 angles of knee flexion (10, 16, 25, 30, 34, 39, 41, and 45°). Patellofemoral congruence angle (PFC), lateral patellar displacement (LPD), and lateral patellar angle (LPA) were determined by digitization.

**Results:** A repeated-measures multivariate analysis of variance was used to compare experimental conditions. Across all angles of knee flexion, a more lateral PFC existed for the control

condition ( $-4.1^\circ$ ) than the brace condition ( $-7.1^\circ$ ) or tape condition ( $-6.1^\circ$ ). Post hoc testing revealed that this difference was statistically different only at  $10^\circ$  of knee flexion. Across all knee angles, LPD was more medial for the braced condition (1.7 mm) than for the tape (2.7 mm) or control (2.6 mm) condition. Post hoc testing revealed that this difference was statistically different only at  $10^\circ$  of knee flexion. No differences existed between conditions for LPA.

**Conclusions:** We conclude that patellar bracing and taping influenced patellar position (PFC and LPD) at  $10^\circ$  of knee flexion during a static MRI condition.

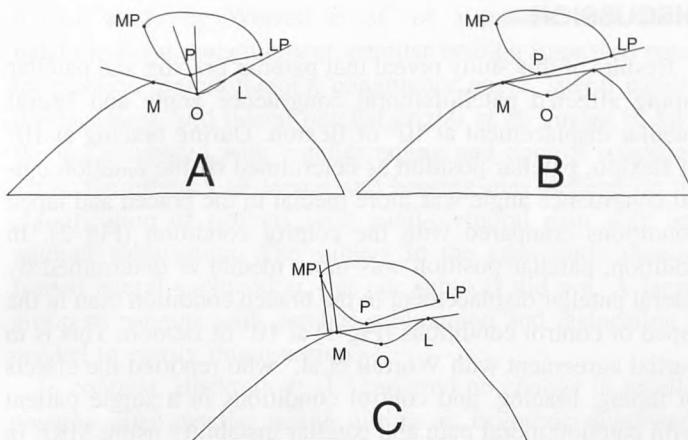
**Key Words:** anterior knee pain, patellofemoral congruence angle, lateral patellar displacement, lateral patellar angle

Patients with patellar pain are frequently referred for rehabilitation. Rehabilitative protocols are prescribed under the assumption that they will reduce symptoms, improve vastus medialis oblique (VMO) activity, and correct patellar alignment.<sup>1,2</sup> Rehabilitation generally consists of specific exercises thought to recruit the VMO,<sup>3</sup> general quadriceps exercises, and stretching of tight lateral structures.<sup>4</sup> In addition, patellar taping<sup>1</sup> and bracing<sup>5,6</sup> have been used in the treatment of patellar pain. The underlying construct of many of these interventions is that patellar position can be improved (ie, medialized) by altering the balance of the medial and lateral forces.<sup>1,3,4,7</sup> However, the ability to selectively fatigue the VMO compared with vastus lateralis (VL) muscle has not been demonstrated in the 0 to  $30^\circ$  arc for normal subjects,<sup>8</sup> nor has patellar taping or selective exercises been demonstrated to alter the VMO:VL ratio in subjects with and without patellar pain.<sup>9</sup> To support the construct that patellar position can be altered as a result of therapeutic interventions, we believe that changes in patellar position attributable to a specific therapeutic intervention must be demonstrated.

Radiologic assessment of the patella attempts to quantify the position of the patella in relationship to bony landmarks of the femoral trochlea (Fig 1). The Merchant's x-ray view is taken with the subject in the supine position on an x-ray table with the knee in  $45^\circ$  of flexion.<sup>10-12</sup> The Merchant's x-ray view

quantifies the position of the patella in the frontal plane in comparison with the sulcus angle as either a positive angle (laterally positioned) or negative angle (medially positioned). This angle is called the patellofemoral congruence angle (Fig 1A).<sup>10</sup> The lateral patellar angle quantifies the position of the patella in the transverse plane within the sulcus angle (Fig 1B). Smaller lateral patellar tilt angles indicate greater lateral tilting of the patella. The lateral patellar displacement quantifies the position of the patella in the frontal plane relative to the medial femoral condyle in millimeters. Positive lateral patellar displacement values indicate a lateral position of the patella, and negative values indicate a medial position of the patella (Fig 1C).

Several authors have used the Merchant's view to determine the effectiveness of exercise and stretching,<sup>4</sup> exercise and biofeedback,<sup>11</sup> patellar bracing,<sup>5,6</sup> and taping<sup>6,12</sup> on patellar position. The Merchant's view of the patella provides valuable information concerning the location of the patella within the trochlear groove<sup>10</sup> but has been criticized because the Merchant's view uses a  $45^\circ$  knee angle in which the patella has already engaged in the patellofemoral groove.<sup>13,14</sup> In addition, the axial view (Laurin's view) has been criticized because of the difficulty of positioning the knee in less than  $45^\circ$  of flexion during a normal radiograph.<sup>13,14</sup> Consequently, the position of the patella at other locations within the range of motion is not



**Fig 1.** A, The patellofemoral congruence angle (PCA) is formed by line O-P and a line bisecting the sulcus angle. If line O-P is medial to the line of bisection, CA is negative. If line O-P is lateral to the line of bisection, CA is positive. The sulcus angle is formed by the angle MOL. B, The lateral patellar angle is formed by lines P-LP and M-L. The value of the angle represents the degree to which the angle opens laterally. In some cases the lines can be parallel or the angle can open medially. C, Lateral patellar displacement is the distance between two lines perpendicular to line M-L. One perpendicular line intersects point MP, the other intersects point M. Medial displacement is negative, lateral is positive.

known. In particular, patellar position is not known in the 0 to 20° arc, though that range is considered important for the diagnosis of patellar malalignment.<sup>13–15</sup> Finally, only one research group<sup>6,11,12</sup> has reported reliability for their method of assessing patellar position. We believe reliability data are needed to facilitate interpretation of the effects of surgical or conservative interventions on patellar position.

Patellar taping and bracing studies have claimed to correct patellar tracking.<sup>1,5</sup> McConnell<sup>1</sup> reported decreased patellar pain and improved function following patellar taping and exercise. She did not, however, quantify changes in patellar position or tracking, though resolution of symptoms in these studies was attributed to increased VMO activity and improvements in patellar tracking. Previously, authors have shown that patellar taping reduced patellar pain but did not change patellar position at 45° of knee flexion in subjects with patellofemoral pain.<sup>12</sup> Cerny<sup>9</sup> reported a 94% decrease in patellar pain following patellar taping in subjects with patellofemoral pain but no change occurred in the VMO:VL electromyogram ratio.

In order to better understand patellar position throughout knee range of motion following patellar taping and bracing, it is necessary to measure patellar position at various knee angles.<sup>14–18</sup> For example, Sanchis-Alfonso et al<sup>18</sup> demonstrated that patients with patellar instability as determined by patellofemoral congruence angle at 0 and 15° had their patellae relocated by 30° of knee flexion. Thus, Sanchis-Alfonso et al<sup>18</sup> recommended patellofemoral assessment in the 0 to 30° arc of motion with computerized axial tomography (CAT) scan or magnetic resonance imaging (MRI) scan. In addition, Worrell et al<sup>6</sup> demonstrated that the patellofemoral congruence angle changed 40° as the knee moved from 10 to 45° of flexion (ie,

the patella moved medially by 40°) in a case study of a subject with a history of patellar dislocation and subluxation.

Finally, Kujala et al<sup>16</sup> reported that, in patients with patellar dislocation, the sulcus angle at 10° of flexion was more diagnostic of anatomic predisposition to recurrent patellar dislocation than other patellar position indices at 30° of knee flexion. Thus, we believe that patellar position must be assessed in knee flexion angles less than 30° to support or refute the construct that patellar position can be changed as a result of patellar taping or bracing.

Therefore, the purpose of this study was to compare static MRI measurements of patellar position using the patellofemoral congruence angle, lateral patellar displacement, and lateral patellar angle at eight knee angles after patellar taping, bracing, and a control condition in a group of subjects with patellofemoral pain.

## METHODS

### Subjects

Twelve subjects (10 females, 2 males; age = 27 ± 8.3 yr, ht = 166.2 ± 7.8 cm, wt = 68 ± 12.6 kg) participated in this study. All patients were diagnosed by an orthopaedic surgeon as having patellofemoral pain, and the surgeon ruled out other knee problems such as meniscal tears or ligament injuries. Subjects with patellar tendinitis were excluded. Subjects' symptoms were primarily pain after prolonged sitting and/or vague anterior knee pain in activities such as ascending or descending steps, walking, or running. The duration of symptoms ranged from 3 to 36 months. Prior to participation, subjects signed a consent form that was approved by two institutional review boards (University of Indianapolis, Indianapolis, IN, and St. Francis Hospital, Beech Grove, IN).

### Experimental Procedure

Subjects were tested under three conditions: 1) patellar taping; 2) patellar bracing (Palumbo Brace, DynOrthotics LP, Vienna, VA); and 3) control (no bracing or taping). Treatment order was randomly assigned. Patellar taping was performed by a physical therapist trained in the McConnell taping procedure using the materials recommended by McConnell.<sup>2</sup> The patellar brace was applied according to the directions accompanying the brace. After each experimental condition, an MRI of the painful knee was taken at eight angles of knee flexion.

### MRI and Digitization

A 1-tesla Picker H.P.Q. magnetic resonance imager (Picker International, Cleveland, OH) was used in this study. Patients were placed supine in the scanner. Five-mm transaxillary images were taken at eight different angles of knee flexion. T1-weighted or intermediate- (proton density) weighted proto-

cols were used. A recovery time of 600 msec and an echo time of 20 msec were used. High resolution was obtained with a  $256 \times 256$  acquisition matrix and a 16-cm field of view (FOV) at one excitation. Spatial resolution was recorded at 0.6 mm in both phase-encoding and frequency-encoding directions. A 16-cm FOV provided adequate visualization of the patellofemoral joint.

MRIs were taken at eight angles of knee flexion: 10, 16, 25, 30, 34, 39, 41, and 45°, while the patient was positioned supine with the quadriceps femoris muscles relaxed. Because of the time required for the scanning, patients were unable to maintain a quadriceps contraction. Ingersoll and Knight<sup>11</sup> reported no difference in patellofemoral congruence angle with the quadriceps contracted compared with relaxed. The knee angles were determined with a goniometer. Spacers were placed under both heels while the thighs were supported on a custom plastic support (wedge) to prevent movement of the extremity. Images were repeated for each of the three conditions (tape, brace, control). Six points were digitized on each picture as described by Ingersoll and Knight,<sup>11</sup> using a Numonics Model Electronic Digitizer (Model # 781698HBL, Numonics Corporation, Montgomeryville, PA) interfaced to a personal computer and custom software. We have demonstrated excellent reliability (intraclass correlation coefficient = 0.97–1.0) with this measurement technique.<sup>12</sup>

Three measures of patellar position were calculated: the patellofemoral congruence angle and sulcus angle (Fig 1A), the lateral patellar displacement (Fig 1B), and lateral patellar angle (Fig 1C) were determined. Again, negative values for the patellofemoral congruence angle and lateral patellar displacement indicated a patella that was medially located to its respective reference points (Fig 1).

## Data Analysis

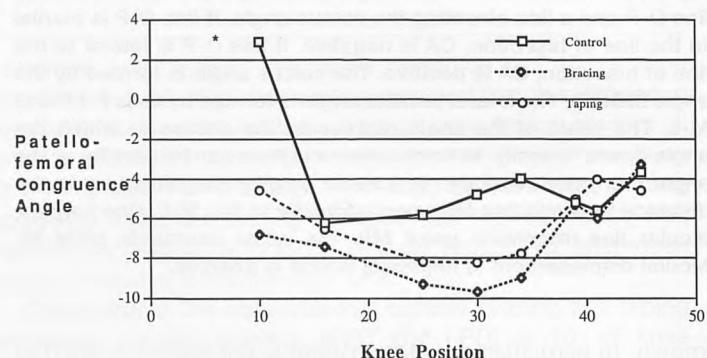
A repeated-measures multivariate analysis of variance with F tests and the Newman-Keuls post hoc analysis were used to compare patellofemoral congruence angle, lateral patellar displacement, and lateral patellar angle during tape, brace, and control conditions. The probability level was set at  $P \leq .05$ .

## RESULTS

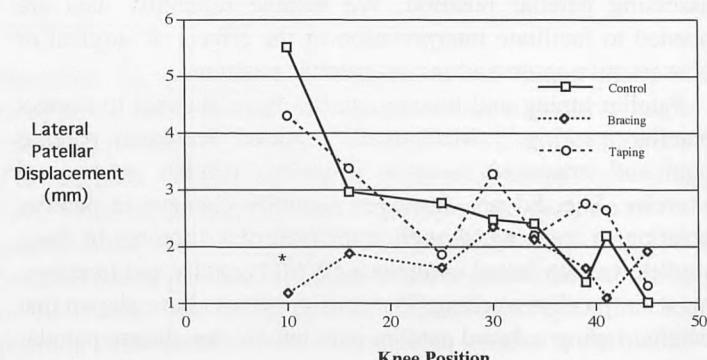
Patellofemoral congruence angle for the control condition ( $-4.1^\circ$ ) was more lateral than the taped ( $-6.1^\circ$ ) or braced ( $-7.1^\circ$ ) conditions across all knee angles ( $F(2,284) = 5.2, P = .01$ ), but a post hoc test revealed that this difference was significant only at  $10^\circ$  of knee flexion (Fig 2). Lateral patellar displacement was more medial for the braced condition (1.7 mm) than for the taped (2.7 mm) or control (2.6 mm) conditions across all knee angles ( $F(2,284) = 4.6, P = .01$ ), but a post hoc test revealed that this difference was significant only at  $10^\circ$  of knee flexion (Fig 3). No differences existed between conditions for lateral patellar angle (Fig 4).

## DISCUSSION

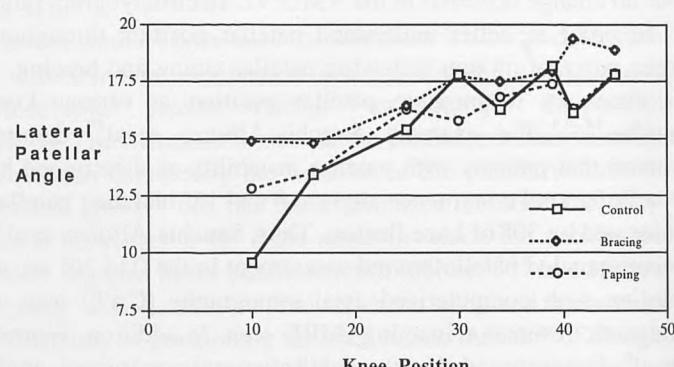
Results of this study reveal that patellar bracing and patellar taping affected patellofemoral congruence angle and lateral patellar displacement at  $10^\circ$  of flexion. During bracing at  $10^\circ$  of flexion, patellar position as determined by the patellofemoral congruence angle was more medial in the braced and taped conditions compared with the control condition (Fig 2). In addition, patellar position was more medial as determined by lateral patellar displacement in the braced condition than in the taped or control conditions (Fig 3) at  $10^\circ$  of flexion. This is in partial agreement with Worrell et al,<sup>6</sup> who reported the effects of taping, bracing, and control conditions in a single patient with patellofemoral pain and patellar instability using MRI. In



**Fig 2. Patellofemoral congruence angle after the three experimental conditions. (\*,  $P \leq .05$ ).**



**Fig 3. Lateral patellar displacement after the three experimental conditions. (\*,  $P \leq .05$ ).**



**Fig 4. Lateral patellar angle after the three experimental conditions.**

a case study by Worrell et al<sup>6</sup> of a patient with severe patellofemoral malalignment, patellar bracing improved patellar position (patellofemoral congruence angle, lateral patellar displacement, and lateral patellar angle) at all angles of knee flexion compared with patellar taping and control condition. Thus, the efficacy of taping and bracing may depend on the classification of patients with patellofemoral pain with and without subluxation. The subject in the case study demonstrated lateral subluxation, but our subjects did not. A larger group of patients with patellar subluxation and dislocation is needed to clarify this question.

In contrast, Bockrath et al<sup>12</sup> reported no change in patellar position after patellar taping during an isometric quadriceps contraction compared with a control position using a Merchant's view x-ray (45° of knee flexion). Subjects in the Bockrath et al<sup>12</sup> study had a normal sulcus angle ( $127 \pm 11.8^\circ$ ) at 45° of knee flexion. The patellofemoral congruence angle at 45° of knee flexion ( $-5.86 \pm 19.96^\circ$ ), however, revealed a medialized patella that would have been classified as normal by Schutzer et al<sup>14</sup> or Merchant et al<sup>10</sup> and medially subluxated by Shellock et al.<sup>20</sup> Thus, what constitutes a "normal" patellofemoral congruence angle remains ambiguous, in our opinion.

Results of this study reinforce the complex nature of patellofemoral pain. In particular, interpretation of the sulcus angle (Fig 1A, angle MOL) as one index of patellofemoral congruence that is cited in the literature is controversial.<sup>10,14,16</sup> At 10° of knee flexion, our subjects' mean sulcus angle ( $123.80 \pm 12.43^\circ$ ) and mean patellofemoral congruence angle ( $-2.93 \pm 6.9^\circ$ ) were similar to those previously reported in asymptomatic subjects.<sup>14,16,18</sup>

Schutzer et al<sup>14</sup> ( $n = 20$  asymptomatic knees evaluated by CAT scan) reported that a patellofemoral congruence angle  $<0^\circ$  at 10° knee flexion was normal. Kujala et al<sup>16</sup> considered the "normal" patellofemoral congruence angle values of Schutzer et al<sup>14</sup> to be a "constrained categorization." For example, Kujala et al<sup>16</sup> using MRI reported that their asymptomatic subjects ( $n = 20$ ) would have been classified as medial "subluxers" by Schutzer et al<sup>14</sup> at 10° of knee flexion (patellofemoral congruence angle at 0° of knee flexion =  $4.9 \pm 8.3^\circ$ ). In addition, Sanchis-Alfonso et al,<sup>18</sup> using CAT scans, reported that asymptomatic subjects ( $n = 14$ ) had patellofemoral congruence angles of  $4.9 \pm 8.3^\circ$ ,  $-4.3 \pm 7.3^\circ$ , and  $-12.1 \pm 3.1^\circ$  and sulcus angles of  $126.6 \pm 8.9^\circ$ ,  $125.4 \pm 49$ , and  $127.3 \pm 6.2^\circ$ , at 0, 15, and 30° of knee flexion, respectively. In their seminal work, Merchant et al<sup>10</sup> reported a mean patellofemoral congruence angle of  $-6 \pm 11^\circ$  and a mean sulcus angle of  $138 \pm 6^\circ$  in 100 asymptomatic subjects (50 females and 50 males, no difference between male and female subjects) using axial x-ray at 45° of knee flexion.

Finally, Shellock et al<sup>19</sup> (130 symptomatic patellofemoral pain subjects; 235 knees) using MRI visually classified knees (while in 5–30° of flexion) into six categories: normal, lateral subluxation, excessive lateral pressure syndrome, medial subluxation, lateral-to-medial subluxation of the patella, and

dislocation. Seventeen percent of those knees ( $n = 41$ ) were classified as "normal" (ie, visual patellofemoral congruence angle of 0°) and 41% ( $n = 106$ ) were classified as "medial subluxation" (ie, visual patellofemoral congruence angle of less than 0°).

Thus, our data support the existence of a subpopulation of patellofemoral pain patients with "normal" patellofemoral alignment as reported in the literature, ie, congruence angles of 0° at 5 to 30°<sup>18</sup> or congruence angles of  $<0^\circ$  at 10°<sup>21</sup>, 15°<sup>20</sup>, or 45°.<sup>10</sup> Since subjects in our study are classified as "normal" according to the criteria established by these authors, we concluded that our subjects had patellofemoral alignment that was within normal limits and that their patellofemoral pain was not a result of patellofemoral malalignment as defined by the current literature. We believe the etiology of their pain is not known. Moreover, the response of this group of patients to rehabilitation is not known. Future study is needed to determine outcomes of patients with patellofemoral pain based on an objective classification system.

Thus, in our present study, subjects with "normal" patellar alignment decreased their lateral patellar displacement while wearing the brace and decreased their patellofemoral congruence angle at 10° of flexion while wearing tape and brace. The results of this study demonstrate the efficacy of bracing and taping at 10° of knee flexion on specific indices of patellar alignment in a static position.

After the conclusion of this study, two patients in this study had surgical realignment (tibial medialization and lateral release) when rehabilitation did not relieve their pain, even though our data demonstrate that those two specific subjects had "normal" patellar alignment. Interestingly, medial subluxation has been reported following lateral release.<sup>20,21</sup> Moreover, Shellock et al<sup>20</sup> reported that 41% of knees in patients with patellofemoral pain were medially subluxated. In our study, 45% (5/12) of the patients' patellae were medially displaced at 10° of knee flexion ( $-2.0$ ,  $-19.9$ ,  $-5.9$ ,  $-9.2$ , and  $-5.1^\circ$ ). These subjects would have been classified as "medial subluxators" by the classification system of Shellock et al<sup>20</sup> or classified as normal by Merchant et al.<sup>10</sup> Poor long-term results have been reported following lateral release procedures for patellofemoral pain.<sup>20,21</sup> Perhaps in some patients, realignment procedures decrease patellofemoral symptoms in the short-term, but the underlying mechanism for the pain may not have been addressed. Long-term follow-up is needed on patients with patellofemoral pain who have been treated with exercise, physical therapy, and surgery to determine their functional outcome.

Patellofemoral pain involves many etiologic factors.<sup>10,22,23</sup> Merchant et al<sup>10</sup> reported that patellofemoral congruence angles  $\geq 16^\circ$  were abnormal (95th percentile). Yet, one of their "normal" subjects had patellofemoral congruence angles of +34 and +23°. Though the patient was asymptomatic, Merchant et al<sup>10</sup> reported that this patient had a family history of patellar dislocation. Merchant et al<sup>10</sup> stressed that "there are multiple factors involved in malalignment and pathology of the

patellofemoral joint, and each factor must be carefully assessed as it relates to the whole." Kannus and Nittymaki<sup>22</sup> prospectively evaluated 22 variables in 49 patients with patellofemoral pain and reported that only age was significantly related to outcome (ie, younger patients improved more than older patients). Messier et al<sup>23</sup> reported on anthropometric, biomechanical, and muscular strength and endurance factors between injured and noninjured runners with patellofemoral pain. Messier et al<sup>23</sup> reported that Q-angle, muscular endurance, and rear foot movement variables were different between injured and noninjured runners. Taylor et al<sup>24</sup> reported no difference between static Q-angle between 50 patients with patellofemoral pain and 50 normal subjects. Thus, the literature supports multiple etiologic factors for patellofemoral pain. We speculate that an interaction exists between these etiologic factors and the activity level and tissue tolerance of the individual. More study is needed to better define this complex relationship.

Finally, we chose to use static MRI because this was the only MRI available for this study. Knowledge of the effect of taping and bracing during dynamic movement is needed to support or refute our findings in the static condition. In addition, information about the effect of activity on patellar taping and bracing is needed.

## CONCLUSIONS

We conclude that in this group of patients with patellofemoral pain and "normal" patellar alignment bracing and taping improved patellar position only at 10° of knee flexion during a static MRI condition. We believe that patellofemoral pain has multiple etiologic factors and that patellar alignment is just one factor that can cause patellofemoral pain. More study is needed to determine the etiologic factors and long-term outcomes of conservative and surgical treatment.

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# Hot-Pack and 1-MHz Ultrasound Treatments Have an Additive Effect on Muscle Temperature Increase

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**Objective:** Therapeutic ultrasound is an effective deep heating modality commonly applied alone or after cooling or heating of the treatment area. The purpose of this study was to examine the tissue temperature rise in the human triceps surae muscle group after ultrasound with prior heating via a silicate gel hot pack.

**Design and Setting:** This study was designed as a  $2 \times 2 \times 3$  factorial with repeated measures on two factors (depth and time). Independent variables were temperature of pack (hot and room temperature), depth of measurement (1 cm and 3 cm), and time (beginning, after pack application, and after ultrasound). The dependent variable was tissue temperature. Subjects were assigned to one of two treatment groups: ultrasound preceded by a 15-minute hot pack treatment or ultrasound preceded by a 15-minute application with a silicate gel pack at room temperature. Measurements were taken while subjects were treated in a university training room.

**Subjects:** Twenty-one uninjured male and female college student volunteers were randomly assigned to one of the two pack groups.

**Measurements:** The hot packs were stored in 75°C water. A 1-MHz ultrasound treatment was administered for 10 minutes

at an intensity of 1.5 W/cm<sup>2</sup>. Tissue temperature was measured every 30 seconds using 23-gauge hypodermic microprobes interfaced with a telethermometer and inserted 1 and 3 cm below the surface of anesthetized triceps surae muscle.

**Results:** At both tissue depths, there was a 0.8°C greater increase in tissue temperature with hot packs and ultrasound. At 1 cm, ultrasound increased temperature 3.5°C after a 0.5°C rise during the room temperature-pack application, but only 0.6°C after a 3.8°C increase during hot-pack application. At 3 cm, ultrasound increased temperature 3.85°C following a slight (-0.26°C) decrease during the room temperature-pack application and 3.68°C after a 0.74°C increase during hot-pack application.

**Conclusions:** Vigorous increases in deep muscle temperature ( $\geq 4^\circ\text{C}$ ) can be reached with 2 to 3 minutes less total sonation time when preheated with a hot pack. Thus, ultrasound and hot packs have an additive effect on intramuscular temperature, but the characteristics of the additive effect are different, primarily because there appears to be a tissue temperature plateau.

**Key Words:** tissue temperature rise, superficial heating

Therapeutic ultrasound is used to treat a variety of conditions.<sup>1–6</sup> It is often used as a thermal modality when treating soft tissue injuries because it selectively heats structures up to 5 cm deep with only minimal increases in skin temperatures.<sup>7</sup> There have been many studies on the independent use of ultrasound and its effects on deep tissue temperature elevation.<sup>6,8–12</sup> We found few studies, however, that examined the effect of heat<sup>13</sup> or cold<sup>14,15</sup> combined with an ultrasound treatment. The one study we found that looked at combined hot pack and ultrasound (human thigh) indicated that hot packs neither enhanced nor diminished the deep heating effects of ultrasound.<sup>13</sup> Those researchers applied the hot pack only for 8 minutes, which may have been too brief to produce tissue heating.

Since the standard application time for hot packs is 15 minutes, we feel Lehmann et al<sup>13</sup> did not adequately investi-

gate the subject. If indeed there is no additional benefit of preceding ultrasound application with hot packs, those who use the technique are wasting time. On the other hand, if there is an added benefit, clinicians should be informed of such and alter their protocols accordingly. Our purpose, therefore, was to reinvestigate the superficial and deep heating effects of ultrasound treatment after a 15-minute hydrocollator heat pack treatment.

## METHODS

A  $2 \times 2 \times 3$  factorial design with repeated measures on two variables (time and depth) guided this experiment. Our dependent variable was tissue temperature. The independent variables were the treatment methods (hot pack and room temper-

ture pack), tissue depth (1 cm and 3 cm below surface), and time (preapplication, postpack, and postultrasound).

Twenty-one male and female subjects (age =  $23.7 \pm 1.7$  yr) volunteered for this study. Data from one subject could not be used due to a thermistor malfunction. Subjects' left triceps surae muscles were free from ecchymosis, infection, swelling, and injury for at least 6 months prior to the experiment and had less than 15 mm skinfold. Each subject read and signed a consent form approved by the Brigham Young University Human Subjects Review Board.

We used an Omnisound 3000 (Physio Technology Inc, Topeka, KS) ultrasound unit at 1 MHz. Its transducer head was  $5 \text{ cm}^2$  and housed a lead zirconate titanate crystal, with a beam nonuniformity ratio of 1.8:1 and an effective radiating area of  $4.1 \text{ cm}^2$  (manufacturer's specifications). Our conducting medium was Ultraphonic Conductivity Gel (Pharmaceutical Innovations Inc, Newark, NJ) at room temperature ( $25^\circ\text{C}$ ). We used a template (2 times the size of the effective radiating area of the applicator) to ensure that the treatment size was consistent throughout the experiment.<sup>16</sup>

Two 23-gauge thermistor needles (Phystek MT-23/5, Physitemp Instruments, Clifton, NJ) were attached to a monitor (Bailey Instruments BAT-12, Physitemp Instruments, Clifton, NJ) that displayed the temperature in degrees Celsius. We recorded intramuscular temperature every 30 seconds. Surface temperature was monitored, but not recorded, with a surface thermocouple (TK80) attached to a multimeter with a temperature module (model 73, Fluke Co, Everett, WA).

Packs for the room-temperature treatment were stored in an unplugged hydrocollator (model M2, Chattanooga Corporation, Hixon, TN). We used a  $25 \times 30$  Tropic Pac (J.A. Preston Corporation, Jackson, MI) silicate gel/canvas hot-pack cover. Packs for the hot pack group were heated  $75^\circ\text{C}$  in an identical hydrocollator and wrapped in a standard terry cloth cover. Subjects were provided extra toweling as needed for comfort (8 subjects required an additional 1.6 layers of toweling).

With the subject lying prone on a table, a 10-cm diameter treatment area on the left medial triceps surae muscle group was shaved, cleansed thoroughly with a Betadine scrub (The Purdue Frederick Company, Norwalk, CT), and swabbed with 70% isopropyl alcohol. An injection of 1 cc of 1% lidocaine was administered at depths of 1 and 3 cm beneath the surface of the treatment site to anesthetize the area. The injection sites were located by measuring down from the upper surface of the muscle belly using a T-square. Thermistors, sterilized in a solution of Cidex (Johnson & Johnson Medical, Arlington, TX) for 15 min<sup>17</sup> before each use, were then inserted at 1 and 3 cm below the skin's surface through the injection sites. Three- and five-centimeter length thermistors were used at the 1- and 3-cm depths, respectively, to ensure that the tip of each thermistor was directly below the treatment site. A bubble level was used while inserting the thermistors to ensure that the probes were level with the skin surface and inserted at the proper depth. The thermistors were then connected to the monitor, and we waited

for the temperature to stabilize (approximately 1 to 3 minutes) and recorded this temperature as the baseline.

We randomly assigned subjects to either the hot-pack/ultrasound group or the room temperature-pack/ultrasound group. After recording a baseline temperature, the pack was placed on the posterior triceps surae muscle belly (directly above the thermistors) for 15 minutes, and temperature was recorded at each depth every 30 seconds.

Ultrasound application began 1 minute after the hot-pack treatment. We attached the ultrasound template to the calf directly above the thermistor tips and applied 15 mL of ultrasound gel to the treatment area (Fig 1). Continuous ultrasound, at a frequency of 1 MHz and an intensity of  $1.5 \text{ W/cm}^2$ , was applied for 10 minutes. The sound head was moved at approximately 4 cm/sec within the template. The room temperature-pack/ultrasound treatment followed the same procedures as the hot-pack/ultrasound treatment except a  $25^\circ\text{C}$  silicate gel pack was used in place of the hot pack. When the treatment was concluded, we removed the thermistors from the subject's leg. The area was again cleansed with a Betadine solution and an adhesive bandage applied over the insertion sites.

We computed tissue temperature change scores during each of three time periods: during pack application, during ultrasound application, and total (sum of pack and ultrasound application scores). These were computed as the differences between the beginning and ending temperatures for each of the time periods. We analyzed the data with two  $2 \times 2 \times 3$  analyses of variance (ANOVAs) with repeated measures on depth and time. For one ANOVA, the dependent variable was the raw temperature score at the beginning of pack application, the end of pack application (which was the beginning of ultrasound application), and the end of ultrasound application. The second ANOVA was computed using temperature change scores as the dependent variable. Significant main effects were further analyzed with Tukey post hoc tests for those

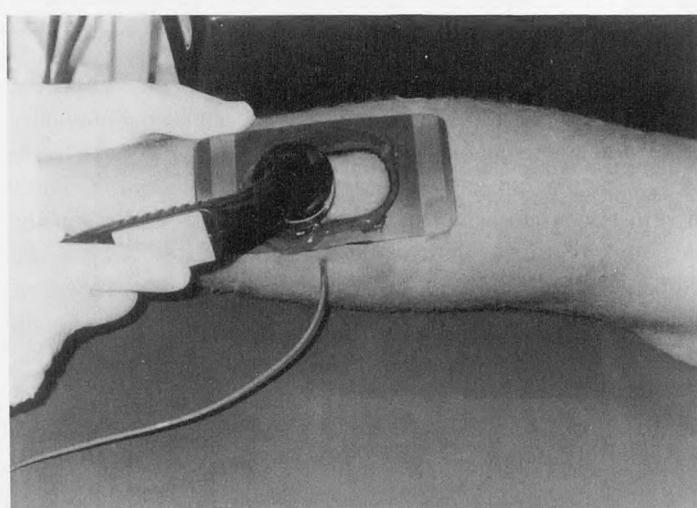


Fig 1. Ultrasound to the muscle belly, guided by a template that is two times the effective radiating area. Note the thermister probe below the template.

comparisons between depth and modality (time) and Scheffe post hoc tests for the comparisons between packs because the latter had unequal cell means. The alpha level for all tests was set at 0.05.

## RESULTS

Tissue temperature increased significantly in superficial and deep tissues during both hot pack and ultrasound application (Table 1;  $F(1,17) = 11.1, P = .004$ ). Although hot packs and ultrasound had an additive effect at both depths, the effects were not linear (Fig. 2); the hot pack appeared to moderate the effects of the ultrasound. For instance, at 1 cm, ultrasound increased temperature  $3.5^{\circ}\text{C}$  after a  $0.5^{\circ}\text{C}$  rise during the room temperature-pack application. But following a  $3.8^{\circ}\text{C}$  increase during hot-pack application, ultrasound added only  $0.6^{\circ}\text{C}$ . At 3 cm, there was no difference in effects of the ultrasound following the two pack conditions, but hot packs increased only the deeper temperature  $0.7^{\circ}\text{C}$  (Table 2). The difference in the overall heating at 3 cm was the result of the tissue temperature rise of the hot pack and the slight cooling effect of the room temperature pack. There was no difference in total temperature rise at the two tissue depths (Table 2).

Although we did not record specific times, we did observe that the temperature at the surface of the skin would level out and begin to decrease at about 8 minutes into hot-pack treatment, as Lehmann et al<sup>18</sup> reported. The temperature at 1 and 3 cm, however, continued to rise gradually throughout hot-pack application.

## DISCUSSION

The additive effect of hot packs and ultrasound are both enlightening and complicated. They are enlightening because our results contradict those of Lehmann et al,<sup>13</sup> who reported no additive effect of hot packs and ultrasound. They applied hot packs for only 8 minutes before the ultrasound treatment. This time was selected because in previous research hot-pack

**Table 1. Triceps Surae Muscle Temperature (at 1-cm and 3-cm depths) Before and After 15-Minute Treatments of Room Temperature Packs or Hot Packs Followed by 10 Minutes of 1-MHz Ultrasound ( $^{\circ}\text{C}$ ; Mean  $\pm$  SD)**

	n	Application		
		Pre	Post Pack	Post US
<b>1 cm Deep</b>				
Room temp pack	9	$34.6 \pm .5^*$	$34.7 \pm .6^*$	$38.2 \pm .5^{\dagger}$
Hot pack	11	$34.1 \pm .7^*$	$37.9 \pm .7^{\dagger\$}$	$38.6 \pm 1.0^{\dagger\$}$
<b>3 cm Deep</b>				
Room temp pack	9	$35.9 \pm .2$	$35.6 \pm .3$	$39.5 \pm .8^{\dagger}$
Hot pack	11	$35.7 \pm .7$	$36.5 \pm .4^{\dagger\$}$	$40.2 \pm .8^{\dagger\$}$

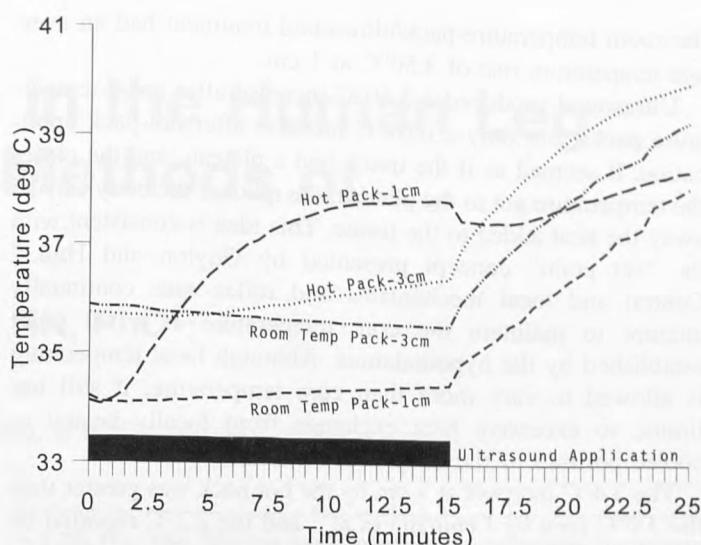
\* 1 cm Deep < 3 cm Deep ( $P < .05$ ).

† Post US > Post Pack and Pre Application ( $P < .05$ ).

‡ Hot Pack > Room Temp Pack ( $P < .05$ ).

§ 1 cm Deep > 3 cm Deep ( $P < .05$ ).

|| Post US > Post Pack > Pre Application ( $P < .05$ ).



**Fig 2. Mean tissue temperature rise of the triceps surae muscle group at 1 and 3 cm following ultrasound preceded by a hot or room temperature pack.**

**Table 2. Tissue Temperature Change at 1-cm and 3-cm Depths During Application of 1 MHz Ultrasound Following Either Room Temperature Pack or Hot Pack Application ( $^{\circ}\text{C}$ ; Mean  $\pm$  SD)**

n	Temperature Rise during application of:		
	Packs (15 min)	US (10 min)	Total (25 min)
<b>1 cm Deep</b>			
Room temp pack*	$.15 \pm .38^{\dagger}$	$3.50 \pm .37^{\dagger}$	$3.65 \pm .49^{\dagger}$
Hot pack‡	$3.83 \pm 1.17^{\dagger\$}$	$.61 \pm .80^{\dagger\$}$	$4.44 \pm 1.09$
<b>3 cm Deep</b>			
Room temp pack*	$-.26 \pm .21^{\dagger}$	$3.85 \pm .65$	$3.58 \pm .73^{\dagger}$
Hot pack‡	$.74 \pm .59$	$3.68 \pm .76$	$4.42 \pm .85$

\* Difference between conditions (Total and US > Pack).

‡ Difference between conditions (Total > US > Pack).

† Difference between packs (Hot Pack > Room Temp Pack).

§ Difference between depths.

applications to the human thigh produced peak surface temperatures at 8 minutes into the treatment.<sup>18</sup> We believe this time was insufficient to obtain the benefits of both treatments. We observed that surface temperature leveled out and decreased at about 8 minutes into our hot-pack treatment, which is similar to the findings of Lehmann et al;<sup>18</sup> however, in both our study and theirs, deeper temperatures (1 and 3 cm) continued to rise throughout the 15-minute treatment.

Lehmann et al,<sup>13</sup> therefore, did not receive the full benefits of the hot pack at the deeper levels before application of the ultrasound. Of the 11 subjects who underwent the hot-pack/ultrasound treatment, 82% (9) had a temperature increase of  $4^{\circ}\text{C}$  or greater at 3 cm. Of the 9 subjects who underwent the room temperature-pack/ultrasound treatment only 22% had an increase of  $4^{\circ}\text{C}$  or greater at 3 cm. If Lehmann et al<sup>13</sup> had left the hot pack on longer, their findings might have been similar to ours.

Our results are complicated because the additive effect we observed at 3 cm did not occur at 1 cm. The ultrasound during

the room temperature-pack/ultrasound treatment had an average temperature rise of 3.50°C at 1 cm.

Ultrasound produced a 3.50°C increase after room temperature packs, but only a 0.61°C increase after hot-pack application. It seemed as if the tissue had a plateau, and the closer the temperature got to the plateau, the quicker the body carried away the heat added to the tissue. This idea is consistent with the "set point" concept presented by Guyton and Hall.<sup>19</sup> Central and local mechanisms and reflex arcs continually attempt to maintain the core temperature at a set point established by the hypothalamus. Although local temperature is allowed to vary more than core temperature, it still has limits, so excessive heat exchange from locally heated or cooled portions of the body is prevented.

The 3.4°C increase at 1 cm by the hot pack was greater than the 3.0°C seen by Lehmann et al<sup>13</sup> and the 2.2°C reported by Halvorson.<sup>20</sup> This hot-pack increase was almost equal to the tissue temperature rise of 10 minutes of ultrasound alone (3.6°C). For joints whose capsule is within 1 cm of the surface, where only moderate heating is desired, either hot packs or ultrasound are acceptable.

It would be interesting to examine the effect of 3-MHz ultrasound with prior heating on tissue temperature rise in superficial tissues. With 3-MHz ultrasound, most of the energy is absorbed in the first 1 or 2 cm.<sup>16,21,22</sup> Both the hot pack and 3-MHz ultrasound are superficial heating modalities, so substantial heating could occur. There are many superficial muscles, tendons, and ligaments that could benefit from treatment methods of this kind.

In conclusion, our study has revealed the following:

1. Overall temperature increases occurred with application of both hot pack and ultrasound.
2. The hot pack made more of a profound impact in temperature increase at 1 cm.
3. The ultrasound made more of a profound impact in temperature increase at 3 cm.
4. The overall heating at 1 cm was greater than at 3 cm.
5. Hot packs reached their maximum heating effect at 15 minutes application (this contradicts the findings of Lehmann et al<sup>13</sup>).
6. Vigorous increases in deep muscle temperature ( $\geq 4^{\circ}\text{C}$ ) can be reached with 2 to 3 minutes less total sonation time when the area is preheated with a hot pack. This decreased sonation time may possibly prevent the periosteal irritation that sometimes accompanies ultrasound treatments of long duration. Also, the clinician may be free to work on other patients while one is undergoing preheating via a hot pack.

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# Temperature Changes in the Human Leg During and After Two Methods of Cryotherapy

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**Objective:** To compare the cooling and rewarming effects of two clinical 20-minute cryotherapy treatments on the temperature of the human leg.

**Design and Setting:** Sixteen subjects were randomly treated with either 20 minutes of a 1.8-kg crushed-ice pack, placed directly over the left calf, or a 20-minute immersion in a cold (10°C) whirlpool. Data were collected at a university human performance research laboratory.

**Subjects:** Seventeen male and 15 female healthy college students.

**Measurements:** Subcutaneous and muscle tissue temperatures were measured by 26-gauge hypodermic needle microprobes inserted in the calf, just below the skin, or 1 cm below the subcutaneous fat, respectively.

**Results:** There was no significant difference in the decrease in intramuscular temperatures between treatments ( $t(30) =$

$-1.76, P = .09$ ). The ice pack treatment significantly decreased the subcutaneous temperature more than the whirlpool ( $t(30) = -2.64, P = .01$ ). The subcutaneous temperature rewarmed significantly more in the ice pack group ( $12.3 \pm 3.3^\circ\text{C}$ ) than the cold whirlpool ( $7.4 \pm 2.1^\circ\text{C}$ ) ( $t(30) = 4.98, P = .0000$ ). The ice pack group's intramuscular temperature increased over each 5-minute interval of the 30-minute post-treatment period for an overall increase of  $2.0 \pm 3.1^\circ\text{C}$ . During the 30-minute post-treatment the cold whirlpool group continued to cool, for an overall decrease of  $1.8 \pm 1.4^\circ\text{C}$ . This difference between groups at the end of the 30-minute post-treatment was significant ( $t(30) = 4.44, P = .0001$ ).

**Conclusions:** As administered in our protocol, cold whirlpool is superior to crushed-ice packs in maintaining prolonged significant temperature reduction after treatment.

**Key Words:** ice packs, whirlpool, rehabilitation

Cryotherapy has become a vital component in the immediate management and rehabilitation of musculoskeletal trauma due to sport injuries.<sup>1–10</sup> Several factors affect the degree of superficial and deep tissue temperature change accomplished during cryotherapy: eg, tissue type, depth of the target tissue, temperature gradient between the target tissue and the cooling agent, size of the area being treated, and length of the application.<sup>3,6,8–13</sup>

The methods available for applying cold are numerous, but perhaps two of the most commonly used clinical techniques are crushed-ice packs and cold whirlpool.<sup>2,3,5</sup> Both methods are inexpensive and widely available. Research is not in agreement with regard to the effects on intramuscular temperature produced by ice packs and cold water baths. Studies have reported increases,<sup>14,15</sup> decreases,<sup>13,14,16,17</sup> and little or no change<sup>10,12,14,18,19</sup> in intramuscular temperatures in the initial minutes after the application of cryotherapy. Reports on rewarming have varied as well. Some researchers have observed immediate rewarming<sup>18</sup> while others have seen continued declines at the conclusion of the cryotherapy treatment.<sup>10,19</sup> Little research has been done examining the effects of ice packs or cold water baths on subcutaneous tissue.<sup>6,12,15,18</sup> Much cryotherapy research has used surface

temperature as a dependent variable for evaluating the effectiveness of cryotherapy. Recent research has questioned the validity of this protocol.<sup>10</sup> It is important that the clinician be aware of the efficiency with which these modalities cool the target tissue (ie, muscle) and the length of time their effects are maintained in order to authoritatively prescribe treatment frequency and duration. Thus, the purpose of our study was to compare the cooling and rewarming effects of 20-minute treatments of crushed-ice pack and cold whirlpool cryotherapy, as commonly applied in the clinic, on the subcutaneous and intramuscular temperatures of the human lower leg.

## METHODS

Thirty-two college students (17 men, age =  $25.2 \pm 2.6$  yr, wt =  $84.7 \pm 12.7$  kg; 15 women, age =  $21.7 \pm 2.3$  yr, wt =  $65.2 \pm 10.5$  kg) volunteered and signed a Brigham Young University Human Subject's Institutional Review Board approved consent form to become subjects. We verbally screened subjects for a history of peripheral vascular disease or allergy to cephalixin hydrochloride (Keftab, Dista Products and Eli Lilly Co, Indianapolis, IN). Subjects were administered one 500-mg dose of Keftab immediately before the experiment to

minimize the risk of infection. Each subject was instructed to take three similar doses at 6-hour intervals following the conclusion of the experiment.

Our procedures were similar to those previously reported.<sup>11</sup> We measured each subject's height, weight, and maximum calf girth of the left lower leg. The skinfold was measured with a Lange Skinfold Caliper (Cambridge Scientific Industries, Ltd, Cambridge, MD) and we divided this measurement by two to determine the depth of subcutaneous fat over each subject's gastrocnemius. Subjects assumed a prone position on a standard examining table. A 4-cm × 4-cm area of skin was shaved over the muscle belly of the left medial calf. We cleansed this area thoroughly, first with a 10% povidone-iodine (Betadine, The Purdue Frederick Co, Norwalk, CT) scrub and then with a 70% isopropyl alcohol swab.

We measured subcutaneous and muscle tissue temperatures with 26-gauge hypodermic needle microprobes (Physitemp MT-26/2 and MT-26/4, Physitemp Instruments, Inc, Clifton, NJ). The microprobes were sterilized in a gas autoclave, using ethylene oxide, following hospital sterilization procedures. We inserted the intramuscular microprobe (MT-26/4) from the medial side into the midbelly of the left calf. The sensor tip of this probe was positioned in the center of the lower leg to a depth of 1 cm below the subcutaneous fat and skin. We measured the appropriate distance down vertically from the posterior surface of the lower leg with a caliper to ensure the probe was inserted at the proper depth.<sup>11</sup> A second probe (MT-26/2) was inserted just below the skin, perpendicular to the first, so that its sensor tip was approximately 0.5 cm distal to the sensor tip of the first probe (Fig 1). The microprobes were then connected to the digital monitor (Bailey Instruments BAT-12, Physitemp Instruments, Inc, Clifton, NJ) and after 3 minutes the baseline intramuscular and subcutaneous temperatures were recorded. Subjects were randomly assigned to either the crushed-ice pack or cold whirlpool treatment group. The ice pack group had 9 men and 7 women, while the whirlpool group had 8 men and 8 women. The ice pack group had a 1.8-kg ice pack (approximately 25 cm × 30 cm × 5 cm) placed directly over the triceps surae muscle group for 20

minutes (Fig 2). The cold whirlpool group immersed their left lower legs in the 244-L extremity whirlpool (Whitehall Manufacturing Inc, City of Industry, CA) to a depth of approximately 5 cm below the joint line (Fig 3). The leg was kept 15 to 20 cm away from the airflow, which remained on low throughout the treatment. The temperature of the water in the cold whirlpool was maintained at 10°C. We recorded intramuscular and subcutaneous temperature every 30 seconds over the entire treatment time and for 30 minutes post-treatment. At the conclusion of the recovery period of each treatment we removed the microprobes, dried the limb, and swabbed the area with 70% isopropyl alcohol. The dry and wet bulb temperatures and relative humidity of the room were  $23.8 \pm 0.5^\circ\text{C}$ ,  $13.5 \pm 0.9^\circ\text{C}$ , and  $31.6 \pm 5.8\%$ , respectively, over the duration of the study.

## Design and Analysis

Our independent variables were treatments and time. Our dependent variable was temperature. For the two treatment groups we calculated the temperature changes, in the two tissues, from the baseline (beginning of the treatment) to the end of each 20-minute treatment. We also calculated temperature change, in both tissues, over each 5-minute interval of treatment for both treatment groups. For each tissue, we analyzed the temperature change between treatments with *t* tests. The same calculations and analyses were performed for the 30-minute post-treatment period.

## RESULTS

In Figure 4 we show mean intramuscular temperature at each time point throughout the treatment and post-treatment along with error bars of  $\pm 2$  standard errors of the mean for both ice pack and cold whirlpool conditions. Table 1 gives the intramuscular temperature change over the same time periods for both conditions. Figure 5 shows the same information as Figure 4 for subcutaneous tissue. Table 2 gives the same information as Table 1 for subcutaneous tissue. Figures 4 and

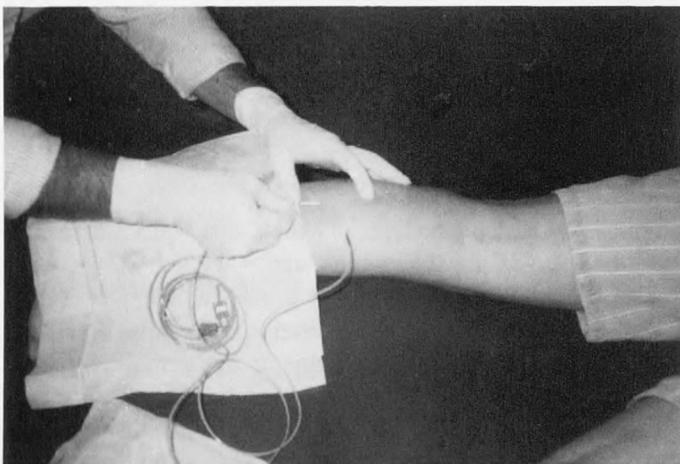


Fig 1. Insertion of the subcutaneous needle microprobe.



Fig 2. Ice pack placement over the triceps surae muscle group.



Fig 3. Immersion of the left lower leg in the cold whirlpool.

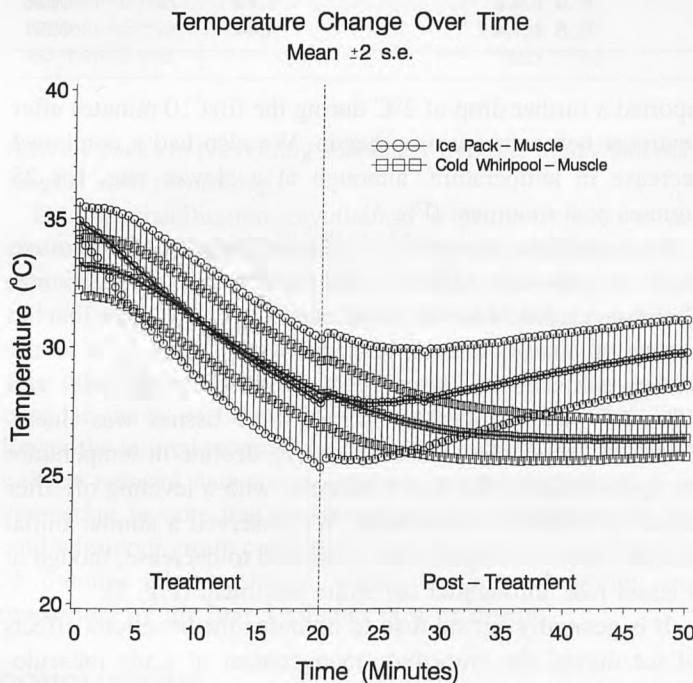


Fig 4. Intramuscular temperature during and after a 20-minute ice pack or cold whirlpool treatment. Figure shows mean values  $\pm 2$  standard errors for each treatment.

5 give an overall view of the temperature change along with appropriate measures of variability in each treatment condition.

There were no significant differences in the decrease in intramuscular temperatures between treatments at each 5-minute interval and at the end of the 20-minute treatment (Table 1). By the conclusion of the 20-minute treatment, the ice pack and cold whirlpool decreased intramuscular temperature  $7.1 \pm 4.1^\circ\text{C}$  and  $5.1 \pm 1.8^\circ\text{C}$ , respectively (Fig 4). The ice pack treatment significantly decreased the subcutaneous temperature more than the whirlpool,  $17.0 \pm 3.8^\circ\text{C}$  and  $13.8 \pm 3.0^\circ\text{C}$ , respectively (Table 2). The subcutaneous temperature rewarmed significantly more in the ice pack group ( $12.3 \pm 3.3^\circ\text{C}$ ) than the cold whirlpool ( $7.4 \pm 2.1^\circ\text{C}$ ) (Table 2). The ice pack group's intramuscular temperature increased over each

5-minute interval of the 30-minute post-treatment period, for an increase of  $2.0 \pm 3.1^\circ\text{C}$  (Table 1). The cold whirlpool group, however, continued to cool during the post-treatment period, for an additional decrease of  $1.8 \pm 1.4^\circ\text{C}$  (Table 1).

## DISCUSSION

Research is not in agreement with regard to the effects on intramuscular temperature produced by ice packs and cold water baths. An early experiment by Bing et al<sup>14</sup> exemplifies the variability found in the ice pack research. Twenty-three subjects had ice placed on their biceps brachii for 5 minutes. The temperature was recorded at a depth of 3 cm. In 10 of the 23 subjects, a rise in temperature of  $0.5^\circ\text{C}$  was observed at the beginning of the treatment. The increased temperature lasted for 3 to 4 minutes before it began to decline. They observed a continuous range from no decrease in muscle temperature to a decrease of  $5.7^\circ\text{C}$  in the 23 subjects. The mean decline was  $2.3^\circ\text{C}$ .<sup>14</sup>

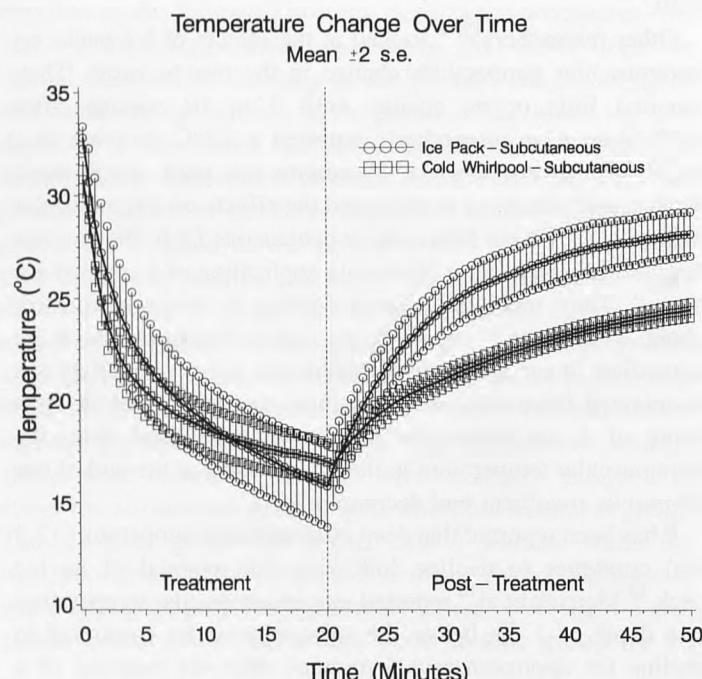
Other researchers<sup>12,18</sup> looked at the effects of ice packs on intramuscular temperature change in the triceps surae. They reported little or no change until 7 to 10 minutes after application. One researcher<sup>12</sup> reported a  $3.3^\circ\text{C}$  decrease at a depth of 5.0 cm after a 30-minute ice pack application. Researchers also have investigated the effects on intramuscular temperature at 1 cm below the subcutaneous fat in the anterior thigh during and after a 30-minute application of a crushed-ice pack.<sup>10</sup> They reported a linear decline in temperature after about 4 minutes.<sup>10</sup> We, on the other hand, observed an immediate linear decline in intramuscular temperature that was maintained throughout our 20-minute treatment (Fig 4). At a depth of 1 cm below the subcutaneous fat and skin, the intramuscular temperature in the triceps surae at the end of our 20-minute treatment had decreased  $7.1^\circ\text{C}$ .

It has been reported that deep intramuscular temperature (2.3 cm) continues to decline following the removal of an ice pack.<sup>18</sup> Merrick et al<sup>10</sup> reported that intramuscular temperature at a depth of 1 cm below the subcutaneous fat continued to decline for approximately 5 minutes after the removal of a crushed-ice pack. Our results indicated that the decline is very minimal and that by 5 minutes post-treatment the muscle has begun to rewarm (Fig 4).

The cold water bath research is just as varied. One researcher,<sup>15</sup> using a  $1^\circ\text{C}$  water bath, reported an initial minimal increase, which was followed by a substantially greater and longer decrease in intramuscular temperature of the brachioradialis at a depth of 1.5 cm. Another investigator,<sup>19</sup> using a  $12.5^\circ$  to  $13^\circ\text{C}$  water bath, noted no change in temperature in the triceps surae until 2 minutes, whereupon the decline was nearly linear. The depth was not given, but the target was the "center of the muscle" and a  $6^\circ\text{C}$  decrease was observed by the end of the 30-minute treatment. Several researchers<sup>13,16,17</sup> have reported an immediate and steady decline in intramuscular temperatures using cold water baths. Two studies,<sup>13,16</sup> using a depth of 2.5 cm in the brachioradialis as the target tissue,

**Table 1. Intramuscular Temperature Change ( $^{\circ}\text{C} \pm \text{SD}$ ) Between Analyzed Time Points Within the Ice Pack and Cold Whirlpool Groups**

Time Points (5-Min Intervals)	Ice Pack Temperature Change ( $^{\circ}\text{C} \pm \text{SD}$ )	Cold Whirlpool Temperature Change ( $^{\circ}\text{C} \pm \text{SD}$ )	t-value	P value
Baseline temperature	$34.9 \pm 1.4$	$33.3 \pm 2.1$	2.54	.01
20 min treatment				
5 min-baseline	$-1.9 \pm 2.9$	$-0.8 \pm 0.6$	-1.60	.12
10 min-5 min	$-1.9 \pm 1.1$	$-1.5 \pm 0.7$	-1.22	.23
15 min-10 min	$-1.8 \pm 0.8$	$-1.5 \pm 0.5$	-1.25	.22
20 min-15 min	$-1.4 \pm 0.7$	$-1.3 \pm 0.4$	-0.53	.60
20 min-baseline	$-7.1 \pm 4.1$	$-5.1 \pm 1.8$	-1.76	.09
30 min post-treatment				
25 min-20 min	$.0 \pm 1.2$	$-.8 \pm 0.4$	2.60	.01
30 min-25 min	$.3 \pm 0.9$	$-.6 \pm 0.4$	3.66	.001
35 min-30 min	$.5 \pm 0.6$	$-.2 \pm 0.3$	4.51	.0001
40 min-35 min	$.5 \pm 0.4$	$-.1 \pm 0.2$	4.89	.0001
45 min-40 min	$.4 \pm 0.3$	$-.0 \pm 0.2$	4.30	.0002
50 min-45 min	$.3 \pm 0.3$	$-.0 \pm 0.2$	3.15	.0036
50 min-20 min	$2.0 \pm 3.1$	$-1.8 \pm 1.4$	4.44	.0001

**Fig 5. Subcutaneous temperature during and after a 20-minute ice pack or cold whirlpool treatment. Figure shows mean values  $\pm 2$  standard errors for each treatment.**

reported decreases of  $12^{\circ}$  to  $13^{\circ}\text{C}$  after 30-minute submersion in  $12^{\circ}\text{C}$  water baths. A third study,<sup>17</sup> using the same depth but in the triceps surae and a  $10^{\circ}\text{C}$  water bath, reported a  $12^{\circ}\text{C}$  decline after 30 minutes and an approximate  $9.5^{\circ}\text{C}$  decrease after 20 minutes of treatment. Our results indicated a 2- to 3-minute delay before a steady linear decline occurred throughout the remainder of the 20-minute treatment (Fig 4). The decrease by the end of our treatment was  $5.1^{\circ}\text{C}$ .

Both immediate rewarming<sup>18</sup> and continued decline<sup>19</sup> of intramuscular temperatures in the triceps surae have been reported following cold water baths. Petajan and Watts<sup>19</sup>

reported a further drop of  $2^{\circ}\text{C}$  during the first 10 minutes after treatment before rewarming began. We also had a continued decrease in temperature, although at a slower rate, for 25 minutes post-treatment (Fig 4).

We found little research<sup>6,12,15,18</sup> examining the effects of ice packs or cold-water baths on subcutaneous tissue temperature. The research did, however, (with one exception)<sup>6</sup> agree that the pattern of change for subcutaneous tissue was closer to the pattern exhibited by the skin than by muscle. Barcroft and Edholm<sup>16</sup> said the decline for all three tissues was linear. Others<sup>15,18</sup> have reported a very rapid decline in temperature for approximately the first 5 minutes, with a leveling off after about 10 minutes of treatment. We observed a similar initial decline, but our temperatures continued to decrease, though at a lesser rate, throughout the entire treatment (Fig. 5).

It is generally agreed that, to optimize the beneficial effects of ice during the immediate management of acute musculoskeletal injury, ice should be applied as quickly as possible following a thorough evaluation.<sup>1-3,5</sup> Knight<sup>3</sup> contends that the primary reason for applying ice during immediate management is to minimize secondary hypoxic injury. The sooner the target tissue is cooled following injury, the less secondary hypoxic injury will occur.<sup>3,7</sup>

Our results indicate that significant intramuscular temperature decreases can be accomplished with either crushed-ice packs or cold whirlpool. Though statistically nonsignificant, the crushed-ice pack produced a temperature decrease of  $2^{\circ}\text{C}$  greater than the cold whirlpool. Second, the rewarming rate of the ice pack group was significantly faster than the whirlpool group. This is important when returning an athlete to play after receiving cryotherapy is desired, because any possible deficit in neural or muscular function that may occur due to the cold will be eliminated upon rewarming.<sup>3,8</sup> It may be, however, that the sustained temperature reductions brought about by the cold whirlpool, after the treatment is concluded, are more effective

**Table 2. Subcutaneous Temperature Change ( $^{\circ}\text{C} \pm \text{SD}$ ) Between Analyzed Time Points Within the Ice Pack and Cold Whirlpool Groups**

Time Points (5-Min Intervals)	Ice Pack Temperature Change ( $^{\circ}\text{C} \pm \text{SD}$ )	Cold Whirlpool Temperature Change ( $^{\circ}\text{C} \pm \text{SD}$ )	t-value	P value
Baseline temperature	30.8 ± 1.8	32.8 ± 1.1	-3.8	.0006
20 min treatment				
5 min-baseline	-10.9 ± 4.5	-10.3 ± 3.4	-.39	.70
10 min-5 min	-2.9 ± 1.3	-1.9 ± .5	-3.11	.004
15 min-10 min	-1.8 ± 0.7	-1.0 ± .3	-4.28	.0002
20 min-15 min	-1.4 ± 0.7	-.3 ± .3	-4.41	.0001
20 min-baseline	-17.0 ± 3.8	-13.8 ± 3.0	-2.64	.01
30 min post-treatment				
25 min-20 min	5.8 ± 2.5	2.6 ± .4	4.38	.0001
30 min-25 min	3.0 ± 1.3	1.5 ± .4	4.60	.0001
35 min-30 min	1.4 ± .4	1.2 ± .3	2.29	.02
40 min-35 min	1.1 ± .3	.9 ± .2	1.36	.18
45 min-40 min	.5 ± .4	.7 ± .2	-1.30	.20
50 min-45 min	.4 ± .3	.5 ± .1	-1.27	.22
50 min-20 min	12.3 ± 3.3	7.4 ± 2.1	4.98	.0000

than ice packs in preventing secondary hypoxic injury that may resume with rewarming.

During rehabilitation, cryotherapy is primarily used to decrease pain and muscle spasm, thereby allowing therapeutic exercise to begin earlier than would otherwise be possible.<sup>1-4,20,21</sup> The most efficient use of cold during rehabilitation is with cryokinetics. The cold is used to partially desensitize the injured area, so that graded, progressive, active exercise can be performed by the injured athlete.<sup>1-4,9,20,21</sup> The longer the injured part remains cold, the longer pain and spasm will be reduced and active exercise can be performed. It is interesting to note that the intramuscular temperature in the cold whirlpool group continued to get progressively colder for 25 minutes after treatment, while the ice pack group was rewarming by the first 5 minutes post-treatment.

## CONCLUSIONS

We believe our results have significant clinical application. If rapid and significant temperature decrease is your goal, as in the immediate management of athletic injuries, our results suggest crushed-ice packs are superior to cold whirlpool. But if your goal is significant prolonged temperature reduction to facilitate active exercise during rehabilitation using cryokinetics, our results indicate cold whirlpool is superior to crushed-ice packs.

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# The Comparative Effects of Sports Massage, Active Recovery, and Rest in Promoting Blood Lactate Clearance After Supramaximal Leg Exercise

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**Objective:** To determine the comparative effect of sports massage, active recovery, and rest on promoting blood lactate clearance after maximal anaerobic (supramaximal) leg exercise.

**Design and Setting:** A counterbalanced experimental design with repeated measures was used. The repeated measures were the three treatment conditions. The order of the conditions was determined by random assignment to a counterbalanced test sequence. All data were collected in the Human Energy Research Laboratory at the University of Pittsburgh.

**Subjects:** Ten male competitive cyclists volunteered for this investigation.

**Measurements:** Serial venous blood samples were drawn and analyzed for blood lactate concentration for each test condition.

Lactate metabolism and its rate of elimination from blood and muscle are important components of recovery following maximal exercise.<sup>1</sup> It has been well documented that performing low-intensity aerobic exercise (active recovery) during the immediate postexercise period is more effective in accelerating lactate clearance than inactive rest (passive recovery).<sup>1-7</sup>

Active recovery promotes lactate clearance by increasing metabolic rate and systemic blood flow, thereby accelerating lactate metabolism via oxidation and gluconeogenesis.<sup>1,4,8,9</sup> Although some controversy exists regarding the optimal intensity for active exercise recovery, a metabolic rate corresponding to 40% of maximum oxygen uptake ( $VO_{2\text{max}}$ ) has been shown to be effective for accelerating lactate clearance following maximal exercise.<sup>1,2,4,6,7</sup>

Sports massage is commonly used in an effort to facilitate lactate clearance despite the lack of controlled research to support its efficacy in this regard. Developed in the 1980s, sports massage incorporates classic Swedish strokes with

**Results:** There were significant main effects for both absolute and relative values of blood lactate concentration between the three treatment groups and across time within groups.

**Conclusions:** After supramaximal leg exercise, active recovery produced significant decreases in both absolute and relative measures of blood lactate concentration when compared with the sports massage and rest conditions. No significant difference was found between sports massage and rest for either absolute or relative changes in blood lactate concentration.

**Key Words:** anaerobic glycolysis, lactic acid, metabolic acidosis

compression, trigger-point therapy, and cross-fiber friction techniques.<sup>10</sup> It was "designed to provide therapeutic impact to meet the unique physical and biomechanical needs of athletes" and is typically divided into pre-event/postevent and maintenance routines.<sup>10</sup>

Specific massage techniques are thought to produce local increases in skeletal muscle blood flow via several mechanisms. Direct mechanical effects on tissue vasculature, circulatory changes secondary to the local release of vasodilators, and reflexive decreases in sympathetic tone elicited by direct tissue stimulation have all been proposed as possible explanations.<sup>11-16</sup> Theoretically, increases in skeletal muscle blood flow may accelerate the rate at which lactate is shuttled to various sites of elimination, thereby promoting its clearance.<sup>11,12,16</sup> Previous studies concerning the effects of massage on skeletal muscle blood flow have been contradictory and difficult to compare due to differences in experimental designs, statistical analyses, and the massage techniques used.<sup>11</sup> However, Hansen and Kristensen<sup>13</sup> reported that effleurage

produced a small and transient increase in blood flow. Hovind and Nielsen<sup>14</sup> reported that petrissage had a variable and inconsistent effect on blood flow, while tapotement produced significant increases in blood flow comparable with exercise hyperemia. The compression stroke, the hallmark of sports massage, is reported to produce significant increases in skeletal muscle blood flow.<sup>15,17</sup> However, there have been no studies to date that have examined the effect of the compression technique on either skeletal muscle flow or the rate of postexercise lactate clearance.

Currently, there is a lack of controlled research to support the efficacy of sports massage on accelerating the rate of postexercise blood lactate clearance. Therefore, the purpose of this investigation was to compare the effects of sports massage, active recovery, and rest in promoting blood lactate clearance after supramaximal leg exercise.

## METHODS

### Subjects

Ten male members of the Panther Cycling Club, ranging in age from 21 to 34 years, volunteered as subjects for this investigation (Table 1). Inclusion criteria for subjects were 1) males, 18 years of age or older, with similar aerobic fitness levels and years of competitive cycling experience; 2) no history of cardiovascular, orthopaedic, or metabolic disorders that may negatively affect the subject's ability to perform high-intensity exercise; and 3) no contraindications to massage therapy. Each subject received information regarding the risks and benefits of the investigation and gave written consent to participate. All procedures were approved by the University of Pittsburgh's Biomedical Institutional Review Board.

### Experimental Design

This investigation used a counterbalanced experimental design with repeated measures under three experimental conditions: sports massage, active recovery, and rest (control). All subjects participated in each of the three experimental conditions. The order of the conditions was determined by random assignment to a counterbalanced sequence using the latin square technique.

Subjects were instructed to refrain from heavy physical exercise 24 hours before each testing session. Testing sessions were separated by at least 48 hours. The consumption of food and fluid, except water, was prohibited for 3 hours before each testing session.  $\text{VO}_2\text{peak}$  was determined for each subject on the first visit to the laboratory. After  $\text{VO}_2\text{peak}$  was determined,

each subject was then randomly assigned to the counterbalanced test sequence.

### Testing Protocols and Equipment

**$\text{VO}_2\text{peak}$ .** We determined  $\text{VO}_2\text{peak}$  using a Monark cycle ergometer (model #818, Monark, Inc, Stockholm, Sweden) with a continuous protocol. Pedaling rate was 80 revolutions per minute and paced by a metronome. We increased the power output every 3 minutes. Subjects began the test at a brake force of 1.0 kg. We increased the brake force by 1.0 kg for stage 2, then by 0.5 kg for the remaining test stages. Our criteria for test termination were 1) inability of the subject to maintain the pedaling rate for 15 consecutive seconds (as determined by the principal investigator); 2) volitional termination by the subject due to exhaustion; or 3) a plateau of  $\text{VO}_2$  in presence of increasing power output. The subject then underwent a cool-down period of cycling at a low brake resistance until he felt sufficiently recovered.

The criteria for  $\text{VO}_2\text{peak}$  were the attainment of at least two of the following: 1) a plateau of  $\text{VO}_2$  in the presence of increasing power output, 2) respiratory exchange ratio (RER) greater than or equal to 1.1, or 3) heart rate  $\pm 5$  beats per minute of the subject's age-predicted maximal heart rate. We determined the value for  $\text{VO}_2\text{peak}$  by averaging the two highest consecutive 30-second  $\text{VO}_2$  values.

We assessed heart rate before the test and during each exercise stage, using an Eaton Care Telemetry unit (Eaton Care, Inc, Ann Arbor, MI) with a CM5 electrode placement. We used a respiratory mouthpiece attached to a two-way Hans-Randolph respiratory valve (Hans-Randolph, Kansas City, MO) to collect expired gases. Respiratory-metabolic data (standard temperature, standard pressure, dry;  $\text{VO}_2$ ,  $\text{VCO}_2$ , and RER) were determined every 30 seconds using an open-circuit spirometry system and on-line computer. Inspired ventilation was measured with a Rayfield Equipment RAM 9200 flowmeter (Ametek Thermox Instruments Division, Pittsburgh, PA). Expired gases were continuously sampled from a 5-L mixing chamber using Ametek CD-3A carbon dioxide and S-3A oxygen analyzers and an R-2 Flow Control Meter (Ametek Thermox). Raw data were continuously monitored by a Lawson Laboratories Data Acquisition program (Lawson Laboratories, Malvern, PA) and 12-bit A/D converter (Ametek Thermox). We calibrated analyzers with standard gases of known composition before and after each testing session.

**Wingate anaerobic test.** We used three successive Wingate cycle tests, with 2-minute rest intervals between each, to elevate blood lactate levels. The protocol calls for the subject to perform 30 seconds of "all out" (supramaximal) cycling at a

**Table 1. Subject Characteristics\***

Age	Height	Weight	$\text{VO}_2\text{peak}$
24.5 $\pm$ 3.98 yr	174.56 $\pm$ 6.62 cm	69.90 $\pm$ 5.46 kg	55.87 $\pm$ 3.82 ml $\cdot$ kg $^{-1}$ $\cdot$ min $^{-1}$

\* Values are mean  $\pm$  standard deviation.

very high braking force that was indexed to body weight.<sup>18</sup> The Wingate test has been shown to rely on anaerobic glycogenolysis as the primary energy pathway, producing blood lactate concentrations ranging from 6 to 15 times above resting levels.<sup>18,19</sup> All Wingate tests were performed on a Monark cycle ergometer interfaced with an IBM-compatible computer. We used a software package manufactured by Sports Medicine Industries, Inc (Version 102A, 1992, St. Cloud, MN) to determine the braking force for each subject and to generate an on-line analysis of anaerobic power. We used toe clips to maximize the involvement of both the quadriceps and hamstrings muscle groups.

**Blood sampling.** We obtained serial blood samples (2 mL) from an indwelling catheter (21-gauge) inserted into a prominent antecubital vein 10 minutes before exercise. The catheter was kept patent by infusion of a heparinized saline solution (0.4 mL/100 mL). Blood samples were obtained before exercise (resting sample), immediately after each Wingate cycle test, 5 minutes after the final Wingate cycle test, and at 5-minute intervals throughout each 20-minute experimental condition (samples 1–9, respectively). Blood lactate concentration (mmol/L) was analyzed using a Yellow Springs 2700 Select Biochemistry Analyzer (Yellow Springs Instrument Co, Inc, Yellow Springs, OH). The recorded value was the average of two readings per sample.

## Sports Massage

The sports massage techniques we employed in our investigation are those typically used in a postevent routine (Table 2). We used the techniques of effleurage, petrissage, tapotement, and compression in an effort to increase blood flow through the previously active muscle beds. Effleurage is defined as any stroke that glides over the skin without attempting to move the deep muscle masses.<sup>20</sup> The technique is applied with firm, even hand pressure in the direction of venous return. Petrissage consists of kneading manipulations that compress and roll the skin and muscle under the hands/fingers.<sup>20</sup> Tapotement is any series of brisk blows that follow

each other in a rapid, alternating fashion.<sup>20</sup> Our protocol used two specific types of tapotement: pounding (closed fists) and hacking (ulnar borders of the hands). Compression involves conforming the hands to the muscle and applying a downward compressive force against the underlying bone, followed by a quick release.<sup>15,17</sup> The technique is applied in a rhythmic fashion along the length of the muscle.

We used a 5-minute sports massage routine for each leg in both the supine and prone positions. Massage was first performed with the subject in the supine position, beginning with the right leg, then the left. The subject was then placed in the prone position and the massage continued, beginning again with the right leg.

The principal investigator, certified in sports massage, performed all massage therapy to ensure consistency within the experimental protocol. To ensure proper timing of techniques, we employed audio cues on a cassette recorder. A massage cream was used after the compression technique to decrease friction between the investigator's hands and the subject's skin.

## Testing Procedures

After the third Wingate test, subjects remained seated for 5 minutes on the cycle ergometer without pedaling, allowing blood lactate levels to reach peak postexercise levels. At the end of this 5-minute period, a blood sample was obtained and one of the three experimental conditions was immediately initiated. The procedures for the three 20-minute treatment conditions were as follows: 1) during active recovery, the subject pedaled the cycle ergometer at 80 revolutions per minute at an intensity equal to 40%  $\text{VO}_{2\text{peak}}$ ; 2) during the massage condition, the subject proceeded immediately to a massage table positioned next to the cycle ergometer; and 3) during the rest (control) condition, the subject proceeded immediately to a table positioned next to the cycle ergometer and remained lying in the supine position for 20 minutes.

## Statistical Analysis

A *t* test was used to determine if blood lactate concentration increased as a result of the three successive Wingate tests. Significance ( $P < .05$ ) was determined by comparing the mean of blood sample one (resting level) with the mean of blood sample five (peak lactate value) across all conditions.

To determine if there were significant changes in blood lactate levels as a result of the treatments, the absolute and relative changes were analyzed separately using a two-factor (treatment  $\times$  time) repeated-measures analysis of variance ( $P < .05$ ). Absolute changes in blood lactate were expressed as a difference (mL/L) between the peak lactate value and the value at the end of the 20-minute treatment condition. Relative changes were expressed as a percent decrease from peak lactate concentration to the end of the treatment.

A Scheffe post hoc procedure was performed to probe significant main and interaction effects in absolute and relative

**Table 2. Sports Massage Protocol**

Time (min:sec)	Technique
Supine position	
0:00 – 1:00	Compression: lower leg/quadriceps
1:00 – 1:45	Effleurage: ankle to crease of hip
1:45 – 2:30	Thumb effleurage: anterior/lateral aspects lower leg
2:30 – 3:00	Petrissage: quadriceps
3:00 – 4:30	Tapotement: quadriceps
4:30 – 5:00	Effleurage: ankle to crease of hip
Prone position	
0:00 – 2:00	Compression: calf/hamstrings
2:00 – 2:30	Effleurage: ankle to upper thigh
2:30 – 3:30	Petrissage: calf/hamstrings
3:30 – 4:30	Tapotement: calf/hamstrings
4:30 – 5:00	Effleurage: ankle to upper thigh

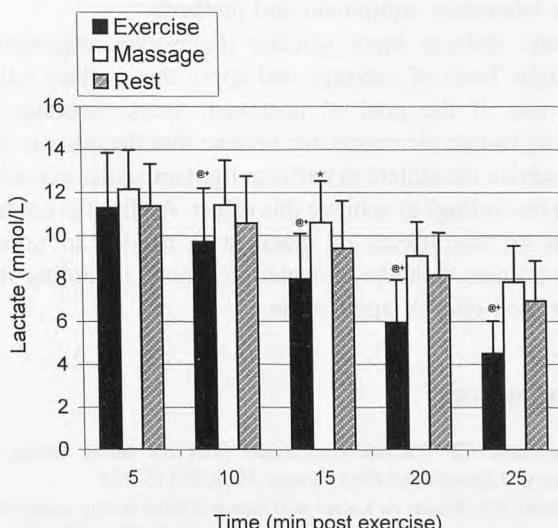
changes in blood lactate between and within the three treatment groups.

## RESULTS

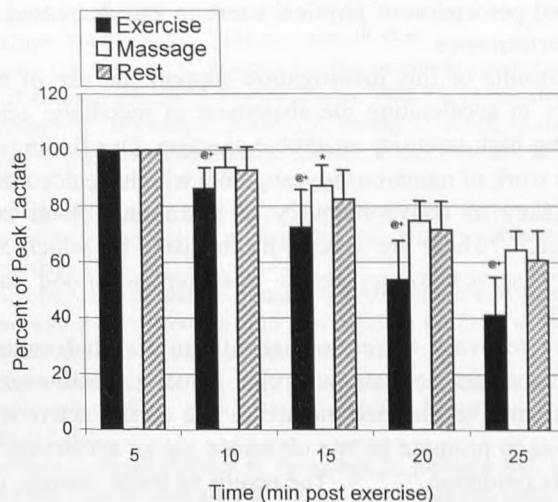
Results of the *t* test revealed a significant increase ( $P < .05$ ) in blood lactate levels after the Wingate cycle tests. This demonstrates that three successive Wingate cycle tests were an effective method for elevating blood lactate levels.

Analysis of variance indicated significant main effects for both absolute and relative values of blood lactate concentration among the three treatment groups ( $F = 6.16, P = .009$  and  $F = 31.52, P = .000$ , respectively) and across time within groups ( $F = 119.34, P = .000$  and  $F = 162.78, P = .000$ , respectively). In addition, a significant condition-by-time interaction effect was also found. Means and standard errors for absolute and relative changes in lactate responses among conditions across time are presented in Figures 1 and 2. Post hoc analysis indicated significant differences for both absolute and relative changes in blood lactate concentration between active recovery and sports massage and between active recovery and rest (control). When expressed in absolute terms, active recovery produced a mean decrease ( $P < .05$ ) of 6.79 mL/L, compared with 4.39 and 4.33 mL/L for the sports massage and rest conditions, respectively. In relative terms, exercise resulted in a 59.38% decrease ( $P < .05$ ) in blood lactate concentration, compared with 36.21% and 38.67% for the sports massage and rest conditions, respectively. A significant difference was found between sports massage and rest conditions at only one time point (15 minutes postexercise) for both absolute and relative changes in blood lactate concentration.

In summary, our results demonstrated that after supramaximal leg exercise 1) 20 minutes of sports massage performed on the involved limbs had no significant effect, when compared with the rest condition, on either absolute or relative changes in



**Fig 1. Absolute postexercise blood lactate concentration for exercise (E), massage (M), and rest (R) conditions. Symbols: \* for M > R ( $P < .05$ ); @ for R > E ( $P < .05$ ); + for M > E ( $P < .05$ ).**



**Fig 2. Relative postexercise blood lactate concentration for exercise (E), massage (M), and rest (R) conditions. Symbols: \* for M > R ( $P < 0.05$ ); @ for R > E ( $P < 0.05$ ); + for M > E ( $P < 0.05$ ).**

blood lactate concentration, and 2) 20 minutes of active recovery exercise at 40%  $\text{VO}_{2\text{peak}}$  produced significant decreases in both absolute and relative values of blood lactate concentration when compared with the sports massage and rest conditions.

## DISCUSSION

During short-term, dynamic exercise at maximal intensity, most of the required energy is provided through anaerobic glycolytic pathways leading to lactic acid production.<sup>19,21-25</sup> At physiologic pH in the blood, the lactic acid molecule dissociates, yielding a hydrogen proton and a lactate anion.<sup>9,26</sup> During this mode of exercise, it is the accumulation of hydrogen ions that decreases blood pH below the normal 7.4, resulting in metabolic acidosis.<sup>1,4,18,26-29</sup>

Metabolic acidosis has been shown to be a major factor in muscular fatigue during short-term, high-intensity exercise.<sup>6,17,27-30</sup> The resultant decrease in muscle force production consequent to lactate accumulation is, in turn, rate limiting for peak anaerobic exercise performance. Therefore, accelerating blood lactate clearance immediately postexercise may be beneficial for a succeeding bout of high-intensity exercise, particularly during athletic competitions that require multiple performances in a single day.<sup>2</sup>

Several mechanisms have been proposed to explain how metabolic acidosis predisposes an athlete to muscular fatigue. Within the exercising skeletal muscle, acidotic shifts in pH secondary to lactate accumulation serve to retard free fatty acid mobilization and slow glycolysis by inhibiting the activity of lactate dehydrogenase and phosphofructokinase. Both of these enzymes are important in regulating anaerobic energy production.<sup>1,2,4,7,26</sup> In addition, high concentrations of intramuscular hydrogen ions may act to displace calcium ions from troponin, thereby inhibiting muscle contraction.<sup>1,4,26</sup> Low blood pH has also been shown to stimulate pain receptors, contributing to an

increased perception of physical exertion and decreased muscular performance.<sup>26,29,30</sup>

The results of this investigation support the use of active recovery in accelerating the abatement of metabolic acidosis following high-intensity anaerobic exercise. Our findings support the work of numerous investigators who have documented the efficacy of active recovery in promoting blood lactate clearance.<sup>1-7</sup> There are several mechanisms by which active recovery serves to accelerate postexercise blood lactate clearance.

Active recovery serves to maintain an elevated metabolic rate but does not activate anaerobic glycolytic pathways to a great extent. The elevated metabolic rate during active recovery serves to promote lactate clearance via an accelerated rate of lactate oxidation.<sup>1,4,8,9,31</sup> The results of tracer studies, using isotope-labeled lactate, provide strong support for the conclusion that oxidation is by far the most significant pathway for lactate elimination, accounting for as much as 70% of lactate disposal.<sup>1,8,9,32</sup>

Active recovery also promotes lactate clearance via an increased use of lactate as a fuel by the heart and contracting skeletal muscle.<sup>8,9,31</sup> Lactate, which is produced in Type IIb fibers, is transported into Type I or IIa fibers, where it is oxidized.<sup>33</sup> Therefore, glycolytic fibers within an exercising muscle bed can shuttle oxidizable substrate (in the form of lactate) to neighboring cells with higher respiratory rates. The greater capillary density surrounding the slow-twitch fibers, coupled with their high lactate dehydrogenase enzyme content, suggests that the delivery, uptake, and subsequent oxidation of lactate is facilitated here.<sup>31,33</sup>

The results of our investigation do not support the efficacy of sports massage in promoting blood lactate clearance after high-intensity anaerobic exercise. There are several factors that can account for our findings. The prevailing popular hypothesis is that postevent sports massage promotes lactate clearance by increasing blood flow through the skeletal muscle bed. Although there is evidence that some massage techniques increase regional blood flow through skeletal muscle,<sup>13,14</sup> the magnitude of the increase may be overestimated. Cafarelli and Flint<sup>11</sup> reported that when effleurage is applied to a limb, the manual pressure applied does not directly increase arterial inflow, but serves to increase arteriolar pressure and empty the veins. Momentarily, this pressure produces a slight negative pressure in the veins that tends to draw blood in through the capillaries. The rate of blood flow is, therefore, transiently increased without an associated increase in metabolism. Similarly, Hansen and Kristensen<sup>13</sup> reported that effleurage produced a small, transient increase in blood flow but concluded that even light muscular exercise would produce a greater circulatory effect. Hovind and Nielsen<sup>14</sup> reported that petrissage did not significantly alter muscle tissue perfusion, concluding that the mechanical emptying of the vascular bed would not necessarily produce a net increase in blood flow, but may be effective for increasing lymphatic return. When describing the effects of tapotement, Hovind and Nielsen<sup>14</sup> noted

that this technique produced immediate increases in blood flow comparable with changes associated with active muscular contractions. They reported that tapotement, specifically hacking, caused repetitive muscular contractions in the treatment area, producing increases in blood flow similar to those produced by voluntary muscular contractions. However, the report clearly stated that the technique was unpleasant to the subjects and would not usually be applied in a therapeutic setting as intensively as it was in the investigation.

Furthermore, evidence suggests that increases in blood flow alone have little or no effect on lactate clearance. Gladden et al<sup>34</sup> examined the effect of blood flow on net lactate uptake in a canine model. They reported that when metabolic rate and blood lactate concentration were held constant, a 65% increase in blood flow (above the baseline) had no effect on lactate uptake and subsequent clearance. It is our opinion that postexercise sports massage, as performed in this investigation, did not beneficially influence the pathways important to lactate metabolism and its subsequent clearance from blood and tissues.

Although the results of our investigation do not support the efficacy of sports massage in promoting postexercise blood lactate clearance, further research in this area may be justified. Examining the compression technique individually, increasing the treatment time, and determining muscle lactate concentration are possible considerations for future research.

## CONCLUSIONS

Athletic trainers are frequently asked to perform sports massage by athletes who believe that these techniques will help speed recovery and enhance performance. Such claims are reported extensively in much of the popular massage literature. However, much of the supportive evidence for the positive effects of massage has been based on a vast body of anecdotal reports, rather than on sound scientific data obtained using modern laboratory equipment and methods.<sup>17</sup>

Athletic trainers must educate themselves regarding the physiologic basis of massage and apply this to their rationale for its use. If the goal of postevent sports massage is to accelerate lactate clearance, we believe that the athletic trainer should advise the athlete to perform light muscular exercise (ie, jogging or cycling) to achieve this effect. Additional controlled research on the effects of massage is needed in order for athletic trainers to make educated decisions regarding its use for sport and clinical application.

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# Establishment of Normative Data on Cognitive Tests for Comparison with Athletes Sustaining Mild Head Injury

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**Objective:** To provide normal data for comparison with objective measures of an athlete's cognitive ability after mild head injury (MHI).

**Subjects:** Seventy-two Division I college athletes.

**Design and Setting:** Athletes were assessed on three test dates (two days apart) in a sports medicine research laboratory.

**Measurements:** Normative data were collected on four cognitive tests (Hopkins Verbal Learning Test, Stroop Test, Reitan Trail-Making Tests, and Wechsler Digit Span Tests).

**Results:** A repeated-measures analysis of variance revealed significant learning effects on all tests except the Hopkins

Verbal Learning Test. A high correlation was noted between the Stroop and the Trail-Making Tests.

**Conclusions:** These normative data can be used as comparisons to provide an objective measure of an athlete's cognitive ability following MHI. By adding this test battery to the athlete's other physical and neurologic tests, the decision to return an athlete to competition after MHI can be made with greater confidence and with less risk of reinjury.

**Key Words:** neuropsychological testing, concussion

One of the most difficult problems facing athletic trainers and sports medicine personnel is the recognition, care, and management of athletes with mild head injuries (MHI). MHI has become a frequent topic of discussion among members of the sports medicine community, in part due to the number of high-profile athletes who have recently suffered complications from repeated head injuries. The lack of information on managing MHI is alarming in light of the incidence of MHI. It is estimated that 500,000 people are treated for head injuries every year in the United States alone.<sup>1</sup> Of these, approximately 250,000 injuries occur in the sport of football,<sup>2,3</sup> including as many as ten deaths every year.<sup>3–5</sup> These statistics do not include the numbers of head injuries that go unrecognized or unreported. The danger of this high incidence is that, once a player receives an MHI, the likelihood of sustaining a second MHI increases by four.<sup>6,7</sup> This phenomenon, known as second-impact syndrome, occurs when athletes return to competition with unresolved symptoms of MHI and, therefore, are placed at increased risk for further injury.<sup>7,8</sup> The difficulty in deciding when to return an athlete with MHI to competition stems from the lack of readily available testing procedures that are sensitive to functional disturbances resulting from MHI. Unlike a shoulder or ankle, in which range of motion, strength, and stability can be easily tested, the testing of MHI is more difficult.

In 1994, the National Athletic Trainers' Association held a summit on mild brain injury in sports. The purpose of the summit was to address the complex issues of evaluation, treatment, and management of head injuries and to offer

recommendations for future head injury research.<sup>9</sup> In addition to establishing consistent definitions and management protocols, it was recommended that future projects focus on neuropsychological parameters that may aid in determining the presence and extent of an athlete's head injury.

Research has indicated that neuropsychological tests can assist the clinician in discovering cognitive deficits that commonly occur after head injury.<sup>5,10–14</sup> These deficits can be measured objectively and compared with standardized normal scores to help determine the status of an athlete's head injury. Cognitive test scores can also be used as part of the decision process in returning an athlete to competition after a head injury. Despite the increased use of neuropsychological tests in the sports medicine arena, little normative data exist on athletes. Therefore, clinicians lack the information necessary for interpreting the results from injured athletes.

Our goals were to establish normative data, including possible learning effects and correlations between various cognitive tests. These data can then be compared with those of individuals tested after MHI and used to determine the influence of practice effects versus actual recovery, which may aid in the decision of when to return an injured athlete to competition.

## METHODS

Seventy-two Division I college student athletes were randomly selected from eleven varsity sports. Forty-one females and thirty-one males were included in the study. The average

age of all athletes was  $20.54 \pm 1.9$  years. Athletes who had previously sustained a head injury, who were known to have a learning disability, or who were color-blind were excluded from the study. Approval for participation was obtained from the involved coach, the athlete, and the athletic department before the athlete was enrolled in the study. All subjects were notified of the testing procedures and were asked to sign an informed consent form in accordance with the Human Subjects Committee at the University of North Carolina at Chapel Hill.

The subjects' cognitive abilities were tested on four neuropsychological tests that have been proved both valid and reliable for determining various cognitive deficits.<sup>15-18</sup>

### **The Hopkins Verbal Learning Test (HVLT) (Johns Hopkins University, Baltimore, MD)**

The HVLT is a clinical test of verbal learning and memory based on the California Verbal Learning Test, which is a more comprehensive test of verbal memory. The HVLT is much faster to conduct and can be administered in six equivalent forms to reduce any learning effects.<sup>19</sup> Each of the six forms consists of a 12-item word list composed of four words from each of three categories. The examiner reads the word list to the patient, who tries to memorize the words. The patient's free recall is tested first, after which a list of 24 words is read and the patient is asked to indicate whether or not the words appeared on the original list. The test is scored by summing the correctly recalled words in each trial and the number of correctly recalled words from the list of 24. A perfect score is 48.

### **The Stroop Test (Stoelting Company, Wood Dale, IL)**

The Stroop test is designed to assess cognitive flexibility and attention.<sup>20,21</sup> The Stroop test examines the ability to separate word- and color-naming stimuli by sorting information from one environment and reacting to this information.<sup>16</sup> The test involves three different sections. Section One is the word test, which involves the reading of 100 items, consisting of the names of different colors written in black ink. The second section is the color test, consisting of 100 items written as four Xs (ie, XXXX) in the various colors of ink named in Section One. Section Three is the color-word test, consisting of the 100 words found in Section One printed in the colors of Section Two. However, in no instance does the word correspond to the correct color. In Section One, the examiner asks the patient to read the word that is printed in black ink. In Sections Two and Three, the patient is asked to give the color of the printed item. The Stroop stimuli are thought to activate automatic verbal processing responses that interfere with the conscious thought process of color naming. The test is scored by counting the number of correctly named items in a period of 45 seconds. An overall score is obtained by summing the scores of the three individual tests.

### **The Reitan Trail-Making Tests (Reitan Neuropsychological Laboratory, Tucson, AZ)**

The Reitan Trail-Making Tests A and B offer a highly reliable ( $r = 0.60-0.90$ ) and well-validated method of assessing orientation, concentration, visual-spatial capacity, and problem-solving abilities.<sup>18,22,14</sup> The Trail-Making Test A involves connecting numbers from 1 to 25, in order, as fast as possible. Test B, which is available in three different forms to minimize practice effects, is similar but involves connecting alternating letters and numbers. The test is scored by recording the time taken to complete each test and adding 1 second for each error (not touching the circled item or connecting the wrong sequence) to the total time.

### **The Wechsler Digit Span Tests (WDS) (The Psychological Corporation, San Antonio, TX)**

The WDS Tests are used to examine a patient's attention span, concentration, distractibility, and immediate memory recall (interview with Mark Lovell, MD, Department of Psychiatry, Allegheny General Hospital, Pittsburgh, PA, January 11, 1995).<sup>11</sup> In the first test, a series of digits is presented by the examiner, after which the patient repeats the digits in order. The digits are read at a rate of one per second and are presented in six pairs of sequences, ranging from three to seven digits in length. Scoring is based on the number of correctly recalled digit sequences. The second part of the test requires the patient to repeat the digits in the reverse order of their presentation. Again, the number of correctly recalled sequences is recorded. A perfect score is 24.

### **Procedures**

All 72 subjects were administered the same four cognitive tests at each of three testing sessions. The order of tests was randomly selected on each day by choosing pieces of paper labeled with the test names. The tests were administered in a noise- and distraction-free environment by the researcher or a research assistant. All tests were administered with strict adherence to the instruction manuals, and the test battery took less than 15 minutes to administer. Tests were administered three times, with one day between test days. When available, alternate forms of the tests were administered to minimize practice and learning effects.

### **RESULTS**

Mean values and standard deviations for the HVLT and the Stroop, Trail-Making, and WDS Tests for each of the three test dates are presented in Table 1. Four separate repeated-measures analyses of variance (ANOVAs) revealed significant main effects for test day (Table 2). Alpha levels were considered significant if  $P < .05$ . Tukey post hoc analyses revealed significant differences on all test dates for the Stroop, Trail-Making, and WDS Tests. A significant difference was found

only between day one and day three of the HVLT, with scores actually decreasing (becoming worse) over time.

Correlational analyses revealed a significant correlation ( $P < .05$ ) between the Stroop test and the Trail-Making Tests on each of the three test dates. Analyses also indicated a significant correlation between the Stroop and Trail-Making Tests and HVLT scores on the second test date. A total performance index was calculated using *t* scores from the four tests on each of the three test dates. While all four tests were significantly correlated with the overall index, the WDS Test seemed to be the least predictive of overall performance. Each of the other three tests proved to be the most correlated, depending on the test date (Table 3).

## DISCUSSION

One of the major obstacles faced by athletic trainers and other sports medicine personnel in the assessment of head injuries is the lack of quantitative data available for comparison during evaluation and subsequent followup procedures. Research has indicated that neuropsychological tests can be a useful tool in determining cognitive deficiencies as a result of MHI.<sup>3,12,13,15,23-28</sup> The scores obtained from such cognitive tests have been used not only in assessment, but also in deciding when to return an athlete to competition after a head injury.

We found significant improvement on each of the four testing dates for the Stroop, Trail-Making, and WDS Tests, indicating a learning effect on these tests from one date to the next. Most likely the subjects were able to improve their performance scores not because there was improvement in their cognitive abilities, but because they became familiar with the tests. For example, improvement on the Stroop Test can be attributed to becoming familiar with the test and knowing what is expected, because the colors and words cannot be memorized. Improvement on the Trail-Making Tests can be the result of a combination of remembering the patterns of circled letters and digits on the paper and becoming familiar with the testing procedures for a practice effect. Surprisingly, there was a significant improvement in the scores between test dates for the WDS Test. This difference may be attributed to subjects' gaining a better understanding of the test procedures and how to memorize digit sequences.

As expected, analysis of the HVLT indicated no learning effect. However, there was an unexpected significant decrease in the scores between test dates one and three. According to previous research,<sup>19</sup> all forms of the HVLT are supposed to be

**Table 2. F Values Indicating Significant Differences Between Testing Days on the Four Cognitive Tests**

Test	F Value = (Significance)
HVLT	F(3, 142) = 3.64 (.029)*
Stroop	F(3, 142) = 183.46 (<.001)*
Trail making	F(3, 142) = 114.94 (<.001)*
WDS	F(3, 142) = 13.69 (<.001)*

\* $P < .05$ .

equivalent and no learning effect should occur. Each test form contains a new word list, so words cannot be memorized between trials. Brandt's research<sup>19</sup> actually indicated a slight increase in scores between test days one and three. The most plausible explanation for the decrease in scores in our study is simply the lack of motivation by the subjects on the third testing date. Decisions regarding cognitive ability should not be based solely on the HVLT due to possible false-positives that may occur as a result of decreased motivation.

When testing individuals who have sustained a head injury, it is necessary to distinguish between improvements due to a learning effect and improvements due to reduction in concussive symptoms. For example, by using the established normal values, it can be expected that a subject will improve by about 8 seconds on each Trail-Making Test session. Smaller improvements than expected may indicate unresolved concussive symptoms. There should be approximately a 20-point increase in the overall Stroop score from day one to day two and an additional 10-point increase between test dates two and three. Analysis of the WDS Test indicates an expected one-point increase from test date one to test date three. However, our data revealed no learning effect when taking the HVLT over several sessions. Therefore, clinicians should not expect to see an increase in scores in normal subjects. Still, any improvement in scores after a mild head injury could be indicative of resolved cognitive deficits.

Because both the Stroop and the Trail-Making Tests involve processing information quickly, we expected a significant correlation between the scores on these two tests. Our results support this theory, indicating a significant correlation between the two tests on each of the three test dates ( $r = 0.40, 0.34$ , and  $0.40$ , respectively). This finding is significant because it establishes that performance on one test is predictive of performance on the other. Clinically this may indicate that both tests need not be administered as part of a testing battery if both tests are unavailable or if time is a factor in administering the tests. Caution should, however, be taken in eliminating tests because each test is sensitive to a different aspect of cognitive functioning. Also, the tests may not correlate in the same way when testing individuals with mild head injuries.

The Trail-Making Tests correlated best with overall performance, but only for the first test date. On test dates two and three, the HVLT and the Stroop Test were found to be more correlated with overall performance. The significant finding was that the WDS Test was the least correlated on each of the three test dates. This may indicate that the WDS Test is

**Table 1. Mean Scores (+/- SD) for Each of the Four Cognitive Tests Across Test Days 1, 2, and 3**

Test	Test Day 1	Test Day 2	Test Day 3
HVLT	39.56 (3.18)	38.64 (2.87)	38.61 (3.06)
Stroop	243.50 (22.48)	262.06 (22.49)	272.04 (23.36)
Trail making	64.75 (12.52)	56.08 (11.64)	48.11 (10.87)
WDS	17.47 (2.80)	18.10 (2.96)	18.62 (3.06)

**Table 3. Pearson's Correlation Coefficients from t Scores Between the Four Cognitive Tests and a Total Performance Index**

	WDS	HVLT	Stroop	Trail Making	Index
WDS	...	<i>r</i> = .1596 <i>P</i> = .181	<i>r</i> = .0865 <i>P</i> = .470	<i>r</i> = .0445 <i>P</i> = .710	<i>r</i> = .5381 <i>P</i> < .001
HVLT	<i>r</i> = .1596 <i>P</i> = .181	...	<i>r</i> = .0557 <i>P</i> = .642	<i>r</i> = .1344 <i>P</i> = .260	<i>r</i> = .5628 <i>P</i> = .001
Stroop	<i>r</i> = .0865 <i>P</i> = .470	<i>r</i> = .0557 <i>P</i> = .642	...	<i>r</i> = .3983 <i>P</i> = .001	<i>r</i> = .6417 <i>P</i> < .001
Trail making	<i>r</i> = .0445 <i>P</i> = .710	<i>r</i> = .1344 <i>P</i> = .260	<i>r</i> = .3983 <i>P</i> = .001	...	<i>r</i> = .6570 <i>P</i> < .001

\* T scores were calculated so an index could be determined while adequately representing timed scores for the Trail-Making Test.

*r* = correlation coefficient.

*P* values < .05 are considered significant.

sensitive to cognitive abilities that are not correlated with the other tests. Thus, the WDS Test would be very valuable in a cognitive test battery for possibly identifying deficits in cognitive ability not discovered by other tests. The ease of administration enables the WDS Test to possibly be used on the sidelines as a quick test of cognitive function.

Although our testing was performed in a controlled (laboratory) environment, it is speculated that these tests can be administered in uncontrolled environments (sideline or locker room). Athletes could be administered the tests on the sideline as part of the regular MHI evaluation. We recommend that cognitive assessment be performed within the first 20 minutes following injury, followed by subsequent testing on days 2 and 4 after the injury. Further research is needed to determine whether these tests can be used in uncontrolled situations, such as on the sidelines.

## CONCLUSIONS

The most important finding in our study was the establishment of normal scores for a battery of cognitive tests that revealed learning curves for three of the four tests. Athletes who sustain a head injury can be given the tests and the results compared with the established normative scores. Low scores may be indicative of unresolved complications of MHI. Sports medicine personnel may make more informed decisions regarding an athlete's ability to return to competition with less risk for complications resulting from second-impact syndrome. Our results indicate that all four tests should be incorporated into a test battery examining cognitive function. Athletes should be tested the day of injury and again 2 and 4 days following the initial test.

It should be emphasized that cognitive testing is only part of the assessment process in the evaluation of a head injury and should not take the place of other physical tests. Cognitive testing does provide an objective assessment tool for the evaluation of a head injury; however, decisions on returning an athlete to competition must not be made solely on the results of these tests. Improving evaluation techniques through the use of cognitive testing will, we hope, help to reduce the frequency of reinjury and potential fatalities related to head injuries.

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# The Use of Nonprescription Weight Loss Products Among Female Basketball, Softball, and Volleyball Athletes from NCAA Division I Institutions: Issues and Concerns

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**Objective:** To identify and describe the use of nonprescription weight loss products among female basketball, softball, and volleyball players from NCAA Division I institutions and to address health and sports performance issues concerning the use of weight loss products by female athletes.

**Design and Setting:** Mailed self-reporting questionnaire, sample of convenience. The Department of Physical Education at the University of South Carolina sponsored this study.

**Subjects:** The researchers sent 371 questionnaires to NCAA Division I athletic trainers of ten basketball teams, ten softball teams, and eleven volleyball teams. The recipients returned all of the questionnaires. Of the subjects, 106 played basketball, 138 played softball, and 127 played volleyball.

**Measurements:** A survey consisting of nine questions related to the use of weight loss products by NCAA Division I female athletes.

**Results:** Approximately 29% of the subjects reported using nonprescription weight loss products, which included general weight-reducing products, diuretics, and laxatives. More volleyball players (71%) used all types of these products than did softball (32%) or basketball (11.3%) players. More white ath-

letes (32.3%) reported using the products than did African American athletes (6.7%). More volleyball players (23.6%) used diuretics than did softball (3.6%) or basketball (1.0%) players. Laxative use was greatest among volleyball players (18.8%), followed by basketball (1.8%) and softball (2.9%) players. Subjects typically reported purchasing nonprescription weight loss products over the counter (96.4%). The mean age of initial use was 16.2 years. Frequency of use increased during the out-of-sport season. The number one reason for using nonprescription weight loss products was for appearance enhancement (79.6%).

**Conclusions:** Based upon the results of this study, the use of nonprescription weight loss products is particularly common among volleyball players, but softball and basketball players also use them. Most subjects used these products during the out-of-sport season; therefore, information and intervention programs should target out-of-season use patterns. These programs should address the effects weight loss products have on sports performance and general health and should address issues relating to physical appearance.

**Key Words:** diuretics, laxatives

**I**t is difficult to document the extent to which female college athletes use nonprescription weight loss products (NPWLPs). Several studies have addressed eating disorders among female college athletes, but few have focused on the use of NPWLPs.<sup>1–4</sup> Researchers who have investigated the use of NPWLPs have drawn from sports whose athletes are traditionally lean and have low body fat.<sup>5–7</sup>

We surveyed college female athletes from the sports of basketball, softball, and volleyball. The sports chosen for this study typically have athletes who are traditionally less lean and of higher body fat than other female athletes who have been studied previously. The purposes of this inquiry were to determine 1) the number of female athletes in these sports who use weight loss products, 2) the types of weight loss products used, 3) the age of initial use, and 4) the purpose for use of

weight loss products. NPWLPs are commonly referred to as over-the-counter weight reduction products other than those classified as diuretics or laxatives. However, for the purposes of this study, NPWLPs will refer to all such products, including diuretics and laxatives, unless otherwise specified.

## METHODS

This study involved NCAA Division I female college athletes who participated in the sports of basketball, softball, and volleyball during the 1994–95 school year. Participants were from institutions located in the southeast and eastern parts of the United States. We sent letters to coaches of teams who participated against the University of South Carolina female basketball, softball, and volleyball teams during the 1994–95

school year and asked that their athletes be permitted to participate. Of the 31 coaches contacted, all agreed to allow their athletes to participate in the study.

We also contacted the individual certified athletic trainer for each of the 31 teams and asked them to participate in the study. All indicated interest in the study and agreed to participate and serve as administrators of the questionnaire. The certified athletic trainers asked all team members of the 31 teams to participate in the study. Athletes had the option to participate or not participate in the study. All team members agreed to participate in the study. This study was approved by the Ethics Committee of the College of Education Faculty Affairs Committee, University of South Carolina, Columbia, SC.

We gave each certified athletic trainer verbal and written instructions for administration of the questionnaires. The certified athletic trainers administered the questionnaires in a quiet setting, such as in a classroom or locker room, where there would be no interruptions. The certified athletic trainers gave each athlete a packet, which included a questionnaire, envelope, description of the study, and two consent forms. The athlete completed the questionnaire and signed both of the consent forms. The certified athletic trainers proctored the completion of the questionnaires. After completing the questionnaire, the athlete placed it in the envelope, sealed it, and marked the seal with an X. The athlete gave the sealed envelope to the certified athletic trainer, along with one signed consent form (keeping the other form for her files). Each athletic trainer returned all envelopes and consent forms to the researchers. We mailed a total of 371 questionnaires to the certified athletic trainers, and the athletic trainers returned all 371 questionnaires. Questions on the survey included 1) types of nonprescription weight loss products used, including general products (eg, Slim-Fast (Slim-Fast Nutritional Foods International, Inc, West Palm Beach, FL) and Sweet Success (Nestlé USA, Inc, Glendale, CA), diuretics, and laxatives); 2) age of initial use of NPWLPs; 3) frequency of NPWLP use in season and out of season; 4) why athletes choose to use NPWLPs, and 5) why athletes choose not to use NPWLPs.

We computed frequency and percentage distributions collectively on the total population and separately on all sports teams, using SPSS-X software (release 2.0, SPSS, Chicago, IL) to calculate means.

## RESULTS

Of the 371 participants, 28.6% ( $n = 106$ ) were basketball players, 37.2% ( $n = 138$ ) were softball players, and 34.2% ( $n = 127$ ) were volleyball players. Ages of the participants ranged from 17 to 23 with a mean age of 19.5 years. White participants accounted for 78.4% ( $n = 291$ ), 18% ( $n = 67$ ) were African American, and 3.5% ( $n = 13$ ) were from other ethnic backgrounds. Most participants (60.1%,  $n = 223$ ) were considered starters in their respective sport, and 55.8% ( $n = 207$ ) had grade point averages of 3.0 or higher on a 4.0 scale. The majority of the athletes lived in residence halls (62.2%,  $n = 231$ ).

Nearly 30% (28.8%,  $n = 107$ ) of the participants used NPWLPs. More volleyball players (71%) used these products than did softball (32%) or basketball (11.3%) players. More white athletes (32.3%,  $n = 94$ ) reported using NPWLPs than did African American athletes (6.7%,  $n = 10$ ).

More volleyball players (23.6%,  $n = 30$ ) used diuretics than did softball (3.6%,  $n = 5$ ) or basketball (1.0%,  $n = 1$ ) players. Laxative use was greatest among volleyball players (18.8%,  $n = 24$ ) followed by basketball (1.8%,  $n = 2$ ) and softball (2.9%,  $n = 4$ ). Among white athletes, 7.9% ( $n = 23$ ) reported using diuretics and 7.2% ( $n = 21$ ) laxatives. Of the ten (6.7%) African Americans who reported using NPWLPs, they used laxatives (40%,  $n = 4$ ) more often than diuretics (20%,  $n = 2$ ). Subjects typically reported purchasing NPWLPs over the counter (96.4%) versus obtaining them from a friend (4.6%). (Total is 101% because subjects could choose more than one answer).

### Initial Age of Nonprescription Weight Loss Product Use

NPWLP use began before age 18, with a mean age of 16.2 years. Softball players reported initial use of NPWLPs at a younger mean age (15.5 years) than did volleyball (16.5 years) or basketball (16.6 years) players. African American athletes started using NPWLPs at a younger mean age (15.3 years) than did white athletes (16.1 years).

### Frequency of Nonprescription Weight Loss Product Use

Most athletes who used NPWLPs did so between 2 and 7 days per week. All participants (basketball 66.7%, softball 58.3%, and volleyball 66.7%) reported using NPWLPs less during the season than out of season. Forty-four percent of volleyball players used these products four or more times during the season, as compared with 50% out of season. Thirty-three percent of softball and basketball players used the products four or more times per week during the season, compared with 53.3% and 66.7%, respectively, out of season. White and African American athletes reported the same usage pattern, ie, the greatest frequency during the off season.

### Why Do Female Athletes Use Nonprescription Weight Loss Products?

Using a 3-point Likert scale (1 = not important, 2 = somewhat important, 3 = very important), female athletes ranked why they chose to use or not use NPWLPs. Most female athletes (79.6%) indicated that the use of NPWLPs for weight loss was very important. Fifty-two percent thought that using NPWLPs to make them feel good was very important. Almost 25% indicated that using NPWLPs was very important to the enhancement of their sports performance.

Those who chose not to use nonprescription weight loss products did so because of concerns about the effects NPWLPs

have on health (82.9%), the effects on athletic performance (63%), and the use of NPWLPs as a means of cheating (33.2%).

## DISCUSSION

There are a variety of over-the-counter NPWLPs. Laxatives and diuretics are popular because of their effect on moving water and waste from the body quite rapidly. Many of the athletes in this study reported using NPWLPs to enhance appearance. It must be noted that these products do not decrease fat; rather, they decrease the water content of the body.<sup>8,9</sup> Laxatives and diuretics can account for two major conditions that often affect both health and athletic performance: potassium deficiency and dehydration. It is interesting to note that our study revealed that 29% of Division I female athletes participating in the sports of basketball, softball, and volleyball used NPWLPs. It is even more interesting that 71% of the volleyball players reported using these products. Results of similar studies found 25% of female athletes who participate in the sports of gymnastics, softball, tennis, track and field, field hockey, volleyball, basketball, golf, and swimming<sup>6,10</sup> practice pathogenic weight control behaviors, including the use of weight loss products. Regardless of who or how many female athletes use NPWLPs, there are detrimental effects on both general health and sports performance.

The use of laxatives and diuretics causes potassium deficiency.<sup>9,11</sup> Low potassium levels cause disturbances in electrolytes, acid-base balance, and nerve impulse transmission. Nervous disorders in the heart may be expressed as life-threatening cardiac anomalies. Although many athletes with abnormally low potassium levels are asymptomatic, there is no way to predict if and when a life-threatening cardiac arrhythmia will occur.<sup>12</sup> Non-life-threatening clinical signs and symptoms in the athletic population may include muscle cramping, muscle weakness, and cardiac weakness.<sup>8,9</sup>

Potassium's role in energy production may also affect the athlete's performance. Potassium assists in the transportation of glucose into the muscle cells, the storage of glycogen, and the production of high-energy compounds.<sup>9,13</sup> Metabolic insufficiency may adversely affect carbohydrate metabolism and contribute to muscle fatigue and injury.<sup>14</sup>

Laxative/diuretic-induced dehydration has a negative influence on the renal, thermoregulatory, and cardiovascular systems. The dehydrating effects of laxatives and diuretics cause the kidneys to increase the specific gravity of urine. Although the change is transient, repeated dehydration episodes may cause kidney problems later in life.<sup>15</sup> Additionally, laxative abuse causes volume depletion, which may lead to renal insufficiency.<sup>16</sup>

Dehydration also affects thermoregulation. The dissipation of body heat is largely dependent on the evaporation of sweat, particularly in warm environments. Failure to dissipate body heat due to dehydration may lead to hyperthermia.<sup>17</sup> A mild state of dehydration may express itself as fainting, fatigue, or

nausea. Severe dehydration may result in a life-threatening heat injury, heat stroke.<sup>9</sup>

The use of NPWLPs may lead to dehydration and hyperthermia, and consequently to central nervous system distress. Dizziness and confusion are typically observed when the body fails to dissipate heat. Elevated body temperatures may also cause central nervous system fatigue, and, as a result, athletic performance suffers.<sup>9</sup> Body water deficits from diuretic use increase the viscosity of the blood and reduce venous return. It is reasonable to assume that a reduced venous return followed by a decreased ventricular filling leads to a decrease in stroke volume and subsequently a decrease in cardiac output. A reduction in cardiac output may explain decreases in maximal aerobic power and physical work capacity deficits. Diuretic-induced dehydration also reduces blood plasma levels.<sup>18</sup> Armstrong et al<sup>1</sup> reported that performance deficits were greater in subjects with diuretic-induced dehydration who were participating in races of greater distances. They were of the opinion that hyperthermia may have been the physiologic mechanism that caused greater performance deficits in dehydrated individuals during events of longer duration. Thus, the reduced plasma volume caused by diuretic use and leading to dehydration decreases exercise performance. Additionally, reduced stroke volume requires the heart to beat faster, affecting an individual's perceived exertion level.

Also, dehydration has deleterious outcomes on other physical performance components: strength, anaerobic power, lactate threshold, and aerobic power.<sup>19,20</sup> Webster et al<sup>18</sup> examined the effects of dehydration on seven intercollegiate athletes. They concluded that typical weight loss methods, including dehydration, that are practiced by wrestlers negatively affect strength, anaerobic power, lactate threshold, and aerobic power output. Although the literature fails to address the effects of dehydration on female athletes, it seems reasonable to infer similar conclusions.

This study highlights the use of NPWLPs among a group of female athletes who are traditionally not perceived to use these products. Weight loss products, particularly diuretics and laxatives, can have detrimental effects on health and sports performance. Diuretic and laxative use can put the female athlete at higher risk for medical complications such as electrolyte imbalances and cardiac arrhythmias. Female athletes already engage in strenuous physical activity, which demands an increase in productivity of the musculoskeletal and cardiovascular systems. The use of diuretics and laxatives may put these athletes at greater risk for musculoskeletal injuries, heat-related disorders, and cardiovascular abnormalities. Although some athletes may assume these products improve performance and enhance their appearance, the evidence suggests that these products, in fact, have deleterious influences on the renal, thermoregulatory, and cardiac systems. As a result, NPWLPs are considered ergolytic rather than ergogenic aids to performance and health.

It may be, based on our study, that information programs concerning the use and effects of NPWLPs for appearance and

performance enhancement need to be provided for female athletes, beginning in junior high school and continuing throughout their careers. However, we did not investigate the correlation between cognitive deficiency and the use of NPWLPs. Future studies addressing this relationship in order to understand the results of education and intervention programs may be informative. Until this research takes place, information and intervention programs are the only tools at our disposal.

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# Cancer Detection: The Educational Role of the Athletic Trainer

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**Objective:** We found in an earlier study that while 26% of athletic trainers had worked with athletes with cancer, only 8% had taught their athletes self-examination procedures. In an attempt to examine why athletic trainers do not teach their athletes self-examination procedures, we investigated athletic trainers' knowledge of breast and testicular cancer risk factors and detection techniques.

**Design and Setting:** One hundred researcher-developed questionnaires were distributed at the 1994 National Athletic Trainers' Association Annual Meeting.

**Subjects:** Sixty-nine certified athletic trainers with an average age of 32 years. Seventy-two percent held master's degrees.

**Measurements:** SPSS-X was used to analyze the results of the study, and chi-square tests were used to compare the athletic trainers' responses by gender.

**Results:** Over 91% of the athletic trainers had never been taught about either breast or testicular self-examination in their

athletic training education. Nearly half of the respondents did not know any of the nine breast cancer risk factors, although females reported significantly more knowledge of risk factors than males. Ninety-one percent of athletic trainers knew none of the four testicular risk factors, although male respondents reported significantly more knowledge of testicular cancer risk factors than females. On a Likert scale, 46% rated breast cancer and 41% rated testicular cancer as being "of little concern" to athletic trainers.

**Conclusions:** Cancer risk factors and detection techniques should be taught in the athletic training curriculum. As advocates for health and wellness, athletic trainers should then teach this information to their athletes.

**Key Words:** breast cancer, testicular cancer, self-examination, athletic trainers' cancer knowledge

Our study is a follow-up to research published in the *Journal of Athletic Training* in March 1996 by Dewald and Zientek,<sup>1</sup> who found that 28% of athletic trainers had worked with athletes with cancer, but only 8% had taught their athletes self-examination procedures. The previous study examined whether athletic trainers taught the athletes they cared for about breast and testicular cancer. Eighty-six percent of athletic trainers did not teach female athletes about breast cancer, and 91% did not teach male athletes about testicular cancer. Our study examined whether a lack of knowledge on the part of athletic trainers could be a reason why breast and testicular cancer were not taught.

## REVIEW OF LITERATURE

Breast cancer is currently the most common type of cancer among American women, resulting in an estimated 46,000 deaths a year.<sup>2</sup> The 5-year survival rate does, however, appear to be improving from 78% in the 1940s to 94% in 1995.<sup>2</sup>

Women who recognize the signs and symptoms of breast cancer can take the important step of consulting a physician for early intervention. Changes in the breast, such as a lump, thickening, dimpling, swelling, skin irritation, retraction, distortion, scaliness, tenderness of the nipple or nipple discharge,

and pain are all symptoms warranting consultation with a physician.<sup>2,3</sup>

According to the 1995 American Cancer Society publication entitled "Cancer Facts and Figures,"<sup>4</sup> risk factors for breast cancer include age (risk increases after age 40), personal history, family history, early age of menarche, late age of menopause, never having had children, late age of first live birth, higher education, and lower socioeconomic status. The 1996 American Cancer Society<sup>2</sup> report also included lengthy exposure to cyclical estrogen as a risk factor. Correlations with variations in fat intake have also been noted, although a causal role has not been firmly established.<sup>2</sup>

The knowledge that women have of breast cancer risk factors varied according to the type of risk factor. Schlueter<sup>5</sup> found, for example, that 83% of the women surveyed were aware of age as a risk factor, 76% were aware of the impact of family history, 30% knew of the postmenopausal risk, and 24% knew women with no children were at risk.

It is interesting, then, to examine where women obtain information regarding breast cancer. Studies of college-aged women (18–22 years of age) found that 95% had been to see a physician during the past three years for a general physical examination. Goldenring and Purtell<sup>6</sup> found that 64% of women studied had received breast self-examination

instruction, with sources of this information listed as a physician (79%), school (21%), and other sources.

Although most women had received a physician's examination and had been taught breast self-examination procedures, the percentages of women who had done regular self-examinations were generally between 30 and 40%.<sup>5,6</sup> Even in the health care professions, the percentages were low. A survey of athletic trainers showed that only 42% of those studied performed self-examinations.<sup>1</sup>

When women were asked why they did not perform self-examination regularly, responses included being too busy, a lack of instruction about self-examination, and preferring not to think about it.<sup>7</sup> Fear, ignorance, anxiety, and lack of confidence also contributed to the lack of self-examination practice.<sup>8</sup> A lack of confidence prevailed even in women who were knowledgeable about breast self-examination. Of those who practiced breast self-examination, 50% of the women felt that they were not confident in the detection of abnormalities.<sup>5</sup>

Women cited a lack of instruction as a reason for not doing breast self-examination. One might then assume that women who possessed accurate information would practice breast self-examination more frequently than those who lacked accurate information. Schlueter, however, found no such thing. In fact, "accurate knowledge was not reflected in frequency of performance of breast self-examination."<sup>5</sup> The definition of "accurate knowledge," then, is important. Schlueter, for example, looked at women who possessed "accurate information of the common ages for developing breast cancer"<sup>5</sup> and found that these women practiced breast self-examination less often than those who were not informed. Thirty-five percent of "knowledgeable" women performed breast self-examination monthly, while 50% who had incorrect information practiced the examination monthly. Of the "accurately informed" women, 29.2% examined themselves infrequently and 23.6% not at all.<sup>5</sup> Clearly, the relationship between knowledge and practice needs to be further delineated.

Testicular cancer accounts for 19% of all cancer deaths in the 15- to 34-year-old age group and is the most common form of cancer in young men.<sup>3,9</sup> In 1996, there will be an estimated 7,400 new cases of testicular cancer and 390 deaths.<sup>2</sup> Testicular cancer, if found early, is one of the most curable cancers.<sup>3</sup> The delayed seeking of medical attention is the primary factor in the deaths attributed to testicular cancer.<sup>6</sup> Goldenring and others<sup>10-12</sup> found the reasons for the delay to include ignorance, fear, and the physician's not finding the tumor before it had spread to the lymph nodes or not recognizing the tumor when the patient was examined.

The early signs and symptoms of testicular cancer include a small, hard, and painless mass either on the side or front of the testicle; a slight enlargement of the affected testicle; a change in the consistency of the testicle; and/or a heavy feeling in the groin or testicle. Later signs and symptoms were found to include enlarged lymph nodes in the groin or neck and pain.<sup>3</sup>

Risk factors associated with testicular cancer included ages 15 to 34 years, undescended testicles at birth, atrophy of the

testicles from mumps or a virus, family history, and males whose mother was treated with the diethylstilbestrol hormone during pregnancy.<sup>3</sup> A suspected cause is repeated trauma to the scrotal area.<sup>11</sup>

Research has found the rate of compliance with testicular self-examination to be between 1.5 and 7.0%.<sup>6,9,11</sup> An educational program has been found to increase the practice of testicular self-examination to 67%.<sup>13</sup> This statistic alone should emphasize the need and value of teaching testicular self-examination to the at-risk age group. Why, then, are young men not being taught testicular self-examination? Studies have found that between 55 and 98% of the young men studied had either been to a physician for a different problem or had a sports physical, yet less than 10% had been talked with about testicular cancer or taught testicular self-examination by their physicians.<sup>9,12</sup> Further, Vaz et al<sup>12</sup> found the source of knowledge to have been from a health class (36%), friends (24%), or television (25%). This study found that only 2% of adolescent males were performing testicular self-examination on themselves. The major reason for not performing testicular self-examination was "not knowing how to perform an adequate examination," ignorance of cancer, denial of symptoms, and the mildness of testicular cancer symptoms.<sup>12</sup>

## METHODS

Sixty-nine athletic trainers (35 males and 34 females) responded to a researcher-developed questionnaire that was randomly distributed at the 1994 National Athletic Trainers' Annual Meeting. One hundred questionnaires were distributed at the registration desk area to athletic trainers attending the convention. A total of 75 questionnaires were returned: 69 were from certified athletic trainers, and 6 were from uncertified athletic trainers. Only certified athletic trainers were included in the analysis. The ages of the respondents ranged from 23 to 56 years, with the mean age being 32 years. Forty percent of the respondents worked in an NCAA-affiliated university or college, 20% in high schools, and 15% in clinics. Seventy-two percent of the subjects held master's degrees. Some questions were asked in yes/no format: eg, "Have you ever been taught about breast self-examination in your athletic training education?" (Table). Other questions were asked in an open-ended format: eg, "What are the risk factors for breast cancer?" Correct responses for the open-ended questions were based on the 1995 American Cancer Society's publication, "Cancer Facts and Figures."<sup>4</sup>

## RESULTS

SPSS-X (release 2.0, SPSS, Chicago, IL) was used to analyze the results of the study, and chi-square testing was used to compare the athletic trainers' responses by gender. The  $P < .05$  level of significance was used for data analysis.

We found that only a small percentage of both male and female athletic trainers were taught about breast and testicular

**Percentages of Female and Male Athletic Trainers Who Responded to Questions About Breast and Testicular Cancer**

Question	Number (%)	
	Females	Males
Were you ever taught about breast self-examination in your athletic training education?	Yes No	3 (4%) 31 (45%) 2 (3%) 33 (48%)
Were you ever taught about testicular self-examination in your athletic training education?	Yes No	2 (3%) 32 (46%) 4 (6%) 31 (45%)
What are the preventative behaviors for breast cancer?		
Mammography	Listed Not listed	19 (28%) 15 (22%) 21 (30%)
Examination (self- or doctor's examination)	Listed Not listed	27 (39%) 7 (10%) 20 (29%) 15 (22%)
What are the preventative behaviors for testicular cancer?		
Examination (self- or doctor's examination)	Listed Not listed	23 (33%) 11 (16%) 20 (29%) 15 (22%)
What age category is most susceptible to breast cancer?		
Over the age of 40	Correct Incorrect Did not respond	11 (16%) 23 (33%) 15 (22%) 19 (28%) ... 1 (1%)
What age category is most susceptible to testicular cancer?		
15–34 years	Correct Incorrect	1 (1%) 33 (48%) 1 (1%) 34 (49%)

self-examination in their athletic training education (Table). Ninety-three percent of the athletic trainers had never been taught about breast self-examination. No statistically significant differences were found between male and female athletic trainers in this regard. Ninety-one percent of athletic trainers had never been taught about testicular self-examination. Again, no significant differences were found between male and female athletic trainers' responses.

Athletic trainers do know detection behaviors for breast and testicular cancer (mammography and breast and testicular examination). Open-ended questions such as "What are the detection behaviors for breast/testicular cancer?" were asked. The two detection behaviors for breast cancer were (1) mammography and (2) examination (breast self-examination or physician's examination). A significant number of the athletic trainers (48%) listed mammography as a detection behavior for breast cancer, with no significant differences between male and female responses. Most (68%) listed either self-examination or a physician's examination as a detection behavior, with no significant differences between male and female responses. The majority of athletic trainers (62%) listed testicular examination as a detection behavior, with males and females responding similarly.

Sixty-one percent of athletic trainers did not know the age category most at risk for breast cancer (over 40 years of age), and 97% of athletic trainers did not know the age category most at risk for testicular cancer (15 to 34 years of age). Knowledge of age categories was not significantly different for males and females for either breast or testicular cancer.

Athletic trainers do not know the techniques of breast/testicular self-examination. The first step for breast self-examination is to describe where the examination should take place (in the shower, before the mirror, supine). Seventy-five

percent of athletic trainers surveyed did not list the place as an important part of breast self-examination. More females (17%) described the place than males (7%) ( $\chi^2 (1, n = 69) = 3.05, P < .05$ ). The second technique for breast self-examination is to use the fingers to palpate. Most athletic trainers (56%) knew this technique, with no significant differences in male and female responses. Visual inspection was listed by only 17% of the athletic trainers, with no significant differences by gender. Seventy-five percent of athletic trainers did not include putting the arm over the head, with more females (17%) than males (7%) listing this technique ( $\chi^2 (1, n = 69) = 3.05, P < .05$ ). The majority of respondents (56%) did not include using a circular motion, and 84% did not include squeezing the nipples (or looking for discharge). There were no gender differences for these two techniques. The total number of steps listed in the technique of breast self-examination ranged from 3 (4%) who knew all five, to 6 (9%) who knew four, 14 (20%) who knew three, 16 (23%) who knew two, 13 (19%) who knew one, and 17 (25%) who knew none.

Questions were also asked regarding techniques for testicular self-examination. Most (55%) did not include rolling each testicle between the thumb and finger (palpation). Males (32%) were more likely to list this technique than females (13%) ( $\chi^2 (1, n = 69) = 7.82, P < .05$ ). Most (67%) also did not include checking for lumps, bumps, or discharge, with males (22%) more likely than females (12%) to list this technique ( $\chi^2 (1, n = 69) = 2.09, P < .05$ ). Overall, males seemed more knowledgeable than females with regard to testicular self-examination. The total number of athletic trainers familiar with the techniques of testicular self-examination ranged from 21 (30%) who knew both steps, 12 (17%) who knew one step, and 36 (52%) who knew neither step (remaining 1% attributable to rounding).

Only a small percentage of male and female athletic trainers were familiar with the risk factors for breast/testicular cancer. When asked in an open-ended question to list risk factors for breast cancer, most did not list women over the age of 40 (87%). Females (12%) were more likely than males (1%) to know this risk factor ( $\chi^2$  (1, n = 69) = 4.80,  $P < .05$ ). Ninety-nine percent did not list personal history, 99% did not list early age of menarche, 100% did not list late age of menopause, 94% did not list never having had children, 99% did not list late age at first live birth, 100% did not list higher education, and 99% did not list socioeconomic status. None of the results in these categories were significantly different for male and female athletic trainers. The only breast cancer risk factor that showed a gender difference was family history, where females (35%) were more likely than males (14%) to list this as a risk factor. Only 49% overall listed family history as a risk factor. When the total number of breast cancer risk factors was calculated for each athletic trainer, 25% knew none, 19% knew one, 23% knew two, 20% knew three, 9% knew four and 4% knew all five.

The results of athletic trainers' knowledge of risk factor for testicular cancer were similar to the findings regarding breast cancer risk factors. Most (96%) did not list undescended testicles at birth, none (0%) listed testicles not developing normally, none (0%) listed mothers who took the hormone diethylstilbestrol during pregnancy, and most (96%) did not list history of injury to the scrotum. There were no significant gender differences in the knowledge of testicular cancer risk factors.

The total number of risk factors for testicular cancer listed by the American Cancer Society is four. When the number of risk factors listed by each athletic trainer was totaled, 91% knew none of the risk factors, 9% knew one, and none knew three or four risk factors.

Athletic trainers see breast/testicular cancer as being "of little concern" to the profession. In the questionnaire, athletic trainers were asked to rate breast cancer as a concern in the athletic training profession. Responses were scored on a Likert scale, 1 = of no concern, 2 = of little concern, 3 = of concern, 4 = of much concern, 5 = of major concern. Results showed that the largest number (46%) listed breast cancer as being "of little concern." Forty-two percent rated it as being "of concern," 9% rated it as being "of no concern," and 3% rated it as being "of much concern." None of the athletic trainers rated breast cancer as being "of major concern." There were no significant gender differences in these results.

Similarly, athletic trainers were asked to rate testicular cancer as a concern to their profession. Again, testicular cancer was rated most frequently as being "of little concern" (41%). Thirty-eight percent rated it as "of concern," 12% rated it as being "of no concern," 9% rated it as being "of much concern," none rated it as being "of major concern," and one did not answer (1%) (1% attributable to rounding).

## DISCUSSION

This survey shows that athletic trainers need to become much more aware of the risk factors and detection techniques for breast and testicular cancer. Athletic training education must start emphasizing how the personal health course materials, such as cancer risk factors, apply to the profession. Research in the area of cancer risk factors and detection techniques applies and relates significantly to their work as athletic trainers. Athletic trainers are either not receiving training or are not retaining the information after their required personal health course.

Female athletic trainers know more about their own cancer risk factors and prevention than about male cancers. On the other hand, male athletic trainers know more about their own risk factors and prevention than about female cancers. Thus, each athletic trainer must learn about cancer issues of the opposite gender. Procedures need to be developed to discuss concerns both with athletes of the same gender as the athletic trainer and with athletes of the opposite gender.

Since we found that athletic trainers rated breast cancer and testicular cancer to be "of little concern," procedures for educating athletic trainers should be established and implemented. Then, perhaps, the next generation of athletic trainers will not view breast and testicular cancer as being "of little concern" to their profession and instead will view breast and testicular cancer as being "of much concern" to athletic training and the daily task of the athletic trainer. The athletic trainer should possess knowledge regarding risk factors and should assist in the early detection of breast and testicular cancer. The role of the athletic trainer in referring athletes for medical care is crucial.

## PRACTICAL APPLICATIONS

There are numerous opportunities to educate young people about cancer prevention and self-examination techniques. These young people may then have a better chance of finding cancerous masses in their own testicles or breasts in the very early stages. Teaching the self-examination techniques and also using breast and testicular practice models are important for improving self-examination compliance. Providing handouts that both athletes and nonathletes can pick up and read at their leisure is another way to raise awareness about the importance of self-examination. The handouts also offer visual diagrams that further reinforce self-examination techniques. The national Breast Cancer Awareness Month campaign in October can also be used as a midyear reminder. Currently, there is no such national campaign for awareness of testicular cancer, but one can create a special testicular cancer month and emphasize testicular self-examination and testicular cancer screening. Handouts are freely available from both the American Cancer Society (1-800-ACS-2345) and the National Cancer Institute (1-800-4-CANCER). Inviting guest speakers who have had cancer is another way to educate the athletic population. Speakers are available in your local area via the

American Cancer Society. The American Cancer Society also has shower cards that are plastic, durable, and intended to be hung in a shower as a reminder to perform breast self-examination or testicular self-examination. These shower cards can be placed in the shower stalls of both interscholastic and intercollegiate athletic departments. By implementing these suggestions, athletic trainers will help to improve the health of their athletes, as well as the health of others in their schools, universities, and clinics. Athletic trainers need to know the indications for referral and to make these known to student-athletes and parents.

Physician visits provide many opportunities for wellness and prevention education that too often are not used fully. The yearly sports physical, medical history questionnaires, and treatment after breast or scrotal injuries in sport all offer ideal opportunities for education and prevention by physicians and athletic trainers. Documentation of scrotal injuries in sport must become required in the medical file. Each time a young male athlete sustains a scrotal injury, there is an opportunity to educate about testicular cancer and testicular self-examination. Direct instruction in self-examination should be followed immediately by having the subject practice the techniques. Opportunities to practice on models provide immediate feedback and help to ease any apprehension that young people might have about touching their own bodies. Every year when athletes have a preparticipation physical examination, the physician and/or athletic trainer should spend a few moments discussing both breast and testicular cancer prevention.

Athletic trainers should also discuss with student-athletes the procedures for obtaining medical evaluation, such as going to the school nurse or university medical center. Athletes should also be told ways to disclose the nature of their concern. Athletes might, for example, discuss how to handle the receptionist's question, "What is your medical problem?"

Breast cancer awareness campaigns are widespread, and the breast cancer message is available in the media via public service announcements, special programming, Breast Cancer Awareness Month, corporate matching funds, etc. A major problem in testicular cancer information is getting the message out to the at-risk age group. Young men are not getting the message, are not being taught testicular self-examination, and cannot be expected to comply with a prevention technique of which they are unaware. Some young men think

that testicular cancer is for elderly men and not their very own age group.

The athletic environment provides a perfect opportunity for personal health education in an informal setting. The athletic trainer's role in the health promotion of students and athletes needs to be emphasized. Procedures to assist the athletic trainer in working with student-athletes should be included in the athletic training curriculum. Ways to involve parents should also be discussed. Parents of student-athletes should be notified by the athletic trainer of the risk factors for breast and testicular cancer, as well as detection techniques. It is now time for a call to action for athletic trainers to promote overall health and not just the care of musculoskeletal injuries.

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# An Assessment of Learning Styles Among Undergraduate Athletic Training Students

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**Objective:** Increased attention has been directed toward assessing and improving academic quality in athletic training education. The educational process has been assessed from a global level, but little is known about how athletic training students learn. The purpose of this investigation was to assess the learning styles of undergraduate athletic training students.

**Design and Setting:** Undergraduate students enrolled in a Committee on Accreditation of Allied Health Education Programs (CAAHEP)-accredited athletic training education program completed a learning styles inventory during a regularly scheduled athletic training class at the start of the spring semester.

**Subjects:** Twenty-seven student athletic trainers (age range, 19–30 yrs, mean age = 20.5 yrs) served as subjects. Sixteen subjects (7 male, 9 female) were in the first year of this 3-year program. Eleven subjects (7 male, 4 female) were second-year students.

**Measurements:** Learning style was assessed using the Productivity Environmental Preference Survey.

**Results:** Parametric and nonparametric one-way analyses of variance for each learning subscale by sex and by year in program revealed significant differences ( $P < .05$ ) in light preferences for male and female students. There were also significant differences ( $P < .05$ ) between first- and second-year students in preferences for afternoon learning activities.

**Conclusions:** These findings suggest that undergraduate athletic training students function best as learners in a well-lit learning environment. The significance of afternoon as the preferred time for learning reinforces the importance of the clinical setting in the introduction and mastery of skills. Athletic training educators and clinical instructors can use these results as they examine their teaching strategies and educational environments.

**Key Words:** learning preferences, Productivity Environmental Preference Survey

In recent years increased attention has been directed toward assessing and improving academic quality in higher education<sup>1</sup> and the education process for athletic trainers. The National Athletic Trainers' Association Education Task Force<sup>2</sup> was created to examine athletic training education on the global level. However, beyond the publication of certification examination results, little is known about athletic training students, and still less is known about how they learn. An understanding of student learning preferences would allow athletic training educators to strengthen the quality of teaching as the content and process of athletic training education are standardized.

A review of the literature related to the investigation of learning styles shows that only Draper<sup>3</sup> has assessed the learning styles of athletic training students. Many other studies of learning styles have employed a variety of assessment instruments.<sup>4–15</sup>

Students in allied health and medical professions have been the most common subjects in learning style investigations, with nursing students studied most frequently.<sup>6,8,10</sup> Most of these studies were completed in the 1980s, with some works extending into the early part of this decade. Despite concerns about its validity and reliability,<sup>6,11,16</sup> the

Learning Styles Inventory developed by Kolb (Kolb's LSI) is the most widely used instrument for investigating learning styles.<sup>7,11,13–15</sup> Several other assessment instruments are also described.<sup>3–5,9,12</sup>

The purpose of this study was to assess the learning styles of students enrolled in a Committee on Accreditation of Allied Health Education Programs (CAAHEP)-accredited undergraduate athletic training education program. Specifically, we investigated differences in learning style between the sexes and between students at different levels of an athletic training education program.

## METHODS

### Subjects

Twenty-seven student athletic trainers (26 white, 1 black; age range, 19–30 yrs, mean age = 20.5 yrs) enrolled in a CAAHEP-accredited undergraduate athletic training education program served as subjects. Sixteen subjects (7 male, 9 female) were in their first year of a 3-year program and 11 (7 male, 4 female) were second-year students.

## Instrument

We used the Productivity Environmental Preference Survey (PEPS) (Price Systems, Inc, Lawrence, KS) to evaluate learning style. The PEPS assesses individual productivity and learning style and analyzes the conditions under which an adult is most likely to achieve, create, produce, solve problems, make decisions, or learn.<sup>12</sup> Subjects complete the PEPS by responding to 100 5-point Likert scale items (strongly agree to strongly disagree) related to 20 different elements of learning (Table 1). Reliabilities for the 20 PEPS subscales range from 0.39 to 0.87; 75% of the reliability coefficients are equal to or greater than 0.60.<sup>12</sup>

Price Systems, Inc calculates raw and standard PEPS scores for all manually completed surveys. Standard scores on each subscale are calculated based on a random sample of 1000 subjects, from a national database of subjects who have taken the PEPS.<sup>12</sup> The mean standard score is 50 with a standard deviation of 10.<sup>12</sup> A standard score of 40 or less, or 60 or more, indicates the relative importance of that variable with respect to learning style.<sup>12</sup> A standard score between 40 and 60 indicates variable importance for that element of learning.<sup>12</sup>

## Protocol

Subjects gave their informed consent prior to participation. This study was approved by the Internal Review Board of The University of Alabama, Tuscaloosa, AL. We administered the surveys at the start of the spring semester during two separate, regularly scheduled athletic training class periods. We instructed the subjects to respond to the survey questions with their immediate reaction. Subjects responded without distinguishing between the different preferences they might have had for studying athletic training materials versus general studies.

## Data Analysis

We returned the completed surveys to Price Systems, Inc for scoring and calculation of raw and standard scores. Standard scores and demographic data for each subject were coded and analyzed using the mainframe version 4.1 of the SPSS statistical software package (SPSS Inc, Chicago, IL). Individual hypothesis tests were conducted using separate parametric one-way analyses of variance (ANOVAs) for 19 of the subscale variables by sex and for these variables by year in program. Nonparametric Kruskal-Wallis one-way ANOVAs were conducted for light by sex and light by year because these data failed to meet the ANOVA assumptions of normality and equal variance. The remaining data satisfied all ANOVA assumptions. The alpha level ( $P < .05$ ) was established a priori for all analyses.

## RESULTS

Descriptive statistics show that standard scores tended to fall in the mid-range for most of the subscales, with scores above 60 indicating a clear preference and scores below 40 indicating no preference, for each particular subscale.<sup>12</sup> Sixty nine percent ( $n = 11$ ) of the first-year students had standard scores above 60 for the Structure subscale and 56% ( $n = 9$ ) scored above 60 on the Authority Figures Present subscale (Table 2). Mean standard scores for these subscales were higher for both female and first-year subjects. The mean standard score on the Structure subscale for the entire sample was 62.78. For the Afternoon subscale, mean standard scores for males and first-year subjects both exceeded 60.

The nonparametric one-way ANOVA showed female subjects preferred significantly more light than male subjects, ( $\chi^2_{1-0.05}(1) = 5.42, P = .02$ ). First-year students had greater

**Table 1. Productivity Environmental Preference Survey Subscale Reliabilities and Descriptions\***

Subscale reliability (r)	Description
Sound (.83)	preference for quiet learning area versus learning area with background noise
Light (.84)	preference for natural and/or artificial light in learning area
Warmth (.85)	preference for warm or cool learning area
Formal design (.74)	preference for formal or informal arrangement of learning area
Motivated/unmotivated (.54)	self-direction to initiate and complete assignments and other learning tasks
Persistent (.66)	perseverance to study and fulfill assignments in a timely manner
Responsible (.84)	accountability and dependability to complete assigned tasks
Structure (.63)	desire for strict project/assignment organization and detail clarification
Learning alone/peer-oriented (.84)	preference for learning alone versus learning as part of a group
Authority-oriented learner (.54)	desire for presence or ready availability of instructor/leader
Several ways (.44)	preference for both supervisor-directed and independent learning activities
Auditory preferences (.78)	preference for learning by hearing
Visual preferences (.67)	preference for learning with visual aids (includes reading)
Tactile preferences (.39)	preference for learning by manipulating or moving aids and devices
Kinesthetic preferences (.58)	preference for learning through physical involvement with activity
Requires intake (.82)	desire to be able to eat and/or drink while learning
Evening/morning (.84)	preference for early morning as time of day for learning
Late morning (.79)	preference for late morning as time of day for learning
Afternoon (.87)	preference for afternoon as time of day for learning
Needs mobility (.78)	preference for being able to move around during learning activities

\* Price Systems, Inc, Lawrence, KS.

**Table 2. Productivity Environmental Preference Survey Subscale Means for Subjects by Group**

Subscale	Total Sample	Male	Female	First Year	Second Year
Sound	52.11	51.79	52.46	52.0	52.27
Light	54.74	51.29	58.46	54.88	54.55
Warmth	51.11	48.14	54.31	52.88	48.55
Formal design	50.07	50.0	50.15	51.50	48.0
Motivated/unmotivated	53.11	52.0	54.31	53.50	52.55
Persistent	53.89	53.29	54.54	54.0	53.73
Responsible	47.56	45.0	50.31	48.38	46.36
Structure	62.78*	61.71*	63.92*	63.5*	61.73*
Learning alone/peer-oriented	54.30	54.36	54.23	54.31	54.27
Authority-oriented learner	59.56*	58.36	60.85*	60.25*	58.55
Several ways	49.89	48.0	51.92	48.94	51.27
Auditory preferences	56.15	56.86	55.38	56.63	55.45
Visual preferences	51.78	50.36	53.31	52.0	51.45
Tactile preferences	54.78	54.57	55.0	54.75	54.82
Kinesthetic preferences	54.37	53.86	54.92	54.31	54.45
Requires intake	56.56	55.0	58.23	56.44	56.73
Evening/morning	44.04	41.43	46.85	42.19	46.73
Late morning	46.67	44.29	49.23	44.06	50.45
Afternoon	58.78	60.36*	57.08	62.63*	53.18
Needs mobility	56.33	55.86	56.85	54.13	59.55

\* Scores above 60 indicate a clear preference for each subscale; scores below 40 indicate no preference.

preferences for afternoon learning and work activities than second-year students ( $F(1,25) = 5.75, P = .02$ ) (Table 3). Year in program explained 19% of the variance in the Afternoon subscale standard score. A factorial ANOVA revealed no significant interactive effects between year in program and sex on the Afternoon subscale.

## DISCUSSION

The lack of a clear preference for kinesthetic and tactile learning experiences among the subjects in our study is somewhat surprising. The desire for hands-on learning activities has been strongly associated with allied medical and medical students.

Draper<sup>3</sup> administered Babich and Randol's Learning Styles Inventory to 102 candidates taking the NATA certification examination. This 35-item survey measures learning preferences on a Likert scale. Results of this study showed that 60% of the respondents were classified as kinesthetic learners.<sup>3</sup>

Other investigations<sup>5,9,14</sup> have identified the importance of direct and kinesthetic experiences to learning in allied health programs. Blagg<sup>5</sup> administered Canfield's Learning Styles Inventory and 3 additional personality tests to 51 graduate students in a variety of allied health programs in order to predict academic success. Canfield's Learning Styles is a 30-item instrument in which subjects rank order their preferences for learning situations. Analysis of learning style scores combined with subjects' master's comprehensive examination scores identified direct, hands-on experience as a useful predictor of academic success.<sup>5</sup>

These data are supported by Stafford's<sup>14</sup> study of occupational therapy students. The 9-item version of Kolb's LSI, a 40-item learning inventory, and subjects' clinical performance evaluations were analyzed. A strong correlation was found

between a preference for hands-on learning and success in working clinically with patients with both mental and physical disabilities.<sup>14</sup>

The Gregorc Learning Style Delineator was administered over four consecutive years to assess the learning styles of 87 dental students.<sup>9</sup> This instrument involves the ranking of ten word sets in order of how they describe the subject as a learner. A concrete-sequential learning style, associated with a preference for hands-on, structured learning experiences, was identified most frequently in these subjects.<sup>9</sup>

The disparity between the Tactile and Kinesthetic subscale results of our study and the literature may be semantic

**Table 3. ANOVA Probability Values for Each Subscale**

Subscale	By Sex	By Year in Program
Sound	.85	.94
Light	.02*	.93
Warmth	.15	.32
Formal design	.89	.46
Motivated/unmotivated	.24	.66
Persistent	.57	.90
Responsible	.09	.54
Structure	.28	.39
Learning alone/peer-oriented	.97	.99
Authority-oriented learner	.36	.54
Several ways	.15	.41
Auditory preferences	.73	.79
Visual preferences	.20	.82
Tactile preferences	.85	.98
Kinesthetic preferences	.50	.93
Requires intake	.28	.93
Evening/morning	.10	.16
Late morning	.23	.12
Afternoon	.45	.02*
Needs mobility	.76	.09

\*  $P < .05$ .

in nature. In addition, each of the preceding investigations used a different assessment instrument, making it difficult to compare across studies. We believe that the previous identification of allied health students as kinesthetic learners is accurate. A more stringent definition of kinesthetic and tactile activities may be contained within the PEPS, resulting in lower scores for these particular subscales. These results may also indicate that subjects' preferences vary according to specific athletic training topics. Athletic training educators must recognize that certain subjects lend themselves to hands-on activities, whereas others do not, and vary activities appropriately.

Sex preferences for light are not reported elsewhere in the learning styles literature. Here again, the identification of this difference may lie in the specificity of the PEPS instrument. Our results suggest that all didactic and clinical learning areas should be well-lit, with the inclusion of areas of even brighter lighting.

The preference among first-year student athletic trainers for afternoon learning and work times poses a challenge and a reminder. Traditionally athletic training classes are in the mornings, with afternoons reserved for supervised clinical experiences. Although didactic and clinical schedules are not flexible, instructors and clinical supervisors should recognize the preference for afternoon learning. Our results reinforce the importance of the clinical setting for the instruction and refinement of practical skills.

First-year students also demonstrated stronger preferences for structured learning experiences and the presence or ready accessibility of authority figures. Although second-year students had lower mean standard scores for these subscales, means for the total sample indicated the importance of these variables to all of the subjects. These findings conflict with those of Draper,<sup>3</sup> who found that 63% of certification examination candidates classified themselves as independent learners. Educators should provide specific instructions and frequent feedback and clarify expectations for assignments. The educator should be accessible for supervision as requested by individual learners.

## CONCLUSIONS

As athletic training evolves and educational standards for the profession become more stringent, athletic training educators must begin to examine their instructional methods and the learning preferences of their students. The relationship be-

tween learning preference, teaching style, and student outcome must be considered. Learning activities in the classroom and the clinical setting must attempt to match student preferences, teaching methods, and instructional environments.

Although this study is limited by repeated testing and the small number of subjects, it provides another piece of information in the evolving area of athletic training education. Further research is needed to investigate the relationship between learning and teaching styles and educational outcomes. Additional study is also needed to examine the impact of demographic and educational variables on learning style and to develop a predictive model for learning preference.

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# Organizational Commitment Among Intercollegiate Head Athletic Trainers: Examining Our Work Environment

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**Objective:** To 1) examine the commitment of head athletic trainers to their intercollegiate work environments, 2) develop a model that better reflects the head athletic trainer's daily work setting, and 3) use new techniques to describe the various ways head athletic trainers demonstrate commitment to their organizations.

**Design and Setting:** Organizational commitment (OC) surveys were sent to 461 head athletic trainers identified for the sample. A response rate of 71.5% (330/461) was obtained from the mail survey.

**Subjects:** A proportional random sample of head athletic trainers was taken from a population identified in the National Association of Collegiate Directors of Athletics (NACDA) directory of intercollegiate athletics as Division I, II, and III institutions.

**Measurements:** Returned OC surveys were analyzed using descriptive and inferential statistics for all demographic and OC variables. Exploratory cluster analysis was performed to examine naturally clustering groups.

**Results:** Exploratory cluster analysis revealed five naturally clustering groups that represent the head athletic trainers'

patterns of commitment across the specific organizational targets. Paired *t* tests indicated that the continuance commitment scores were significantly lower than the affective and normative scores across the sample. Analysis of variance tests indicated significant differences for specific commitment dimensions based on gender and NCAA division demographics. Beyond that, the five-cluster solution revealed no particular demographic characteristics that predisposed individuals to specific clusters.

**Conclusions:** The findings reinforce a central theme in intercollegiate athletic training: that student-athletes and student athletic trainers are the primary focus of the head athletic trainers' commitment. Positive attachment and obligation directed toward student-athletes and student athletic trainers link the five clusters. Commitment patterns in areas other than student-athletes and student athletic trainers define the cluster membership or head athletic trainer "type" presented in this study. In addition, specific commitment differences based on gender and NCAA division may warrant further investigation.

**Key Words:** affective commitment, continuance commitment, normative commitment, exploratory cluster analysis

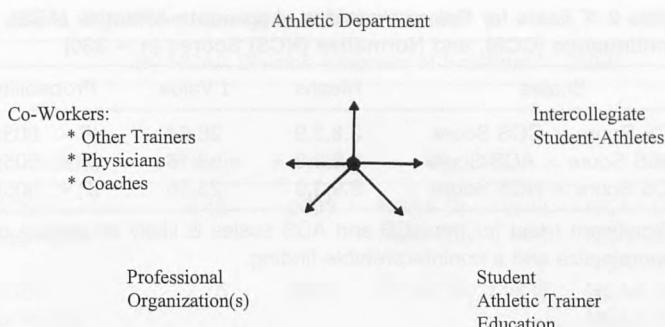
**R**esearch has traditionally defined organizational commitment (OC) as the strength of an individual's identification with the goals and values of a particular organization.<sup>1</sup> However, recent studies suggest that measuring relationships only between commitment and organizational goals and values fails to fully utilize the OC construct.<sup>2,3</sup> Reichers<sup>2</sup> argues that because organizations are complex and many different factors affect peoples' commitment, the commitment construct must be reconceptualized to capture the full range of its meaning.

Literature focusing on the OC construct has evolved to the point where the utility of a three-dimensional model of commitment has been recognized: affective, continuance, and normative commitment make up the three commitment types.<sup>4–6</sup> Three distinct scales are used to measure each commitment type. The affective commitment scale (ACS) measures an employee's emotional attachment to, identification with, and involvement in the organization. The continuance commitment scale (CCS) measures commitment based on the costs that an employee associates with departing an organization. The normative commitment scale (NCS) mea-

sures an employee's feeling of obligation to remain with the organization.

The athletic training literature lacks any studies measuring dimensions of OC in work settings common to the athletic trainer. Researchers in other allied health fields have examined OC.<sup>7,8</sup> However, these efforts have been limited to correlational studies examining commitment and job satisfaction. To assess organizational commitment among intercollegiate head athletic trainers, an instrument was developed that addressed two central issues: 1) the multiple targets to which head athletic trainers may express commitment, and 2) the multiple commitment dimensions (ACS, CCS, and NCS) that make up the current OC definition (Fig 1). By giving full consideration to these two areas, the proposed organizational model provides a better reflection of head athletic trainers' work settings.

The athletic trainer's job has been delineated into five commonly shared domains: 1) prevention of athletic injuries, 2) recognition, evaluation, and immediate care of athletic injuries, 3) rehabilitation and reconditioning of athletic injuries, 4) health care administration, and 5) professional development and responsibility.<sup>9</sup> The health care administration



**Fig 1. Targets of organizational commitment among head athletic trainers. Arrows represent three possible commitment dimensions: affective (ACS), continuance (CCS), and normative (NCS).**

domain often occupies a disproportionate amount of the head athletic trainer's time in comparison with the role of health care provider. Head athletic trainers are often torn by competing constituency-determined roles demanding their professional attention. Moreover, each setting is unique in that student-athletes, student athletic trainers, specific coaching staffs, team physicians, other coworkers, and many groups native to that setting define an individual's commitment. Understanding the commitment-based links between head athletic trainers and the complex organizations they work in may allow for a greater understanding of how commitment is divided among the head athletic trainers' many competing work roles.

This study investigates the commitment of head athletic trainers to their intercollegiate work environments, seeks to develop a model that better reflects the head athletic trainer's daily work setting, and uses new techniques to describe the various ways head athletic trainers demonstrate commitment to their organizations. Confirmatory and exploratory tools are used to identify naturally clustering groups of head athletic trainers. These clusters allow for a better understanding of how the multiple dimensions of the OC construct can be applied in this unique work environment. The findings provide insight into the athletic training profession's ability to describe various ways head athletic trainers are committed to their organizations.

## METHODS

Four hundred and sixty-one head athletic trainers were randomly selected from NCAA member institutions identified as Divisions I, II, or III in the National Association of Collegiate Directors of Athletics (NACDA) directory.<sup>10</sup> A proportional random sample was obtained in order to discuss OC issues within as well as among groups of head athletic trainers.<sup>11</sup> A proportional random sample insures that the sample is drawn in proportion to the actual number of members in each of the three NCAA divisions. A self-administered mail survey, based on a multiple target and multiple commitment organization model, was sent to all the participants.

Affinity exercises as described by Brossard<sup>12</sup> were used to identify appropriate targets of commitment for athletic trainers

working in the intercollegiate setting. A group of certified athletic trainers, all with experience in the intercollegiate setting, was asked to participate in this exercise. The exercise produced five targets of commitment: intercollegiate student-athletes, student athletic trainer education, professional organizations, coworkers, and athletic department. The number of targets was limited to five in the interest of manageability. Multiple dimensions of commitment were measured using Meyer and Allen's<sup>13</sup> scales for affective and continuance commitment, and Weiner's<sup>14</sup> measures of normative commitment. Low response rates are a threat to the internal and external validity of mail surveys.<sup>11</sup> To insure proper response rates, the survey distribution followed the method outlined by Dillman.<sup>15</sup>

Data were analyzed using basic descriptive statistics and statistical measures of consistency under appropriate conditions. Statistical parameters were determined a priori and an alpha level of 0.05 was used for all comparison decisions. Paired *t* tests, employing aggregate scores for the three OC dimensions, were used to examine differences among overall commitment scores for each of the three dimensions. One-way analysis of variance (ANOVA) tests were used to test the targeted OC variables against independent demographic variables. Post hoc comparisons employing Scheffe's method were used to protect the alpha level during multiple comparisons.

In order to examine the naturally clustering groups of head athletic trainers based on their links to the OC dimensions and targets, an exploratory cluster analysis was performed. Aggregate scores for the three commitment dimensions were used as cluster points for the exploratory cluster analysis. Exploratory cluster analysis allows for the exploration of responses to the target-specific questions and provides a foundation to generate further hypotheses from the information gathered. Like objects (responses) are combined and then built stepwise into larger clusters.<sup>16</sup> The resulting mathematical coefficients are then analyzed to explore appropriate cluster solutions. If coefficient values show large increases from one cluster solution to the next, this is indicative of clusters with increasingly dissimilar members.<sup>17</sup> Estimates of logical cluster solutions are then analyzed. Cluster solutions with interpretable and logical data were further explored using descriptive statistics to describe the head athletic trainers common to each cluster.

## RESULTS

Surveys were mailed to 461 head athletic trainers with 345 returned, for a return rate of 74.8%. Fifteen of the 345 returned surveys were deemed unusable by the author due to incomplete responses. Surveys that did not contain demographic data or failed to complete entire sections were judged unusable. Therefore, the overall response rate to the survey was 71.5% (330/461).

Data were gathered on gender, education (degree obtained), field of study, tenure in current position, the route to athletic

training certification, and NCAA division of employing institution (Table 1). These demographic variables were used to describe the naturally occurring clusters of head athletic trainers.

Paired *t*-test results are summarized in Table 2. Paired *t* tests indicate that the CCS mean is significantly lower than the ACS ( $t = 20.64, P < .005, n = 330$ ) and the NCS ( $t = 23.56, P < .005, n = 330$ ) means for this sample of head athletic trainers. In addition, a significant *t* test was obtained in comparing the NCS and ACS means ( $t = 20.64, P < .005, n = 330$ ). However, due to the proximity of the means (NCS = 3.9, ACS = 3.8), this is likely an artifact of sample size and not an interpretable finding.

Significant results from the one-way ANOVA are summarized in Table 3. Mean scores on the NCS questions were significantly different for the Division III head athletic trainers when compared with their Division I and Division II counterparts ( $F = 8.46, DF = 2328, P = .0003$ ). The mean NCS scores were lower for the head athletic trainers in Division III. The Division I and Division III head athletic trainers' OC scores differed significantly on the ACS and NCS dimensions specific to the coworker target (ACS coworker  $F = 7.75, DF = 2,328, P = .0005$ ; NCS coworker  $F = 9.15, DF = 2328, P = .0001$ ). Once again, Division III head athletic trainers had lower mean scores on these two scales when compared with Division I.

The athletic department target also represented a significant difference across the three divisions. Division III mean NCS scores were significantly lower than Division I and II scores ( $F = 11.18, DF = 2328, P = .0000$ ). Differences were also noted between Division I and Division III head athletic trainers for the CCS student athletic trainer education targets ( $F = 4.40, DF = 2328, P = .0130$ ). Division I head athletic trainers demonstrated lower mean CCS scores for this dimension.

**Table 2. *T* Tests for Paired Variables. Aggregate Affective (ACS), Continuance (CCS), and Normative (NCS) Scores ( $n = 330$ )**

Scales	Means	<i>t</i> Value	Probability
ACS Score × CCS Score	3.8,2.9	20.64	( $P < .005$ )
*NCS Score × ACS Score	3.9,3.8	3.16	( $P < .005$ )
CCS Score × NCS Score	2.9,3.9	23.56	( $P < .005$ )

\* Significant *t* test for the NCS and ACS scales is likely an artifact of sample size and a noninterpretable finding.

Additional demographic variables showed differences when examined by gender. The coworker target provided significant differences for the ACS and NCS scales (NCS coworker:  $F = 9.79, DF = 1329, P = .0019$ ; ACS coworker:  $F = 18.58, DF = 1329, P = .0000$ ). Female head athletic trainers revealed lower mean scores on these coworker targets than their male counterparts (NCS coworkers: females 3.57, males 3.89). The female head athletic trainers also demonstrated lower means on the ACS athletic department target (Means: females 3.35, males 3.58;  $F = 4.85, DF = 1329, P = .0282$ ).

Significant findings were also found across the tenure dimension. However, these findings hold limited meaning because of a design flaw in the study that does not adequately capture the potential differences based on tenure. The categories used in this study are not appropriate to compare head athletic trainers with extended longevity in their positions.

The exploratory cluster analysis yielded a five-cluster solution using Ward's minimum variance linkage method. Observed demographic variables for each cluster in the five cluster solutions were compared with expected demographic variables using a chi-square test. Expected values were obtained using the observed percentages in Table 1 and multiplying them by the  $n$  for a given cluster. No significant

**Table 1. Demographics Data**

Gender	Frequency ( $n = 330$ )	(%)	Education	Frequency ( $n = 328$ )	(%)
Male	268	81.2	Bachelor's	40	12.1
Female	62	18.8	Master's	277	83.7
			Doctorate	11	3.3
Major/Area of Study	Frequency ( $n = 330$ )	(%)	Route to Certification	Frequency ( $n = 330$ )	(%)
Physical Education	99	30.0	Curriculum	116	35.1
Athletic training	56	17.0	Internship	172	52.1
Education	37	11.2	Grandfather clause	32	9.8
Health	36	10.9	Non-NATA state regulated	7	2.1
Exercise sci./phys.	35	10.6	Non Cert./regulated	3	.9
"Sports medicine"	19	5.7			
Physical therapy	18	5.5			
Other/nonresp.	30	9.1			
NCAA Division	Frequency ( $n = 330$ )	(%)	Tenure	Frequency ( $n = 330$ )	(%)
Division I	140	42.4	Less than one year	31	9.4
Division II	91	27.6	One to three years	51	15.5
Division III	99	30.0	Three to five years	36	10.9
			Five to seven years	40	12.1
			Greater than seven	172	52.1

**Table 3. Significant One-Way ANOVA Results\* ( $n = 330$ ,  $P < .05$ )**

By NCAA Division (Degrees of Freedom = 2328)					By Gender (Degrees of Freedom = 1329)				
Scale	F Ratio	F Prob.	Sig. Diff.	Means	Means				
					Scale	F Ratio	F Prob.	Males	Females
NCST Aggregate	8.46	.0003	NCAA Div. I vs III NCAA Div. II vs III	NCAA Div. I 3.84 NCAA Div. II 3.79 NCAA Div. III 3.46	ACS Coworker	18.58	.0000	3.81	3.39
ACS‡ Coworker	7.75	.0005	NCAA Div. I vs III	NCAA Div. I 3.88 NCAA Div. III 3.53	NCS Coworker	9.79	.0019	3.89	3.57
NCS Ath. Dept.	9.15	.0001	NCAA Div. I vs III	NCAA Div. I 3.99 NCAA Div. II vs III NCAA Div. II 2.82 NCAA Div. III 3.42	ACS Ath. Dept.	4.85	.0282	3.58	3.35
CCS§ St. Ath. Tr. Ed.	4.40	.0130	NCAA Div. I vs III	NCAA Div. I 2.82 NCAA Div. III 3.08					

\* OC dimension scores (dependent variable) by demographics (independent variables).

† NCS = Normative OC scores.

‡ ACS = Affective OC scores.

§ CCS = Continuance OC scores.

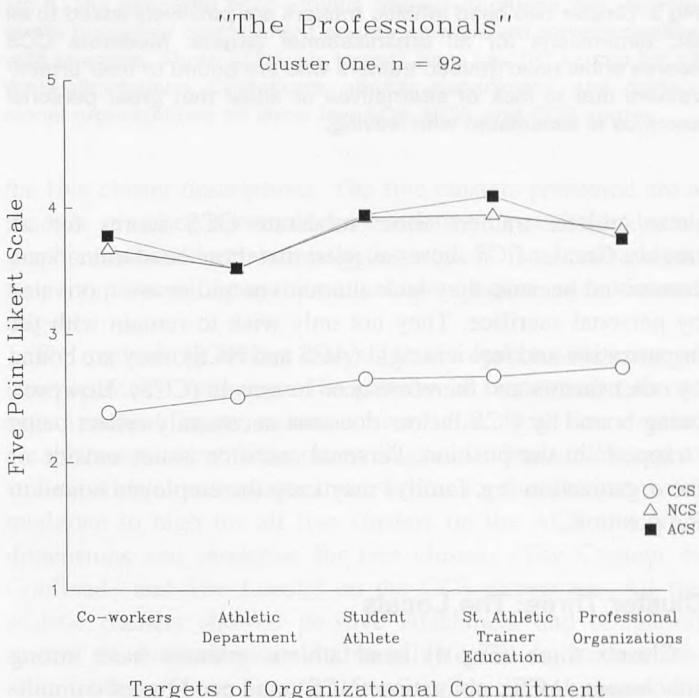
chi-square values were obtained. Thus, the demographics for each cluster reflected the demographics of the sample as a whole. Despite the similarity in the demographic makeup of each cluster, the five groupings describe very distinct OC dimension and target attributes.

### Cluster Descriptions

Cluster descriptions for the five cluster solutions have been assigned labels to allow for description and discussion. Each cluster name is based on the unique characteristics that define the types of organizational commitment put forth for each group.

### Cluster One: The Professionals

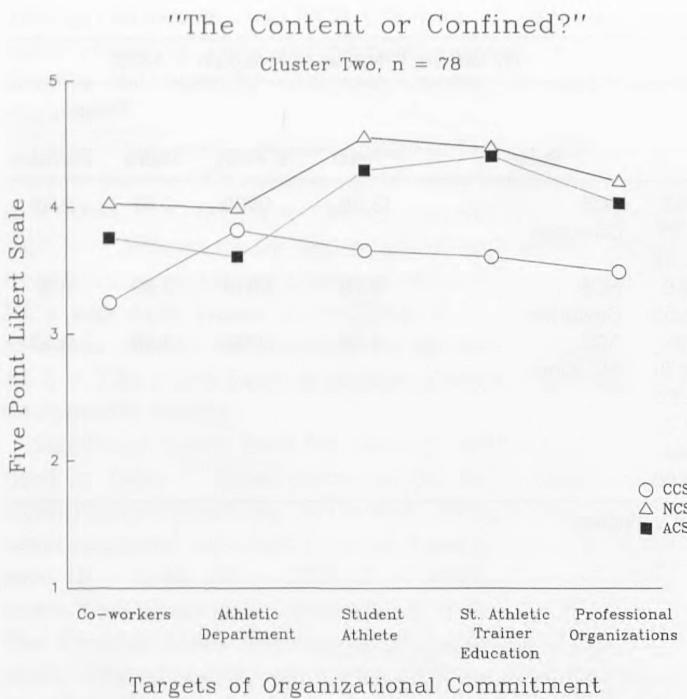
The head athletic trainers who are grouped in cluster number one ( $n = 92$ ) show strong commitment scores on the affective (ACS) and normative (NCS) dimensions. This cluster (Fig 2) is composed of individuals who are linked to their organization through attachment and obligation. Their highest scores are on the ACS student athletic trainer education target, with consistently high ACS and NCS scores for their coworkers, student-athletes, and professional organizations. They are distinct in their consistently low scores on the CCS, indicating that they are not bound by specific needs linking them to the organization. Low CCS scores may suggest that these athletic trainers are more mobile.<sup>18</sup> However, on the ACS and NCS scales, cluster one head athletic trainers are committed to all the targets that define their organization. They are likely linked to the organization by their desire to remain and their feeling that it is right to do so.



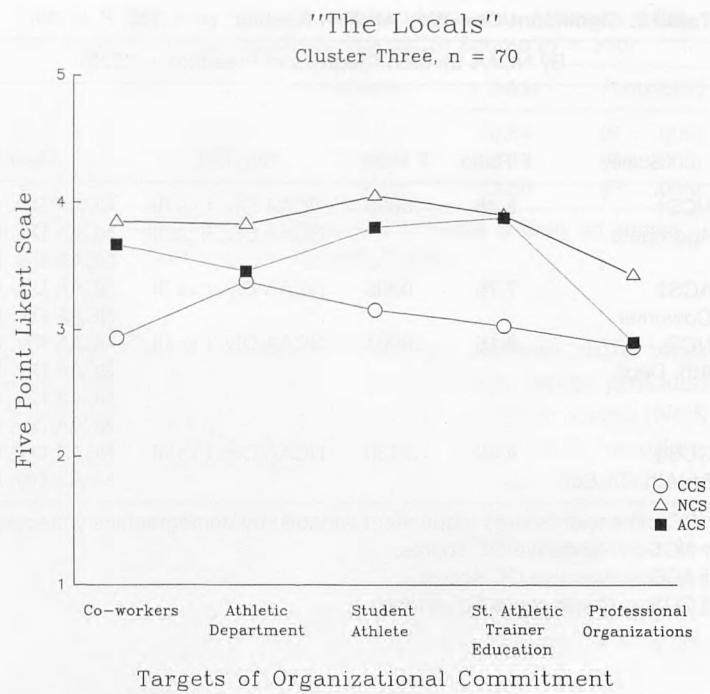
**Fig 2. Cluster one head athletic trainers show consistently low CCS scores. They demonstrate strong OC for all targets on the ACS and NCS scale.**

### Cluster Two: The Content or Confined?

Cluster two ( $n = 78$ ) is identified by head athletic trainers who are linked to their organization to some degree by all three OC dimensions. The cluster (Fig 3) is identified by the high commitment scores on the ACS and NCS dimensions for the student-athlete, student athletic trainer education, and professional organization targets. The ACS and NCS coworker scores also reflect strong commitment. Unlike cluster one,



**Fig 3.** Cluster two head athletic trainers are positively linked to all OC dimensions for all organizational targets. Moderate CCS scores show head athletic trainers who are bound to their organizations due to lack of alternatives or show that great personal sacrifice is associated with leaving.



**Fig 4.** Strong attachment (ACS), obligation (NCS), and need-based (CCS) commitment toward targets that reflect their immediate job environment (coworkers, athletic department, student-athlete, student athletic trainer education) defines the head athletic trainers in cluster three.

these athletic trainers show moderate CCS scores for all targets. Greater CCS scores suggest that these head trainers are committed because they lack alternatives and/or are motivated by personal sacrifice. They not only wish to remain with the organization and feel it is right (ACS and NCS), they are bound by other factors and therefore need to remain (CCS). However, being bound by CCS factors does not necessarily reflect being "trapped" in the position. Personal sacrifice issues outside of the organization (eg, family) may keep the employee bound to the position.

#### Cluster Three: The Locals

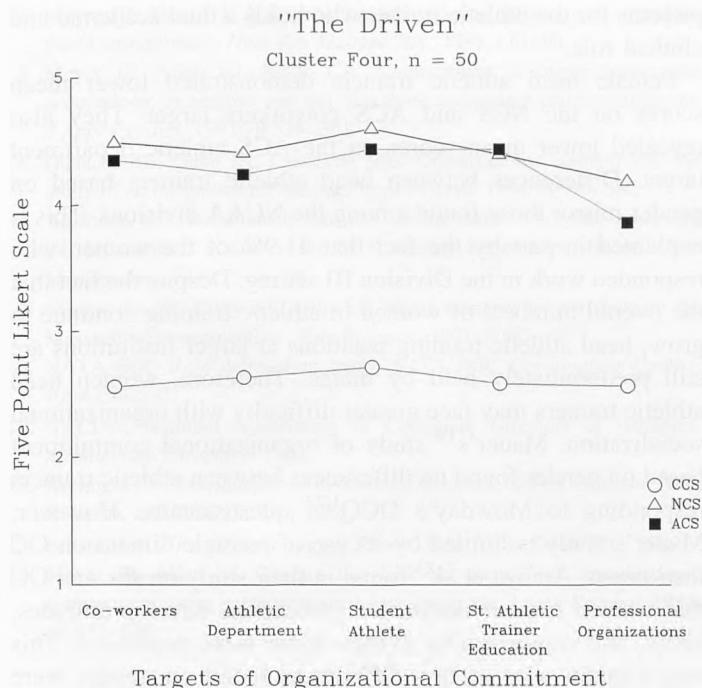
Cluster three (Fig 4) head athletic trainers have strong attachment (ACS), obligation (NCS), and need-based commitment (CCS) toward the targets that reflect their immediate job environment. Head athletic trainers in cluster three ( $n = 70$ ) display moderate commitment to coworkers, student-athletes, and student athletic trainer education on the ACS and NCS dimensions. Cluster three head athletic trainers stand out by their low commitment scores toward the professional organization target. They also demonstrate moderate CCS scores on four of six targets. This cluster describes committed professionals focused on targets central to their internal organization. These head athletic trainers are linked to the organization by their attachment (ACS) and obligation (NCS). They may also be bound to the organization by lack of alternatives or personal sacrifice issues (needs).

#### Cluster Four: The Driven

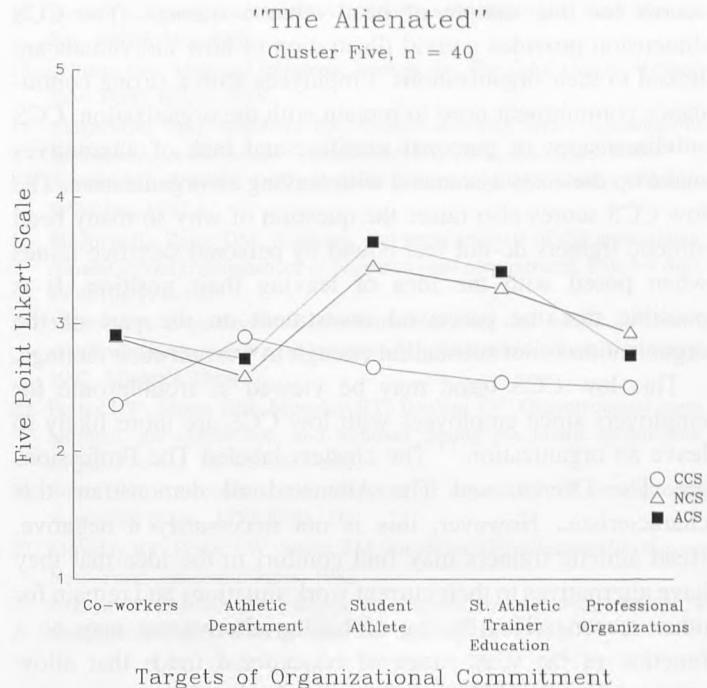
This cluster (Fig 5) is not bound by need-based (CCS) factors and its members are, therefore, more likely to seek another position. They have the highest attachment (ACS) and obligation (NCS) links to their organization of all five clusters. Low CCS scores for all targets, in contrast to very high ACS and NCS scores, define the head athletic trainers in cluster four ( $n = 50$ ). These individuals show high commitment scores on the ACS and NCS dimension for every target with the exception of one moderate score for the ACS: professional organization target.

#### Cluster Five: The Alienated

Cluster five ( $n = 40$ ) individuals (Fig 6) are characterized by demonstrating moderate commitment scores only toward targets dealing with students. Their low need-based (CCS) scores may indicate they are looking to move, and their low attachment (ACS) and obligation (NCS) scores are reflective of little desire or feeling of obligation toward their coworkers, athletic department, or professional organizations. Three of the six targets have low commitment scores for all three dimensions. Coworkers, athletic department, and professional organizations all show low ACS, NCS, and CCS scores. The CCS scale has low scores for each of the six targets. The student-athlete and student athletic trainer education targets show moderate commitment scores for the ACS and NCS dimensions.



**Fig 5.** Low CCS scores for all organizational targets in contrast to very high ACS and NCS scores define the head athletic trainers in cluster four.



**Fig 6.** The Alienated head athletic trainers in cluster five demonstrate moderate commitment scores only toward targets dealing with students. Three of the six targets have low OC scores for all three dimensions. Coworkers, athletic department, and professional organizations all show low ACS, NCS, and CCS scores.

## DISCUSSION

Only Maurer's unpublished master's thesis<sup>19</sup> attempts to measure organizational commitment for a group of athletic trainers. She compared the OC of certified athletic trainers working in intercollegiate athletics by gender. Maurer<sup>19</sup> hypothesized that female athletic trainers would have lower measures of OC to the athletic training profession than their male counterparts. However, her results showed no differences between these groups. Maurer's work is limited by the use of the Organizational Commitment Questionnaire (OCQ)<sup>20</sup> as a primary instrument. The OCQ provides a measure only of the ACS. Recent literature<sup>4,5,6</sup> suggests that using a single-dimension OC instrument is not a reliable measure to test a hypothesis concerning commitment to a profession. In addition, failing to recognize the multiple commitment nature of organizations and the fact that the OCQ measures only the affective dimension limits the application. Meyer, Allen, and Smith's<sup>5</sup> study on the extension and test of the three-component conceptualization uses a population of nurses for their research. Although their study does explore multiple dimensions of commitment, it does not focus on multiple targets of OC.

The practical implications of the findings from this study center on the descriptions of the head athletic trainers in each of the five clusters. The findings of the exploratory cluster analysis show that there are no distinct commitment types of individuals. There are no particular demographic characteristics that predispose individuals to specific cluster membership; rather, the head athletic trainers are fairly homogeneous across

the five cluster descriptions. The five clusters presented are a product of other personal characteristics beyond the demographics solicited in the study, as well as the head athletic trainers' patterns of commitment across specific organizational targets.

The exploratory cluster analysis leaves open a wide range of interpretations. With regard to patterns of commitment across organizational targets, common threads linking all five clusters are the commitment to the intercollegiate student-athlete and to student athletic trainer education. Scores for these targets were moderate to high for all five clusters on the ACS and NCS dimensions and moderate for two clusters (The Content or Confined? and The Locals) on the CCS dimension. All the athletic trainers showed positive attachment and obligation toward the intercollegiate student-athlete and the student athletic trainer. These findings reinforce a central theme for athletic training in the intercollegiate setting: the student-athlete and the student athletic trainer are the primary customers we serve. Scores and commitment patterns in areas other than these two targets (coworkers, athletic department, and professional organizations) define the cluster memberships or type of head athletic trainer. For example, The Alienated head athletic trainer reveals low commitment scores to the coworkers, athletic department, and professional organizations targets, while the remaining clusters demonstrate more balance across those targets.

Three of the five clusters reveal low CCS scores ( $n = 182$ ). This is consistent with the overall paired *t*-test findings that the CCS scores are significantly lower than the NCS and ACS

scores for this sample of head athletic trainers. The CCS dimension provides a vivid illustration of how individuals are linked to their organizations. Employees with a strong continuance commitment need to remain with the organization. CCS subdimensions of personal sacrifice and lack of alternatives make up the costs associated with leaving an organization. The low CCS scores also raises the question of why so many head athletic trainers do not feel bound by personal sacrifice issues when posed with the idea of leaving their position. It is possible that the perceived investment on the part of the organization is not substantial enough to warrant such feelings.

This low CCS trend may be viewed as troublesome for employers since employees with low CCS are more likely to leave an organization.<sup>13</sup> The clusters labeled The Professionals, The Driven, and The Alienated all demonstrate this characteristic. However, this is not necessarily a negative. Head athletic trainers may find comfort in the idea that they have alternatives to their current work situations and remain for other reasons. This feeling of having alternatives may be a function of the wide range of educational fields that allow entrance into the athletic training profession.

It is likely that cluster membership is tied to other organizational issues such as organizational culture or climate. Some dominant themes to many of the written comments provided by the respondents emphasize the idea that commitment and loyalty are a two-way street. Steers<sup>21</sup> proposed that individuals come to an organization with certain needs, desires, skills, and so forth, and expect to find a work environment where they can utilize their abilities and satisfy many of their basic needs. When the organization provides such an environment, the likelihood of commitment is apparently enhanced.<sup>21</sup> These conclusions are most applicable in the discussion of the ACS dimension. ACS is characterized by an employee's emotional attachment to, identification with, and involvement in the organization.<sup>22</sup> Further research is needed to better understand which organizational actions will produce an environment that allows employees to exert positive commitment behaviors.

Differences among head athletic trainers based on NCAA division may be due to differences in the structure of those organizations or the institutional emphasis on intercollegiate athletics. Division I and Division II head athletic trainers demonstrated higher levels of commitment to their athletic department (NCS) and coworkers (ACS and NCS) than their Division III counterparts. The Division III athletic department is often affiliated with an academic department, which may result in competing commitment patterns when compared with the other two divisions. The Division III head athletic trainer is less likely to have a large athletic training staff and may demonstrate different levels of commitment toward other coworkers outside of the sports medicine area. Understanding these structural differences contributes to the idea that not only actions by the organization dictate the commitment patterns, but the organizational structure may also allow for or limit OC. Future studies should seek to delineate further the commitment

patterns for the athletic trainer who holds a dual academic and clinical role.

Female head athletic trainers demonstrated lower mean scores on the NCS and ACS coworkers target. They also revealed lower mean scores on the ACS athletic department target. Differences between head athletic trainers based on gender mirror those found among the NCAA divisions. This is explained in part by the fact that 41.9% of the women who responded work in the Division III setting. Despite the fact that the overall numbers of women in athletic training continue to grow, head athletic training positions at larger institutions are still predominately held by males. Therefore, women head athletic trainers may face greater difficulty with organizational socialization. Mauer's<sup>19</sup> study of organizational commitment based on gender found no differences between athletic trainers responding to Mowday's OCQ<sup>1,22</sup> questionnaire. However, Mauer's study is limited by its use of a single-dimension OC instrument. Aranya et al<sup>23</sup> found in their study on sex and OC that women in male-dominated professions develop attitudes, needs, and values similar to men in the same profession. This may explain why so few differences based on gender were found.

## CONCLUSIONS

The results of this study indicate that the commitment patterns of the head athletic trainers cluster them into five distinct groups. These groups are defined by relationships between OC dimensions and target constituencies. This study extends the use of exploratory cluster techniques to describe patterns of commitment and assess specific organizational targets. The common thread linking the head athletic trainers was their positive attachment and obligation toward student-athletes and student athletic trainer education. Understanding how to serve these two central constituencies while recognizing the other target areas that demand attention is critical to the success of the head athletic trainer. In addition, specific commitment differences based on sex and NCAA division may warrant further investigation.

## ACKNOWLEDGMENTS

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# Rupture of the Distal Biceps Tendon in a Collegiate Football Player: A Case Report

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**Objective:** To provide health care personnel with guidelines for the management of a distal biceps tendon rupture.

**Background:** Traumatic ruptures of the biceps tendon are rare, but serious, and usually involve the long head of the proximal insertion. Ruptures of the distal tendon account for only 3% of all biceps tendon ruptures. A history of tendinitis, overuse, or anabolic steroid abuse may predispose tendons to rupture. Surgical repair, followed by a comprehensive rehabilitation program, is indicated to regain full strength and range of motion in both flexion and supination.

**Differential Diagnosis:** Rupture of the distal head of the biceps brachii muscle at the insertion on the radial tuberosity.

**Treatment:** After the injury, the athlete continued to compete for the remainder of the collegiate football season. He then underwent surgery to repair the tendon at its insertion. Postoperatively, the athlete was immobilized in a cast and then a

brace to prevent any movement of the muscle. Rehabilitation proceeded with isometric exercises and manual resistive exercises of the shoulder and wrist. At 16 weeks, the athlete was cleared for biceps curls and wrist supination. At 6 months, the athlete had regained full use of the muscle.

**Uniqueness:** This is a relatively rare injury, usually occurring at the proximal tendon insertion and in those who are middle aged (30 to 50 years old). Also, the surgical intervention in this case was delayed without detrimental effects to the patient.

**Conclusions:** This study shows that, while surgical intervention to repair a ruptured distal biceps tendon is necessary, appropriate conservative measures can be taken to allow surgery to be delayed without harm to the patient. The athletic trainer should be aware of how to recognize and treat this injury.

**Key Words:** biceps brachii, upper extremity, tendinitis

**A**n extreme amount of stress is placed upon the biceps muscle in athletic competition. However, injuries to this muscle are not common, and, in fact, the rotator cuff and other muscles of the shoulder complex are more often injured.<sup>1</sup>

Traumatic ruptures of the biceps tendon are rare. When a rupture does occur, it usually involves the long head of the proximal insertion. Ruptures of the distal tendon account for only 3% of all biceps tendon ruptures.<sup>2</sup> Although the pathology of tendon ruptures is unknown, a history of tendinitis, overuse, or anabolic steroid abuse have been suspected to predispose tendons to rupture.<sup>1</sup> Tendon ruptures can occur at any age; however, most individuals injured are middle aged, ranging from 30 to 50 years of age.<sup>1,3</sup>

Anatomically, the biceps brachii muscle is the main flexor of the elbow and supinator of the forearm (Fig 1). It has a long head, which originates from the upper lip of the glenoid fossa, and a short head, which originates from the coracoid process of the scapula, with a distal insertion on the radial tuberosity (Fig 2).<sup>4</sup> The mechanism of injury to the biceps brachii is most commonly an eccentric contraction or resisted flexion of the elbow resulting from weight lifting or a fall onto an outstretched hand.<sup>5</sup> The athlete usually hears or feels a "pop," and the contour of the upper arm appears abnormal. The distal tendon is normally easily palpable at the antecubital space; the examiner's inability to palpate this tendon calls for immediate referral to an orthopaedist. Failure to recognize a tendon

rupture and treat it appropriately could result in severe atrophy and loss of function.<sup>3</sup>

## CASE REPORT

A 21-year-old male linebacker sustained a rupture of the distal biceps tendon during a collegiate football game. The athlete was an avid bodybuilder with well-defined musculature. He had no previous muscle pain in the biceps brachii muscle and no history of tendinitis. The athlete denied any anabolic steroid use. The athlete was hit from behind and knocked down onto his hands and knees, with the elbows slightly flexed. The opponent then landed on his back, which caused the biceps muscle to contract eccentrically to absorb the shock. The athlete felt a "pop" in his left arm and a period of extreme pain, which quickly subsided. The athlete continued to play and did not notify the medical staff of any injury. During a time out, the athletic trainer noticed a deformity in the left biceps muscle and referred the athlete to the team physician. The biceps muscle was contracted proximally and the distal tendon was not palpable. A rupture of the distal biceps tendon was diagnosed. The athlete had minimal pain at this time, and, although he had limited function, he was permitted to continue playing. After the game, the athlete was reevaluated and was placed in a sling and treated for pain.

A decision was made by the athlete, the athletic training staff, and the team physician to allow the athlete to continue

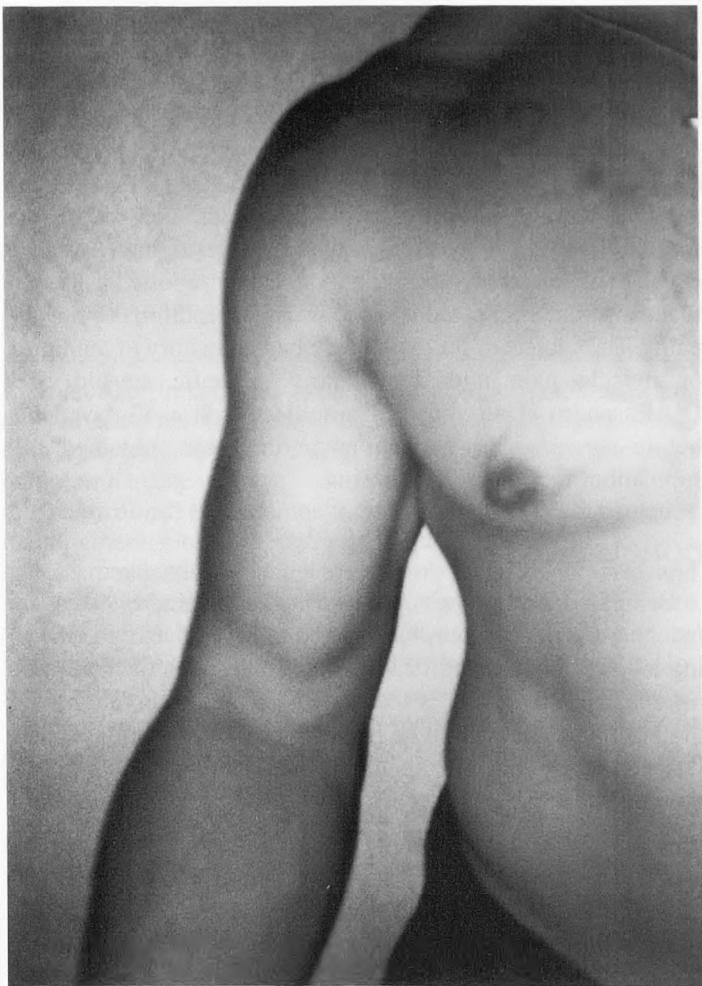


Fig 1. Superficial view of the biceps brachii muscle.

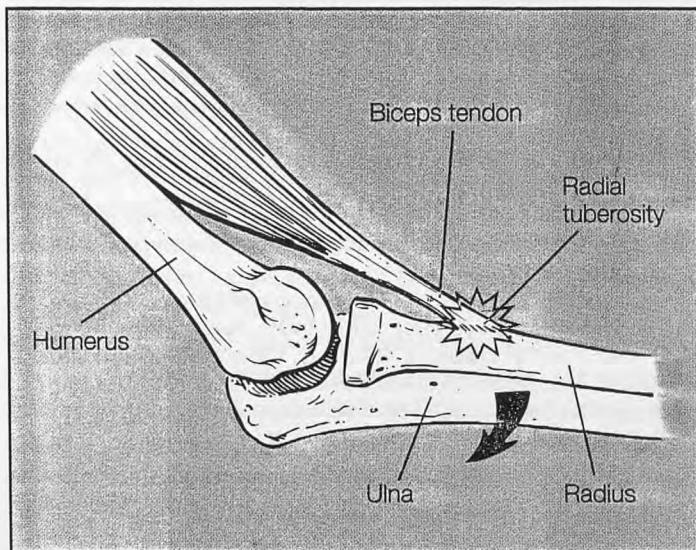


Fig 2. Anatomic illustration of the elbow joint and the insertion of the biceps brachii muscle on the radial tuberosity.

playing and finish the regularly scheduled season. Upon manual muscle testing, the brachioradialis muscle had sufficient strength to compensate for the biceps and to allow the

athlete to perform as a linebacker. The athlete was kept out of contact during weekly practices and was taped to prevent elbow hyperextension during competition (Fig 3).

Two months postinjury, the athlete underwent a surgical repair of the biceps tendon using the two-incision technique described by Boyd and Anderson.<sup>6</sup> The tendon was found to be very short and frayed, and there was difficulty in moving the muscle distally. A tendon graft approximately 2.54 cm (1 inch) wide and 10.16 cm (4 inches) long was taken from the iliotibial band in the left thigh. The graft was inserted into the radial tuberosity and then sutured proximally to the existing biceps tendon, allowing 70° of elbow flexion.

The athlete was placed in a cast postoperatively for 6 weeks and was then placed in a brace with limited elbow extension. During this time, wrist exercises and isometric exercises of the forearm and shoulder were done. The athlete had minimal pain, which was managed with ice and electrical stimulation. At 12 weeks postoperatively, the patient was removed from the brace but was instructed not to stretch the arm into extension to avoid placing stress on the tendon graft. Manual resistive exercises for the shoulder in internal/external rotation, abduction, and adduction were performed, as well as wrist flexion, extension, radial deviation, supination, and pronation exercises. At 16 weeks, the athlete was cleared to perform biceps curls and wrist exercises. Wrist curls and supination were done with free weights, starting with minimal resistance, and slowly increasing resistance as pain and strength allowed. Six months after surgery, the athlete had regained full range of motion and full strength compared with the uninjured side. The athlete was released to play without restrictions (Fig 4).

## DISCUSSION

Surgical repair of a ruptured biceps tendon is the preferred method of treatment.<sup>1,4,6,7</sup> Patients treated nonoperatively have

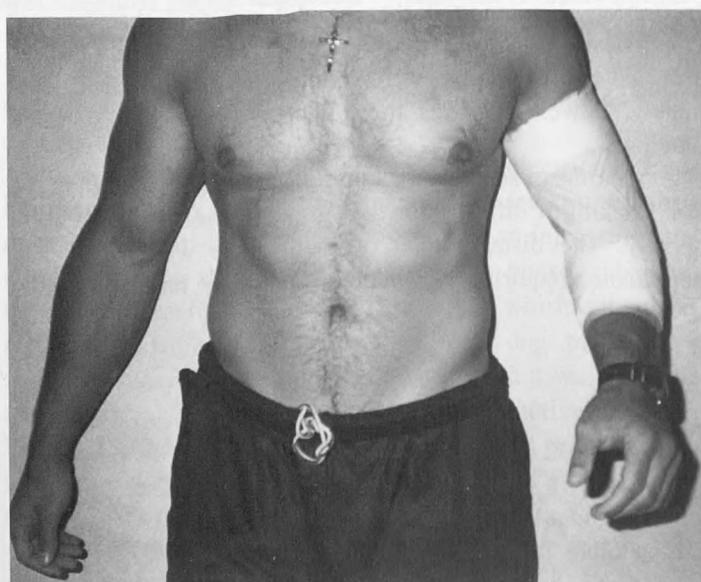


Fig 3. Prophylactic taping to prevent elbow hyperextension.

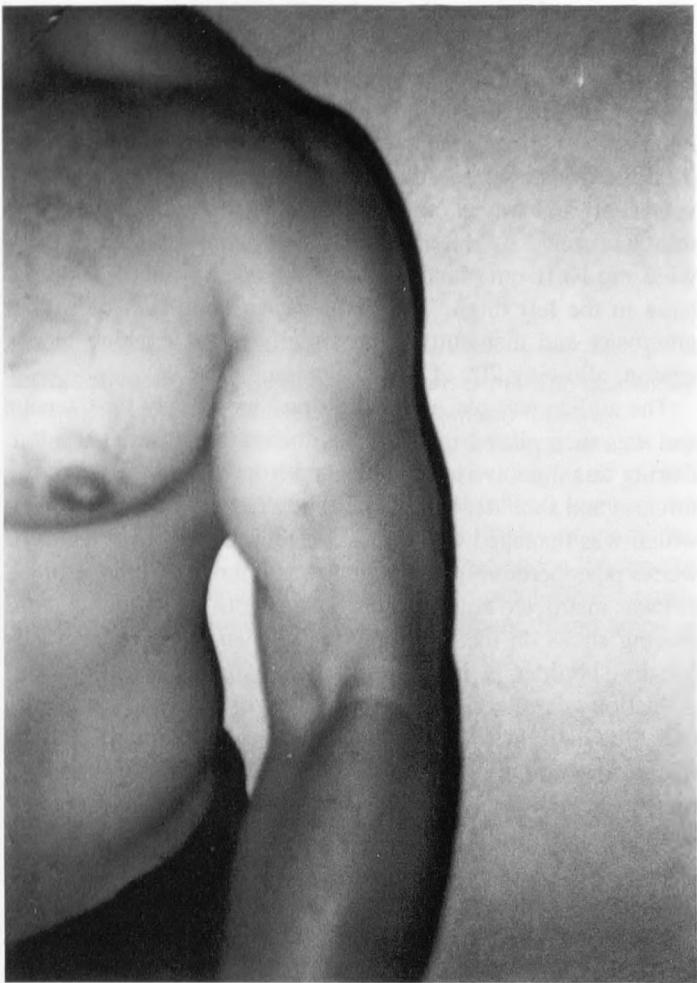


Fig 4. The patient 6 months after surgery.

shown deficits of 40% in supination strength and 30% in flexion.<sup>3,7</sup> In this case, the surgical repair was delayed to allow the athlete to complete the football season. The athlete changed his mind several times about delaying surgery due to pain and frustration. He reported that he did not feel that he was effective in his position due to the lack of strength in his left arm and that opponents were running through his arm. Ultimately, however, it was the athlete's decision to continue playing.

At the time of surgery, the muscle was contracted high in the arm, making it difficult for the surgeon to retract the muscle distally. The distal tendon of the muscle was frayed and nonpliable, requiring a tendon graft to be taken from the

iliotibial band. The tendon had virtually exploded upon rupture, which suggests that this complication was not related to the surgical delay.

The cause of this patient's tendon rupture is unclear. In most cases of tendon rupture, there is a history of tendinitis, overuse, or anabolic steroid abuse. While anabolic-androgenic steroids greatly increase muscle mass and strength, they cause the muscle tendon to become stiff and less elastic and therefore capable of absorbing less energy.<sup>1</sup> Other reported cases of tendon ruptures followed a long history of tendinitis or muscle pain.<sup>1</sup> The subject of this case study had no history of tendinitis or muscle pain and denied any anabolic steroid use. D'Alessandro et al<sup>7</sup> reported a subject with a 42-day delay before surgery. The patient, as in this case, regained full supination, flexion, and extension.

## CONCLUSIONS

Biceps tendon ruptures are a rare but serious injury. They are recognized relatively easily with the athlete's history of hearing a "pop" in the anterior arm after contraction of the biceps muscle. The deformity is usually visible on observation, and the biceps tendon cannot be palpated in the antecubital space. Delayed recognition of a tendon rupture can lead to complications; however, surgical repair should still be recommended.<sup>8</sup> Surgical repair versus nonoperative therapy is indicated to sustain full strength and range of motion in both flexion and supination. A comprehensive rehabilitation program must also be emphasized.

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# Spermatic Cord Hematoma in a Collegiate Football Player: A Case Report

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**Objective:** In order to expand the athletic trainer's awareness of acute scrotal injuries, the objective is to present a case of a collegiate football player sustaining a spermatic cord hematoma injury.

**Background:** Hematomas tend to resolve with conservative management. However, untreated testicular injuries may have serious ramifications, including ischemic atrophy, necrosis, and secondary infection. Exploratory surgery remains the standard for any acute scrotal lesion that cannot be diagnosed by physical examination or by diagnostic testing. Surgical exploration, however, is unnecessary in cases of scrotal hematoma.

**Differential Diagnosis:** Epididymitis, incarcerated inguinal hernia, testicular torsion, testicular hematocele, and scrotal trauma with hematoma formation.

**Treatment:** Conservative management including bedrest, ice, slight elevation of the lower extremities, and nonsteroidal anti-inflammatory drugs.

**A**cute scrotal injuries resulting in painful swelling are typically associated with testicular torsion, testicular rupture, epididymitis, and hernias.<sup>1</sup> Swelling in the scrotal sac after direct trauma is well documented.<sup>1–6</sup> However, acute scrotal swelling after a noncontact episode has been reported infrequently. Exploratory surgery is often needed when the diagnosis of an acute scrotal lesion cannot be confirmed on physical examination or with diagnostic testing.<sup>2,4,6</sup>

We describe the case of a collegiate football player with a spermatic cord injury that resulted in moderate swelling, a painful scrotal mass, and a decrease in activities of daily living. The spermatic cord hematoma formed after an atraumatic, noncontact maneuver while the athlete was pass rushing. Although we believed the adductor strain to be significant, we are unclear as to how that injury contributed to the formation of the hematoma. In this patient, surgery was avoided and the injury resolved with conservative treatment. The purpose of this paper is to report a unique case study with an unusual etiology.

## CASE REPORT

### Initial Injury

A 23-year-old, 125.63-kg (277-lb) defensive tackle on a Division I football team had an acute grade II right hip adductor strain in a game on October 12, 1996. While pass

**Uniqueness:** Noncontact scrotal injuries resulting in moderate swelling, pain, and disability are rare in athletes. This case study presents an athlete who suffered a moderate adductor strain 1 month before the formation of a spermatic cord hematoma. Comparison of the two episodes may be found in the subjective history. The question arises as to whether or not the hematoma formation was a possible complication of the initial adductor muscle injury.

**Conclusions:** Although scrotal injuries are not life threatening, untreated testicular injuries can have immediate and severe consequences. It is essential that athletes with acute scrotal injuries accompanied by swelling and tenderness be evaluated by a physician with training in clinical urology.

**Key Words:** scrotum, adductor strain, incarcerated hernia

rushing, he lost his balance and fell into a "split," with secondary contact from the opposing lineman. On physical examination, we found point tenderness and swelling deep between the pubis and the femur. However, no discoloration or palpable muscular deformity was noted. There were no signs or symptoms of scrotal injury. The athlete could actively abduct his hip to approximately 45 degrees. Resistive range of motion was measured for hip adduction by applying resistance proximal to the ankle. When compared bilaterally, the athlete scored 4 out of 5 on the manual muscle testing (MMT) scale in adduction. Specific deficits were found in the beginning range of adduction.

Initial treatment included rest, ice, and electrical stimulation three times per day. The team orthopaedist prescribed nonsteroidal anti-inflammatory drugs and an injectable corticosteroid. As the acute inflammatory phase subsided, therapeutic treatment consisted of warm whirlpool, ultrasound, hip isometrics, thigh and lower leg progressive resistance exercises, stationary bicycling, and walking. Ice and electrical stimulation were used after active exercise. By day 13, the athlete could jog pain free and progressed to running and cutting activities. We also added a slide board to increase hip flexibility and muscular endurance.

The athlete returned to limited practice on October 30 protected with a hip spica. Objectively, he continued to have a decrease in adductor strength in the beginning range of motion

(4 of 5 on MMT scale) after abducting his leg to approximately 45 degrees. Subjective complaints were stiffness in the inguinal fold region and sharp pain with quick abduction movement during athletic participation.

### Primary Injury

During a game on November 9, the athlete removed himself from participation due to sharp pain in the lower right abdominal region. While passing rushing to his right, he had forcefully planted on his right leg and attempted to reverse pivot to his left. He felt a pop and immediately had sharp pain just inferior to the original injury site. On sideline examination, active hip adduction and flexion were moderately painful. Initially, we believed the athlete had reinjured the adductor muscle at its point of origin. Ice was placed over the inguinal fold for 25 minutes, but the athlete was unable to return to competition. Physical examination took place in the locker room after the game. The athlete had moderate swelling in the scrotum and inferior to the right inguinal fold. Ambulation was adversely affected due to moderate pain. Palpation of the scrotum revealed guarding and marked tenderness. The athlete was placed supine to relieve discomfort from gravity. During the team physician's examination, palpation revealed severe pain over a swollen mass superior to the right testicle and deep within the scrotum. The physician was concerned that the mass consisted of bowel contents incarcerated within the scrotal sac. He was unsuccessful in attempting to reduce the mass. Differential diagnosis included incarcerated right inguinal hernia, moderate/severe muscle strain, acute bacterial epididymitis, and spermatic cord injury. Compression shorts were applied for support. Since a wheelchair was unavailable, the athlete used crutches for assistance in ambulating to and from the car in which he was driven to the hospital.

In the emergency room, physical examination, complete blood workup, and a scrotal ultrasonography were performed by a urologist. Ultrasound showed a large hematoma in the right scrotum and a small hydrocele on the left testicle (Fig 1). Complete blood count was normal. The athlete returned home with instructions to rest, elevate the lower extremities and scrotum, and apply ice to the scrotum. Lortab 5 mg (hydrocodone bitartrate, Russ Pharmaceuticals, Birmingham, AL) was prescribed for pain, two tablets every 4 to 6 hours as needed.

Over the next week, the athlete exhibited increased swelling and marked ecchymosis of the scrotum and right medial thigh (Fig 2). Although the athlete had stopped all physical exercise, he had continued substantial periods of walking, including stair climbing. On followup examination, the urologist defined the hematoma's location as on the spermatic cord at the external ring. The physician advised the athlete to rest as previously instructed and to avoid walking outside his home.

By week 2, he showed signs of improvement. Swelling and pain were decreasing daily and hip range of motion and strength were returning to normal. The athlete scored 4+ of 5

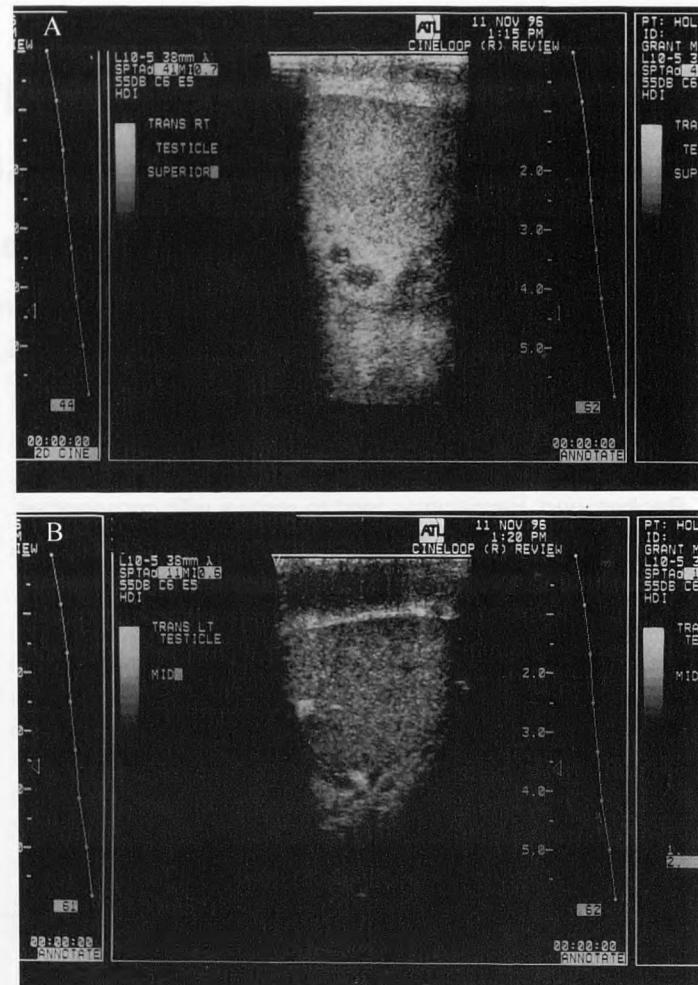


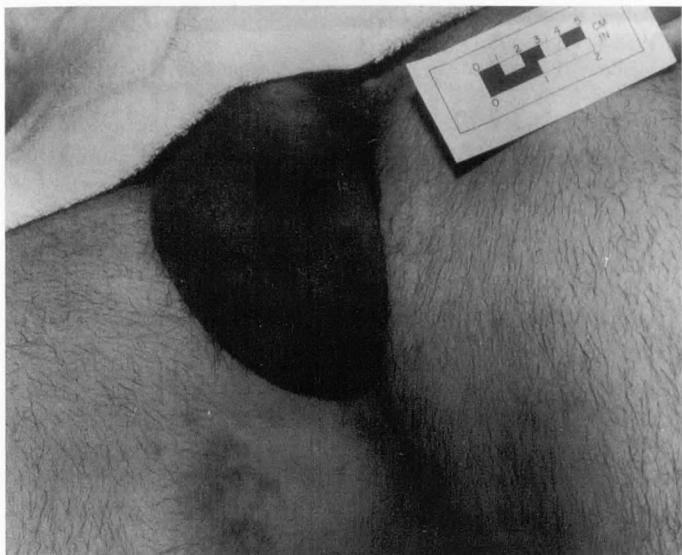
Fig 1. A, Scrotal ultrasonogram showing right testicle. Note hematoma formation on spermatic cord located superior to testicle. B, Ultrasonogram of healthy left testicle.

on the MMT scale in adduction. He returned to practice as tolerated on November 20. We did not apply a hip spica because of his functional improvement and because we believed that the hip spica may have contributed to increased pressure in the inguinal canal and lower abdominal cavity. An athletic supporter and compression shorts offered support against the effects of gravity.

The athlete played in the season finale on November 23 without further incident. He continued ice treatments, weight lifting, and running during the postseason. The hematoma diminished over the following 8 weeks. By 12 weeks, his functional activities were within his normal preinjury values. The hematoma resolved 14 weeks postinjury.

### DISCUSSION

This injury is unique in terms of site, etiology, and physical examination. Spermatic cord injuries in athletes have rarely been documented. In this case, diagnosis was unclear due to the pre-existing hip adductor strain. Although scrotal injuries are not life threatening, untreated testicular injuries may have serious complications, among them testicular rupture, necrosis,



**Fig 2. Swelling and ecchymosis of scrotum and right medial thigh 1 week postinjury.**

and infection.<sup>2,4,6</sup> Exploratory surgery remains the standard for any acute scrotal lesion that cannot be diagnosed by physical examination or by diagnostic testing.<sup>2,4,6</sup>

The differential diagnosis in noncontact painful scrotal masses includes epididymitis, incarcerated inguinal hernia, testicular torsion, testicular hematocele, and scrotal trauma with hematoma formation.<sup>6-8</sup> Epididymitis is often the result of bacterial infection and is characterized by the gradual onset of scrotal pain and fever.<sup>6,7,9</sup> In men younger than 35 years of age, acute epididymitis is transmitted sexually and is usually preceded by genitourinary tract infection.<sup>6,9</sup> Testicular torsion can occur as a result of a direct contact to the scrotum or from a forceful cremasteric contraction.<sup>10</sup> Testicular torsion injuries typically present with the cardinal signs and symptoms of severe pain, nausea, vomiting, and fever.<sup>7,10</sup> A man with a hernia that extends into the scrotal compartment through the inguinal canal may demonstrate a palpable mass superior to the testicle at the external ring.<sup>7,9</sup> The upper portion of the scrotum is enlarged and painful.<sup>9</sup> The spermatic cord is not usually palpable due to the overlying bowel contents.<sup>6</sup>

The etiology of the hematoma formation in our patient is puzzling. Clearly, direct contact did not occur. His subjective history suggests that an excessive closed kinetic chain force combined with an increase in intrathecal pressure were factors contributing to the spermatic cord injury. Ragozzino<sup>11</sup> reported a case of acute scrotal swelling and pain in an individual attempting low-back stretching. When the individual reenacted the stretch, dressed in his usual compressive shorts, compression of the scrotum was evident. In our case, the athlete was wearing a taut, 15.24-cm (6-in) double-length hip spica. The hip spica was heavily taped over the inguinal fold. As a result, we believe that compression from the hip spica was a significant factor in the hematoma formation.

The extent of the relationship between the adductor strain and the hematoma formation is unanswered. The athlete had

very little pain following his return on November 20. Running and cutting agilities were significantly improved. Subjective remarks included return to full speed, an increase in mobility, and the feeling like "scar tissue had torn away." This comment is significant in relating the hematoma formation as a possible complication of the initial adductor muscle injury.

In examining patients with acute scrotal trauma, palpation is a useful tool that can be employed early in the evaluation process. Correct positioning incorporates gently grasping the neck of the scrotum.<sup>7,12</sup> Three fingers are positioned posterior and superior to the involved testicle while the thumb is placed on the anterior scrotum.<sup>7</sup> Scrotal swelling below the thumb may indicate testicular trauma, epididymitis, or a hydrocele.<sup>7</sup>

In cases where swelling is separate from the testicle and superior to thumb placement, an incarcerated inguinal hernia or spermatic cord trauma should be considered.<sup>7</sup> The spermatic cord is palpable in this position.<sup>7,12</sup> However, the spermatic cord is usually not palpable in the case of a scrotal hernia due to the overlying and tender bowel contents.<sup>7</sup> Obviously, testicular spasm injuries should not be palpated.

Following the history and physical examination, the physician may proceed to noninvasive diagnostic tools such as scrotal ultrasonography or radionuclide scintigraphy.<sup>5,6,12</sup> Ultrasound's ability to illustrate the spermatic cord through the inguinal canal and its vascular components makes it the choice as a diagnostic tool.<sup>5</sup> The testicles and epididymis can also be scrutinized by ultrasound.<sup>5</sup> In cases where a definitive diagnosis cannot be made by noninvasive techniques, immediate scrotal surgery is indicated.<sup>6</sup>

After an accurate diagnosis is made, appropriate acute care for the injured athlete includes bedrest, ice to the affected area, elevation of the lower extremities and scrotum, and analgesics.<sup>3,10,12</sup> An athletic supporter or compression shorts should be worn to support the scrotum.<sup>10</sup> A wheelchair may be used when ambulation is too painful.

We believe the increase in our patient's symptoms during the first week after the scrotal injury was due to the athlete's daily activities, including substantial walking and stair climbing. Adherence to bedrest and ice treatments produced a substantial decrease in pain and swelling. We found that the athlete's pain-free physical activity was directly proportional to the reduction in scrotal swelling.

Although scrotal injuries are not life threatening, untreated testicular injuries can result in a variety of complications, including ischemic atrophy, necrosis, and secondary infection.<sup>2,5,12,13</sup> Authors have demonstrated that the quality of recovery from testicular rupture and/or torsion injuries is directly related to early surgical exploration.<sup>5,12</sup> However, surgical exploration is unnecessary in cases of scrotal hematoma. Therefore, it is essential that acute scrotal injuries be carefully examined. We hope this case presentation will raise the athletic trainer's awareness of acute scrotal injuries.

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# Technical Note: The Initial Stages of Statistical Data Analysis

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**Objective:** To provide an overview of several important data-related considerations in the design stage of a research project and to review the levels of measurement and their relationship to the statistical technique chosen for the data analysis.

**Background:** When planning a study, the researcher must clearly define the research problem and narrow it down to specific, testable questions. The next steps are to identify the variables in the study, decide how to group and treat subjects, and determine how to measure, and the underlying level of measurement of, the dependent variables. Then the appropriate statistical technique can be selected for data analysis.

**Description:** The four levels of measurement in increasing complexity are nominal, ordinal, interval, and ratio. Nominal

data are categorical or "count" data, and the numbers are treated as labels. Ordinal data can be ranked in a meaningful order by magnitude. Interval data possess the characteristics of ordinal data and also have equal distances between levels. Ratio data have a natural zero point. Nominal and ordinal data are analyzed with nonparametric statistical techniques and interval and ratio data with parametric statistical techniques.

**Advantages:** Understanding the four levels of measurement and when it is appropriate to use each is important in determining which statistical technique to use when analyzing data.

**Key Words:** research design, level of measurement

How many times have you had a great research idea but you failed to follow through with it because you did not know how to design the study? How many times have you had a manuscript sent back for revision, or sent back for shredding, because you used the wrong statistics? Many of you who conduct research projects and report your results to your peers are well versed in the disciplines of research design, data collection, and statistical analysis. However, many others either know enough to get into trouble or simply don't have the experience and expertise to get through a project from beginning to end. Unfortunately, many important research questions in the field of athletic training remain to be answered because those with the questions are not comfortable with research design and data analysis techniques. It is my desire, and I trust the desire of the editors at the *Journal of Athletic Training*, to equip potential authors with the tools necessary to correctly design their studies, analyze their data, and interpret and report their results. To this end, I welcome the opportunity to offer some guidelines that will hopefully aid those of you who will be submitting manuscripts to *JAT*. This article will provide an overview of some important data-related considerations in the design stage of a research project. I will begin by briefly discussing the initial steps of defining your question and identifying your variables. The subsequent sections will review the levels of measurement and their relationship to the statistical technique you choose for your data analysis.

## WHAT IS YOUR QUESTION?

One of your first tasks as a researcher is to clearly define your research problem and narrow it down to a specific

question, or to specific questions, that you can test. For example, you might be looking for differences in performance time between a control group and two or more treatment groups. You might be looking for a relationship between length and type of therapeutic treatment and recovery time. Your purpose might be to survey and interpret athletic trainers' ideas and opinions on important issues in the field. You might be attempting to find the reliability of a measuring instrument or treatment technique. Throughout the project, you should focus on answering your fundamental question(s). Each of these questions, or problems, typically requires a statistical tool to aid in the interpretation of the data. Your choice of the design and accompanying statistical analysis technique can determine the ultimate success of your project.

## WHAT ARE YOUR VARIABLES?

After you have clearly defined your fundamental question or purpose, you need to identify the variables in your study, decide how you will group and treat your subjects, and determine how you will measure your dependent variable(s). It is at this point, if not sooner, when you will need to determine the underlying "scale" or "level" of measurement of your dependent variable(s). I highly recommend that you take the time to establish the underlying level of measurement of your variable(s) and determine the statistical analysis technique before you begin collecting data. Those who are in a hurry to collect data and "see what they can find" often overlook this critical step in a properly designed study.

## **DETERMINING THE LEVEL OF MEASUREMENT**

Establishing the underlying level of measurement will aid you in determining the correct statistical analysis technique. The statistical technique must fit the data if an accurate interpretation is to be made. The four levels of measurement, listed in order of complexity, are "nominal," "ordinal," "interval," and "ratio."

### **Nominal Level**

Nominal data are categorical or "count" data. Nominal data are qualitative in nature and, although they are occasionally reported in numerical form, the numbers are actually treated as labels. If your data collection procedure involves asking the question, "how many," you are probably dealing with nominal data. For example, if you surveyed athletic trainers to determine the preferred method of treatment for second-degree ankle sprains, you would first categorize the various types of treatments and then count the number of athletic trainers who use each method. Nominal data are analyzed with a nonparametric statistical technique such as the chi-square test. The appropriate chi-square test will depend upon your fundamental question and the design of your study.

### **Ordinal Level**

Ordinal data, like nominal data, are also categorical. However, unlike nominal data, the categories can be ranked in a meaningful order by magnitude. An example of ordinal data would be athletes' responses to a question regarding pain. Categories of pain could include "no pain," "some pain," or "a great deal of pain." These three categories can be ordered by the amount of pain experienced. However, it is often difficult to determine how much pain is necessary for a response to be categorized in one category or another. Often, the categories are numerically coded (1, 2, 3) for data analysis. It is important to note that although "2" is twice as much as "1," a score in category 2, "some pain," does not necessarily represent twice as much pain as a score in category 1, "no pain." Furthermore, adding "1" (no pain) to "2" (some pain) does not equal "3" (a great deal of pain). Those who have dealt with ordinal data probably have been privy to discussions concerning the appropriate types of analysis for this type of data. One position on data analysis states that, due to the failure of ordinal data to meet the assumptions of parametric statistics, nonparametric analysis techniques, such as the Mann-Whitney U, Kruskal-Wallis H, Wilcoxon matched-pairs signed rank, or the Friedman matched-samples test should be used. Another position contends that there are instances where the magnitude of the differences between categories is similar and, therefore, parametric statistics such as analysis of variance (ANOVA) may be used for data analysis. An important concept to remember when dealing with these types of data is to not designate the level of measurement by the arbitrarily assigned category number, but by the underlying measurement scale. For exam-

ple, 1 to 5, or 1 to 7 (Likert) scales are typically used in survey research to represent various levels of a dependent variable such as "amount of agreement." Respondents choose a number that coincides with a qualitative response category such as, "strongly agree," "agree," "disagree," etc. Although the numerical "distance" between numbers is equal from number to number, the "amount of agreement" between levels, or the underlying measurement scale, may not be. When the underlying measurement scale is clearly ordinal in nature, nonparametric tests are recommended for statistical analysis.

### **Interval Level**

Interval-level data possess the characteristics of ordinal data with the added characteristic of equal distance between levels of the variable. Variables measured at this level, such as temperature on the Fahrenheit scale, have an arbitrary zero point. The arbitrary zero point means that although you can add and subtract values of temperature in a meaningful way ( $10^\circ + 20^\circ = 30^\circ$ ), you cannot use multiplication and division meaningfully. Assume you are measuring skin temperature during ice therapy. It would be meaningful to say that temperature increased or decreased by a given number of degrees. However, it would not be meaningful to say that a skin temperature of  $80^\circ\text{F}$  was twice as warm as a skin temperature of  $40^\circ\text{F}$ . We are not able to make these statements because interval level data lack an absolute starting point, where there is an absence of the entity being measured.

### **Ratio Level**

Variables measured at the ratio level have a natural zero point. Physiologic characteristics such as height, body weight, and temperature on the Kelvin scale all have baselines, or zero points, from where we begin our measurements. Using the example of temperature measured on the Kelvin scale,  $0^\circ\text{K}$  represents the absence of molecular movement and therefore serves as a baseline for measurement.

Although there is a difference between the interval and ratio levels of measurement, the difference does not affect the choice of a statistical technique. Parametric statistical techniques, including *t* tests, the various forms of ANOVA, and correlation and regression techniques (when inferences are being made about a population) are appropriate for both interval- and ratio-level data.

## **THE ROLE OF STATISTICS**

Obviously, refining your fundamental research question(s), determining the level of measurement of your variables, and deciding whether your statistical technique will be parametric or nonparametric are only a few of the many details to consider when designing your study. However, they are fundamental to the proper statistical analysis and interpretation of your results.

Although the application of statistical techniques is an integral part of most studies, in-depth knowledge of your subject matter is the key to correctly answering your research questions. The role of statistics should be like the role of good sports officials: they serve an important purpose, but they should remain in the background. Don't allow your statistics to drive your project; use statistics as tools to help you answer your questions. We have all seen instances where a piece of equipment is donated to a lab, and research projects are immediately designed to use the new equipment instead of first asking a question and then acquiring the equipment to answer the question. The same can be done with statistics. We can become comfortable with a procedure, such as a *t* test or ANOVA, and try to manipulate our experimental designs to suit our statistical test. I will admit that it is easy to become comfortable with a particular type of analysis. However, we need to find the statistical tool that fits

our design, fits our data, and will ultimately help us answer our research questions.

LOOKING AHEAD

Due to the unique nature of each research project, design and analysis articles often raise as many questions as they answer. In-depth discussion of various statistical techniques, as well as other topics related to experimental design, data analysis, and presentation of results, will be the focuses of future articles in the Technical Notes section of *JAT*. I welcome comments and questions regarding these topics. You may contact me through the Journal office or directly by E-mail: [dtandy@ccmail.nevada.edu](mailto:dtandy@ccmail.nevada.edu).

Editor's Note: Richard D. Tandy, PhD, is a statistical consultant for the *Journal of Athletic Training*.

# Continuing Education in Athletic Training: An Alternative Approach Based on Adult Learning Theory

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**Objective:** To offer an alternative perspective on current continuing education practices and to propose a model for facilitating continuing education in the athletic training workplace.

**Background:** Professional knowledge can quickly become outdated, and the personal/professional contexts of allied medical fields such as athletic training are becoming increasingly more complex, making continuing education paramount. Adult learning theory suggests that individuals are self-directed, autonomous learners in nature and that experience is a rich source for learning, subsequently making the workplace a fruitful environment in which to engage in continuing education. Unfortunately, mandating continuing education may violate the voluntary nature of adult learning, making the practice questionable. Therefore, alternative aspects of continuing education may be helpful.

**Description:** This article consists of a brief synthesis of related literature that offers an alternative perspective of continuing education and proposes a model for facilitating continuing education in the workplace. The model's foundation includes preparing an environment conducive to learning and then focuses on identifying learning needs, setting goals, implementing specific strategies to facilitate self-directed learning, and assessing learning. Additionally, the model suggests that ongoing reflection is a key factor in enhancing the identification of learning needs, goals, and strategies.

**Advantages:** The model may best be used by clinical coordinators, directors, and supervisors to better facilitate employee learning and subsequently improve patient care delivery.

**Key Words:** adult learning principles, self-directed learning

The need for professionals to continue education throughout their careers is fueled by public accountability, advancing technology, and an ever-increasing amount of information.<sup>1</sup> Given today's technological complexity and constant change, continuing education is necessary for effective, efficient, and safe practice by allied medical professionals.<sup>2</sup> Carpenito<sup>2</sup> estimates that the half-life of professional knowledge gained through formal education may be as little as 2–1/2 years. The simple conclusion is that professional knowledge can quickly become outdated and that continued learning is necessary. The purpose of this article is to examine the current state of continuing education in athletic training and to build a case for alternative approaches for facilitating continued learning. In so doing, adult learning principles will be examined and a model for facilitating self-directed learning will be offered.

## THE CURRENT STATE OF CONTINUING EDUCATION

Professional continuing education is a vital component to ensuring clinical competence and preventing professional obsolescence.<sup>3,4</sup> Coupled with public demand for accountability, these factors may well be the premier argument for mandating professional continuing education. Within the allied medical

field, however, mandatory continuing education has not been proved to ensure competence.<sup>5</sup> Continuing education is obtained primarily by workshop or seminar attendance, and attendance is thought to equate to competence.<sup>6</sup> Although continuing education is measured, its value is often based on attendance or satisfaction. Unfortunately, evaluating attendance and satisfaction may not measure a person's learning achievement.

At the very least, mandatory continuing education forces individuals who may not otherwise engage in learning activities to attend a learning program. However, mandatory continuing education has been reported to violate the voluntary nature of adult education,<sup>2</sup> as well as adult learning principles.<sup>7</sup> Alluding to the nursing profession, Carpenito<sup>2</sup> stated that most professionals are autonomous learners, and mandatory continuing education may not change those individuals who lack the autonomous self-directed learning attitudes.<sup>7</sup> Moreover, if clinicians are not self-directed regarding continuing education or are uninterested in conventional continuing education (seminars, symposiums, or workshops), then attending programs merely becomes a time-serving event. Therefore, perhaps we should focus some of our efforts on considering alternative approaches to continuing education and helping the small percentage of athletic training professionals who are not currently self-directed to become more self-directed with

regard to their education. Athletic training supervisors, directors, and mentors may need to act in the capacity of learning facilitators to assist in maintaining quality professional continuing education among individuals who lack self-directedness. Facilitating self-directed learning, however, requires an understanding of both adult learning characteristics and specific techniques to promote self-directed learning.

## **ADULT LEARNING PRINCIPLES**

Adult learning is a somewhat “slippery” term and is not necessarily confined to adults. Rather it refers to adulthood, since maturity defines its limits.<sup>8</sup> The classic set of adult learning principles was proposed by Knowles:<sup>9</sup> 1) learners become more self-directed as they mature; 2) an adult’s experience acts as a rich educational resource; 3) adults like their learning to be problem centered and meaningful to their life situation (social/professional role); and 4) adults learn best when they can immediately apply what they have learned.

In addition to those principles posited by Knowles,<sup>9</sup> Brookfield<sup>10</sup> suggested that adults learn throughout their lives when negotiating transitional stages, when they have diverse learning styles, and when effective adult learning is linked to their self-concept. In the context of athletic training, these principles have significant bearing on facilitating continuing education.

## FACILITATING SELF-DIRECTED EDUCATION

Because certified athletic trainers may tend to be more problem centered and wish to apply what they learn to the immediate professional context (ie, patient care), and because experience acts as a rich educational resource, the workplace can be a fruitful environment in which to encourage self-directed continuing education. Moreover, many practicing professionals believe that the knowledge they gain from the workplace is far more useful than the more conventional forms of education.<sup>11</sup> Therefore, program leaders, directors, and supervisors of athletic trainers can be effective facilitators of self-directed learning.

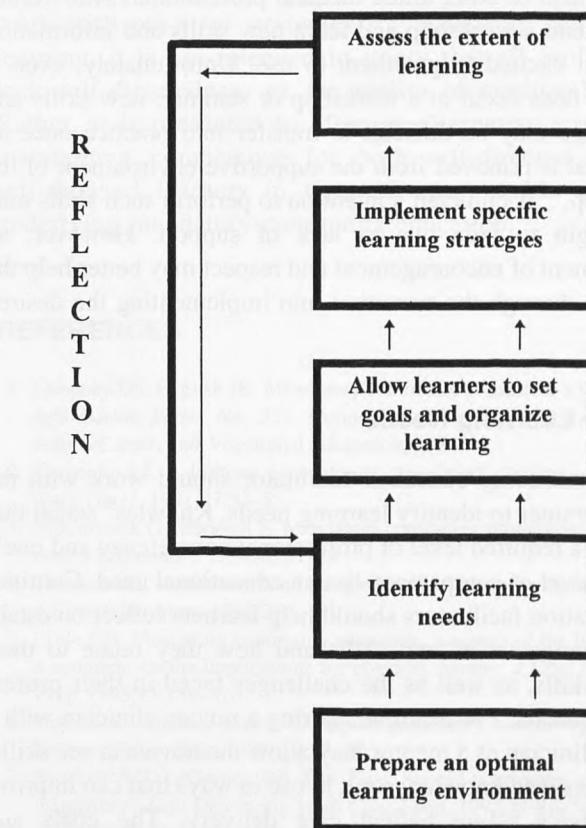
Regardless of how we choose to define self-directed learning, one of its principal aims is to help learners develop skills and competencies required to continue their self-education.<sup>12</sup> Within an allied medical context, Kathrein<sup>13</sup> offered several tenets that may be utilized by continuing education facilitators as a framework for continuing education. One tenet is that learning occurs in a socio-professional context. For example, some of the athletic trainer's most useful learning takes place while he or she is practicing athletic training, thus supporting the notion that the workplace is suitable for continuing education. Another tenet states that continued learning is directed toward the achievement of goals. Unfortunately, many learners do not state their goals or formally evaluate them for attainment. Consistent with adult learning theory, Kathrein<sup>13</sup> stated that the pattern of learning is designed by the learner and expresses the learner's individuality and creativity in learning,

and the learner determines the goals, directions, and processes of learning.

Brookfield<sup>10</sup> suggested that a facilitator of adult continuing education should attempt to offer learners alternative perspectives and challenge their goals, directions, and processes of learning. While these aforementioned skills lend some clarity about how to enhance self-directed learning, specific strategies are neglected. Carpenito<sup>2</sup> offered supervisors, facilitators, and managers of continuing education in the allied medical field some practical suggestions: for example, creating an environment where new ideas are expected, establishing goals to be accomplished by each allied medical staff in a 1-year period, holding a discussion once a month that highlights a new allied medical concept, encouraging different styles of professional practice among personnel, and promoting role models.

## **AN ATHLETIC TRAINING CONTINUING EDUCATION MODEL**

To summarize these strategies, skills, and principles, I propose a continuing education model that can be effectively utilized by program leaders, directors, supervisors, and clinical educators to facilitate self-directed learning that is meaningful to personnel and may subsequently help to enhance patient care (Fig 1). The intent of this continuing education model is to present essential elements of educational planning found in the



**Fig 1.** An athletic training model for continuing education in the workplace.

adult education and human resource development literature<sup>9,10,14-18</sup> and to highlight those aspects that may be most valuable to athletic trainers. The model consists of six steps, beginning with creating a learning environment and progressing to identifying learning needs, allowing learners to organize learning, implementing specific strategies to facilitate learning, and assessing what they have learned. I also suggest that facilitators encourage ongoing reflection that will impact future planning, goal setting, and strategy implementation.

### **Prepare an Optimal Learning Environment**

At the foundation of the athletic training continuing education model is the creation of a learning environment. The continuing education facilitator must establish a climate of respect that values the learner and his or her level of experience.<sup>9</sup> A facilitator of continuing education should foster an environment that provides support and feedback to encourage professional development.<sup>10</sup> Moreover, a facilitator should offer a learner encouragement and exercise much patience because it often takes time to understand the commitment that learning implies and to see how learning relates to both personal and clinical professional needs. An environment that values a comprehensive view of learning as a continuous and lifelong process<sup>13</sup> is preeminent.

A perfect example of the need for an optimal learning environment can be found in the postseminar transition. Athletic trainers or other allied medical professionals who voluntarily attend a workshop and learn new skills and information are often excited to put them to use. Unfortunately, even if learning does occur at a workshop or seminar, new skills and knowledge may be difficult to transfer into practice once an individual is removed from the supportive environment of the workshop.<sup>16</sup> A clinician's intention to perform such skills may then begin to fade due to lack of support. However, an environment of encouragement and respect may better help the clinician through the transition into implementing the desired skills.

### **Identify Learning Needs**

The continuing education facilitator should work with the athletic trainer to identify learning needs. Knowles<sup>9</sup> stated that between a required level of professional competency and one's present level of competency lies an educational need. Continuing education facilitators should help learners reflect on established competencies and skills and how they relate to their current skills, as well as the challenges faced in their professional contexts. For example, pairing a novice clinician with a master clinician as a mentor may allow the novice to see skills, techniques, and knowledge put to use in ways that can improve the novice's future patient care delivery. The goals and objectives that emerge from the identified needs are individual to each learner.

### **Allow Learner To Set Goals and Organize Learning**

Because adult learners tend to become more self-directed as they mature, they should create their own learning goals and objectives. However, the continuing education facilitator should help the learner to see alternative perspectives and should challenge the learner to set goals and objectives that will help meet the learning needs.<sup>10</sup> While it is desirable that the learner be completely self-directed, the less mature learner may attempt to get by with little effort. An astute facilitator will not allow the learner to simply submit goals haphazardly. Rather, the facilitator will examine the goals based on the established learning needs. Using a learning plan to clarify and implement specific learning strategies is helpful when organizing the learning.

### **Implement Specific Learning Strategies**

Because the learning strategies will be unique and individualized, the strategies selected should be based on the individual's learning style.<sup>13</sup> The learner should determine (with the assistance of a facilitator) where to learn, when to learn, the sequence of the learning activity, and the mode of learning.<sup>13</sup> To help learners develop self-directed learning skills, it is often helpful to have them create learning plans. Learning plans have the following characteristics: 1) they are goal directed; 2) they are focused on short-term actions that promote continual learning; and 3) they are modified based on the latest up-to-date information.<sup>17</sup> A sample learning plan is offered in Figure 2.

An additional strategy that may promote continued learning in the workplace includes the use of patient care conferences in which team learning can take place and assumptions can be challenged.<sup>13</sup> In a patient care conference, interesting cases are presented and standards of care can be challenged, facilitating deep reflection. When individuals convene to reflect on past performance, learning is maximized when the discussion is balanced with inquiry into others' perspectives.<sup>18</sup>

### **Assess the Extent of Learning**

It is difficult to determine whether goals have been met unless an assessment is made. Much attention has been given to outcome-based assessment at the undergraduate level. In fact, the 1997 NATA Research and Education Foundation's Professional Educators Workshop in Dallas, Texas, highlighted outcome-based assessment. However, little has been written regarding the assessment of continuing education in athletic training, and, consequently, attendance has been the main form of documentation. The assessment of learning outcomes can take many forms, including interviews with the learner, the development of a portfolio, and testing an individual's knowledge base. A potentially more effective avenue for assessment of learning in the workplace may be the performance evaluation. The method of evaluation should be selected and stated in

Learning Goals	Learning Action	Evidence	Resources	Completion Date
Identify what knowledge or skills would be helpful to meet clinical challenges.	What specific action will be initiated in order to acquire specific knowledge or skills identified as learning goals?	What evidence will be demonstrated to prove that goals have been met and learning has taken place?	What resources are necessary to implement the learning action and achieve learning goals (ie, finances, mentors)?	Target date for achieving stated learning goals.

Example:  
Because so many musculoskeletal injuries are the result of cumulative stress, myofascial techniques may improve patient care delivery.

Example: Attend myofascial release workshop and then shadow a master clinician for further instruction.

Example: The learner (employee) will teach a 2-hour hands-on inservice to other certified athletic trainers.

Example: Time off for workshop, money, staff mentor/master clinician to reinforce learning environment upon the learner's return from the workshop.

Example: Workshop attendance from October 12-16. Inservice to be taught December 5.

**Fig 2. A sample learning plan. (Permission to adapt this figure from an out-of-print title<sup>20</sup> was granted entirely by Globe Fearon.)**

the learning plan when the learner organizes the learning strategies.

## Reflect

Once learning has been completed, the learner must reflect on the experience. Reflection involves not only thinking about the clinical actions that we have taken as professionals, but also exploring problems that occurred in the learning process itself. This reflection is likely to lead to understanding and identifying new learning needs and developing strategies for continual learning. According to Mezirow,<sup>19</sup> reflective learning involves not only confirming but also transforming ways of interpreting experience. Reflection may represent the most critical phase of the learning process,<sup>18</sup> and in fact, experience without reflection may not result in learning. The reflective practitioner is able to expand the speed, depth, and breadth of the learning and continually identify learning needs, goals, objectives, and strategies to meet the ever-changing health care environment. Therefore, reflection is offered as a vital step in this particular model.

## CONCLUSIONS

Mandatory continuing education in the allied medical profession will, most certainly, continue. Although its efficacy is questionable, its purpose has merit. Given today's rapidly changing technology and society's quest for accountability, continuing education will take a progressively larger role in enabling clinicians to maintain clinical competence. Perhaps, then, we should consider alternative avenues of continuing education, specifically enhancing the

self-directedness of allied medical professionals to learn. The workplace may be a fruitful location in which designated learning facilitators can help to instill a commitment to self-directed learning. Although the athletic training continuing education model proposed here offers a framework with practical strategies for enhancing self-directed learning, it is not intended to imply that all professionals lack self-directedness or the ability to continually learn. Rather, it is presented to offer an alternative strategy for maintaining competence for both self-directed and less self-directed learners in light of questionable principles underlying mandatory continuing education.

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# CAN'T FIND THE CEU QUIZ? Look in the NATA News.

The CEU Quiz, formerly placed in the *Journal of Athletic Training*, now appears in the *NATA News*, a monthly magazine for NATA members. The quiz schedule for 1998 is:

<u>Articles in Journal</u>	<u>Quiz in NATA News</u>
March (Vol. 33, No. 1)	April 1998
June (Vol. 33, No. 2)	June 1998
September (Vol. 33, No. 3)	October 1998
December (Vol. 33, No. 4)	January 1999

The CEU Quiz also is posted on the NATA Fax-on-Demand Service. Access the quiz by dialing toll-free (888) ASK-NATA or 214-353-6130 from a touch-tone telephone. Follow the automated instructions, requesting Document #112. Deadlines for submitting each quiz are posted in the *NATA News*.

For more information about the *Journal of Athletic Training*, visit <<http://www.nata.org/jat>>

## ■ 21st 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 (eg, original research articles, literature reviews, case reports, clinical techniques articles, or communications articles) must be on topics germane to the profession of athletic training.
3. Entries must neither have been published by, nor be under consideration for publication by, any journal.
4. The winning entrant will receive a cash award and recognition as the winner of the Annual NATA Student Writing Contest. The winning paper will follow the normal process of submission and review for possible publication in the *Journal of Athletic Training*. One or more other entries may be given honorable mention.
5. Entries must conform to the *Journal's Authors' Guide*, which provides the most current information on format and style. For advice about writing, we suggest that authors consult Kenneth L. Knight and Christopher D. Ingersoll's "Structure of a Scholarly Manuscript: 66 Tips for What Goes Where" (*J Athl Train*. 1996;31:201-206) and "Optimizing Scholarly Communications: 30 Tips for Writing Clearly" (*J Athl Train*. 1996;31:209-213).
6. Entries must be received by March 1, 1999. The winner will be announced 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 each entry must be received at the following address by March 1, 1999:

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



# 1998 REQUEST FOR PROPOSALS

The NATA Research & Education Foundation is pleased to announce that \$130,000 is available in 1998 for Research and Education Grants. Priority consideration will be given to proposals which include an NATA-certified athletic trainer as an integral member of the research or project team. *There are three separate grant applications: 1) research grants, 2) doctoral research grants and 3) educational program and research grants.*

## **Research Grants**

No. of Awards:	Multiple awards are available
Available:	\$100,000 total, no minimum or maximum dollar amounts for individual grants
Deadlines:	March 1 and September 1
Notification:	July and February

## **I. General Grants**

The Foundation will fund a number of studies which address important issues in four categories: basic science, clinical studies, sports injury epidemiology and observational studies.

## **II. Pediatric Sports Health Care**

This request for proposals is intended to stimulate research that provides an expanded foundation of basic and applied science related to pediatric sports health care. The goal is to encourage research studies that will have clinical relevance to the development of the pediatric athlete, and the prevention, treatment and rehabilitation of injuries sustained by the physically active pediatric participant.

### **Background**

Very little experimental evidence concerns the impact of physical activity upon the general development of the child. The recent, tremendous growth of children's participation in organized sport has outpaced efforts to clearly understand the consequences of intense physical activity on the developing young adult. The incidence of organized sports participation

by preadolescents and adolescents has increased dramatically in the past two decades. It is estimated that more than 30 million children and adolescents are participating in organized sports in the United States. This is in addition to those in physical education classes. Children represent the largest group of individuals engaging in organized sport in this country.

Furthermore, the number of children and adolescents participating in sport increases regularly from year to year. Despite this increase, the President's Council on Physical Fitness has determined that the fitness levels of young adults in this country are on the decline and urges regular participation in sport and exercise by a much higher percentage of the childhood population.

It is assumed that exercise and sports participation have positive effects on children, and there is increasing evidence that regular exercise is important to their physical and psychological well-being. The United States Department of Health and Human Services in its compendium on National Health Promotion and Disease Prevention Objectives recommends significant increases in daily physical activity for children to combat problematic sedentary lifestyles and obesity among young adults. Many experts believe that lifestyles leading to adult heart disease often begin in childhood and that habitual physical activity during development may play an important role in slowing the progression of cardiovascular disease, particularly in high-risk children. Moreover, the increasing awareness and interest in exercise as a treatment medium by the medical community has undoubtedly influenced parents' perceptions of the importance of regular physical activity in the lives of their children.

Yet, participation in sport does pose risks. Exercise is a human stressor which results in bodily adaptations that can have beneficial or adverse effects on health. Increasing sports specialization at younger and younger ages has placed a high premium for athletic success. Childhood and adolescence as developmental periods, introduce variables that are not found in the adult athlete. Asynchronous rates of development among similarly-aged children present difficult challenges to those who teach and supervise the physical activity of young athletes. Attempts to develop training programs for the young athlete pose a dilemma that the exercise science and medical professions have yet to resolve satisfactorily. A developing child differs significantly in anatomical and physiological parameters from the mature adult. These differences must be taken into account when prescribing exercise programs for young athletes. Children in the 8-15 year age group are in a complicated and critical growing period. Muscular development also varies considerably and the actual strength of muscle relates to the stresses that can be placed on the skeletal framework without injury. For example, the growth centers in the hip, knee, shoulder and vertebral column do not fuse until 18 to 25 years of age in the male. If children and adolescents are involved in organized sports, it is obvious that a considerable amount of skeletal growth is occurring simultaneously with periods of intense physical activity.

The repetitive microtrauma and overuse syndromes associated with sports, and their development in children's growth plates have been widely debated. Traumatic sports injuries to the growth plate do occur and the potential for a growth disturbance is always a concern of parents and physicians. While the growth plate seems relatively immune to damage from overuse, it remains to be seen if this sensitive area of children's anatomy remains protected from the increasingly rigorous training to which young athletes are subjected.

### **Objectives**

The Research and Education Foundation, therefore, encourages high quality research proposals that will help establish a firm scientific foundation for basic and applied programs in pediatric sports health care. Areas of interest may include but are not limited to: conditioning of the child athlete, prevention, treatment and rehabilitation of pediatric athletic injuries, exercise pathophysiology, injury mechanisms in children, musculoskeletal healing processes in children, rehabilitation modalities, and epidemiology of athletic injuries in children.

### **III. Doctoral Research Grants**

No. of Awards: Two  
Available: \$2,500 for each grant  
Application Deadline: March 1  
Notification: April 15  
Sponsor: Active Ankle Systems

Applicants must be current certified member of the NATA. You must be a doctoral student at the institution where the research is to be performed. You must have doctoral student status during the term of the grant to be considered for funding.

### **Education Research and Program Grants**

No. of Awards:	Multiple awards are available
Available:	\$25,000 total, no minimum or maximum dollar amounts for individual grants
Deadlines:	March 1 and September 1
Notification:	July and February

### **I. Clinical Instruction and Learning Styles**

Research indicates that knowledge of student learning styles directly impacts the quality of clinical instruction in other allied health professions, such as physical therapy, nursing and physician assistant programs. However, no studies have been undertaken to determine the relevance of student learning styles in athletic training clinical education. The Foundation will fund proposals addressing this area including (a) what factors affect learning styles in the clinical setting, (b) assessment of learning styles for student athletic trainers and clinical instructors, (c) incorporation of learning styles in traditional versus non-traditional clinical settings, and (d) the effectiveness of matching the learning styles of student athletic trainers and clinical instructors. The goal of this research is to better meet the needs of students by enhancing the quality of clinical instruction in athletic training.

### **II. Education Research Grants**

Include studies investigating teaching methods and evaluation and learning tools used in the area of athletic training education. Areas of particular interest to the Foundation are computer and competency based learning and methods used to evaluate clinical learning skills.

### **III. Education Program Grants**

Include seed money for seminars, lectures, or any other education program focusing on the health care of the physically active or athletic training education.

### **Application Procedure**

To receive a copy of the Education Grant Application, the Research Grant Application or the Doctoral Research Grant Application, please write to NATA Research & Education Foundation, 2952 Stemmons, Dallas, TX 75247, e-mail the request to [BarbaraN@nata.org](mailto:BarbaraN@nata.org) or call 800-TRY-NATA ext. 121. □

# NATA Research & Education Foundation

## CALL FOR ABSTRACTS

1999 National Athletic Trainers' Association — Annual Meeting & Clinical Symposia

Kansas City, Missouri • June 16-19, 1999

**DEADLINE FOR ABSTRACT SUBMISSION: JANUARY 5, 1999**

### 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 starting at 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 (including the city and state) where the research or case report was conducted on the same line following the name(s) of the author(s).
5. Double space and begin typing the text of the abstract flush left in a single paragraph with no indentations. Do not justify the right margin. Do not include tables.
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 starting at the left margin.
4. Provide all information requested on the information form on the next page. Please note that the institution (including the city and state) where the clinical case occurred should be cited, not the current address of the author(s), 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 Symposia. 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:

**Christopher D. Ingersoll, PhD, ATC**  
**Athletic Training Department**  
**Indiana State University**  
**Terre Haute, IN 47809**

**Responses preferred by December 1, 1998**

## Instructions for Submitting Abstracts (either Free Communications or Clinical Case Reports)

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 Microsoft Word for Windows; if you must send it in Macintosh format, please use a high-density diskette) of your abstract to:

**NATA Research & Education Foundation**  
**Free Communications**  
**2952 Stemmons Freeway**  
**Dallas, TX 75247**

**ABSTRACTS POSTMARKED AFTER  
JANUARY 5, 1999 WILL NOT BE ACCEPTED.**

### Abstract Author Information Form

**Mailing Address of Presenting Author:**  
(Please type; provide full name rather than initials)

I was a student at the time of this study.

Name \_\_\_\_\_

Institution \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_

State \_\_\_\_\_ Zip \_\_\_\_\_

Work Telephone \_\_\_\_\_

Fax # \_\_\_\_\_

NATA Membership Number \_\_\_\_\_

e-mail \_\_\_\_\_

**Key Words:** (two to six words that identify your abstract)

**Indicate the most appropriate TYPE for the presentation:** (check one only)

Clinical Case Report       Free Communication

**If FREE COMMUNICATION, indicate the most appropriate CATEGORY for your presentation:**  
(check one only)

<input type="checkbox"/> Basic Science	<input type="checkbox"/> Clinical Studies
<input type="checkbox"/> Educational Research	<input type="checkbox"/> Sports Injury
<input type="checkbox"/> Observation/Informational	Epidemiology
Studies	

**Indicate your presentation preference:**

(check one only; choice does not influence acceptance)

Poster       Oral       Indifferent

# A bstracts

Clint Thompson, MS, ATC

**Ainsworth BE, Stolarczyk LM, Heyward VH, Berry CB, Irwin ML, Musculman LM. Predictive accuracy of bioimpedance in estimating fat-free mass of African-American women.** *Med Sci Sports Exerc.* 1997;29:781-787.

The purpose of this study was to identify the BIA (bioimpedance analysis) equation that yields the best estimate of body composition for 122 premenopausal African-American women (18–40 yr). Total body density (Db) was determined by hydrodensitometry at residual lung volume and converted to %BF<sub>HD</sub> using the Siri formula. %BF<sub>HD</sub> was used to calculate reference fat-free mass (FFM). Resistance and reactance were measured using a Valhalla bioimpedance analyzer. The predictive accuracy of generalized, age, gender, race-specific, fatness-specific, and the Valhalla manufacturer's BIA equations was compared. There were significant correlations between FFM<sub>HD</sub> and /bxFM<sub>BIA</sub> for all BIA equations ( $r = 0.85$  to  $0.92$ ). Except for the modified Segal fatness-specific equations, the prediction errors (SEE and E) exceeded 2.8 kg. For individuals, the %BF derived from FFM<sub>BIA</sub> predicted by the modified Segal equations was within  $\pm 3.5\%$ BF for 69% of the subjects. This percentage was less (33% to 53%) for other equations. These results suggest that the predictive accuracy of BIA for estimating body composition of African-American women is improved when fatness-specific equations are used. We recommend using the modified Segal fatness-specific equations to assess FFM and %BF of premenopausal African-American women.

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*Medicine and Science in Sports and Exercise.*

**Axler CT, McGill SM. Low back loads over a variety of abdominal exercises: searching for the safest abdominal**

**challenge.** *Med Sci Sports Exerc.* 1997; 29:804-810.

Abdominal exercises are prescribed for both the prevention and treatment of low back injury. However, these exercises sometimes appear to have hazardous effects on the lumbar spine. The purpose of this study was to identify quantitatively abdominal exercises that optimize the challenge to the abdominal muscles (rectus abdominis, external oblique, internal oblique) but impose minimal load penalty to the lumbar spine. Nine volunteers performed 12 different abdominal exercises. For a given task the maximum abdominal muscle EMG value was divided by the maximum compression value, resulting in an abdominal challenge versus spinal compression cost index. In general, the partial curl-ups generated the highest muscle challenge-to-spine cost indices. However, those exercises that generated the best challenge-to-cost indices did not necessarily record the lowest compression levels along with the highest EMG activations. No single exercise was found that optimally trained all of the abdominal muscles while at the same time incurring minimal intervertebral joint loads. It was concluded that a variety of selected abdominal exercises are required to sufficiently challenge all of the abdominal muscles and that these exercises will differ to best meet the different training objectives of individuals.

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*Medicine and Science in Sports and Exercise.*

**Booth J, Marino F, Ward JJ. Improved running performance in hot humid conditions following whole body precooling.** *Med Sci Sports Exerc.* 1997;29:943-949.

On two separate occasions, eight subjects controlled treadmill speed to run the greatest distance possible in 30 min in a hot, humid environment (ambient

temperature  $32^{\circ}\text{C}$ , relative humidity 60%). For the experimental test (precooling), exercise was preceded by cold-water immersion. Precooling increased the distance run by  $304 \pm 166$  m ( $P < .05$ ). Precooling decreased the pre-exercise rectal and mean skin temperature by  $0.7^{\circ}\text{C}$  and  $5.9^{\circ}\text{C}$ , respectively ( $P < .05$ ). Rectal and mean skin temperature were decreased up to 20 and 25 minutes during exercise, respectively ( $P < .05$ ). Mean body temperature decreased from  $36.5 \pm 0.1^{\circ}\text{C}$  to  $33.8 \pm 0.2^{\circ}\text{C}$  following precooling ( $P < .05$ ) and remained lower throughout exercise ( $P < .01$ ) and at the end of exercise (by  $0.8^{\circ}\text{C}$ ;  $P < .05$ ). The rate of heat storage at the end of exercise increased from  $113 \pm 45$  to  $249 \pm 55 \text{ W} \cdot \text{m}^{-2}$  ( $P < .005$ ). Precooling lowered the heart rate at rest (13%), 5 minutes (9%), and 10 minutes (10%) exercise ( $P < .05$ ) and increased the end of exercise blood lactate from  $4.9 \pm 0.5$  to  $7.4 \pm 0.9 \text{ mmol} \cdot \text{L}^{-1}$  ( $P < .01$ ). The  $\text{VO}_2$  at 10 and 20 minutes of exercise and total body sweating were not different between tests. In conclusion, water immersion precooling increased exercise endurance in hot, humid conditions with an enhanced rate of heat storage and decreased thermoregulatory strain.

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**Wagner DR, Heyward VH, Kocina PS, Stolarczyk LM, Wilson WL. Predictive accuracy of BIA equations for estimating fat-free mass of black men.** *Med Sci Sports Exerc.* 1997;29:969-974.

This study assessed the predictive accuracy of previously published bioelectrical impedance analysis (BIA) equations in estimating the fat-free mass (FFM) of black men, 19 to 50 years. The reference method was hydrostatic weighing (HW) at residual lung volume. Body density (Db) was converted to relative

body fat (%BF) for calculation of FFM<sub>HW</sub> using the Schutte et al equation. Resistance and reactance were measured with a Valhalla bioimpedance analyzer. Age-specific, generalized, and fatness-specific BIA equations were cross validated using regression analysis. The Segal fatness-specific equations were modified using a method recommended by Stolarczyk. All of the equations significantly ( $P < .05$ ) underestimated the average reference measure of FFM<sub>HW</sub>. However, the underestimation of FFM for the modified Segal fatness-specific equation was relatively small ( $-1.8$  kg) and not likely to have much clinical significance. Furthermore, this equation had a high correlation with reference FFM<sub>HW</sub> ( $r_{yy'} = 0.97$ ), low prediction errors (SEE = 2.1 kg, E = 2.7 kg), and accurately estimated the FFM within  $\pm 3.5$  kg for 78% of the individuals in the sample. Thus, we recommend using the modified Segal fatness-specific BIA equation for estimating the FFM of black men.

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*Medicine and Science in Sports and Exercise.*

**McCrory PR.** Were you knocked out? A team physician's approach to initial concussion management. *Med Sci Sports Exerc.* 1997;29(suppl 7):S267-S212.

To present an evidence-based approach reviewing the acute management of concussive brain injury in sport. All published articles on the acute management of sport-related brain injury were extracted using searches of computerized databases (Medline, Embase, Sport Discus) as well as detailed literature reviews based upon the published bibliographies in this area. The review details the aspects where prospective scientific data are available upon which to base clinical management strategies. The first few minutes after an athlete receives a concussive injury provides a window of opportunity during which time the initial medical management forms a crucial and potentially lifesaving treatment. All clinicians involved in care of the concussed athlete need to have an understanding of the early management of the concussed

athlete and a strategy by which they may manage such problems. An efficient and appropriate response to the immediate concussion management will help minimize the potential sequelae that may impact upon the athlete's ability to return to sport.

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*Medicine and Science in Sports and Exercise.*

**Cantu RC.** Stingers, transient quadriplegia, and cervical spinal stenosis: return to play criteria. *Med Sci Sports Exerc.* 1997;29(suppl 7):S233-S235.

This article focuses on sports-related spinal cord and nerve injuries, ranging from mild "stinger" syndrome to complete quadriplegia. Particular emphasis is placed on recommendations for return to competition after such injuries. Cervical spinal cord symptoms after a spine injury from contact sports require more precise work up to detect cervical spinal stenosis than radiographic bone measurements alone can provide. Imaging technology such as MRI, contrast positive CT, and myelography more accurately identify true spinal stenosis and allow for safer return-to-play decisions.

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*Medicine and Science in Sports and Exercise.*

**Bolgla LA, Keskula DR.** Reliability of lower extremity functional performance tests. *J Orthop Sports Phys Ther.* 1997;26:138-142.

Clinicians routinely have used functional performance tests as an evaluation tool in deciding when an athlete can safely return to unrestricted sporting activities. These practitioners assumed that these tests provide a reliable measure of lower extremity performance; however, little research has been reported on the reliability of these measures. The purpose of this investigation was to determine the reliability of lower extremity functional performance tests. Five male and 75 female volunteers were evaluated using the single hop for distance, triple

hop for distance, 6-m timed hop, and cross-over hop for distance as described by Noyes. One clinician measured each subject's performance using a standardized protocol and retested subjects in the same manner approximately 48 hours later. The order of testing was randomly determined. Subjects' average and individual scores on each functional performance test were used for statistical analysis. Intraclass correlation coefficients (ICCs) and standard error of measurement (SEM) values based on average day 1 and day 2 scores were used to estimate the reliability of each functional performance test. Intraclass correlation coefficients were 0.96, 0.95, and 0.96, and SEMs were 4.56 cm, 15.44 cm, and 15.95 cm, respectively, for the single hop, triple hop, and cross-over hop for distance tests. An ICC of 0.66 and SEM of 0.13 seconds for the 6-m timed hop resulted from limited variability between measurements; however, its small SEM value implied that the inconsistency of measurement would occur in an acceptably small range. A repeated measures analysis of variance revealed no significant difference ( $P > .05$ ) between individual trial scores except for the single hop for distance. We concluded that this difference represented a learning effect not found with the other tests. The results of this investigation demonstrate that clinicians can use functional performance testing to obtain reliable measures of lower extremity performance when using a standardized protocol.

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*Journal of Orthopaedic and Sports Physical Therapy.*

**Wu Y, Li RCT, Maffulli N, Chan KM, Chan JLC.** Relationship between isokinetic concentric and eccentric contraction modes in the knee flexor and extensor muscle groups. *J Orthop Sports Phys Ther.* 1997;26:143-149.

We investigated whether in normal subjects isokinetic concentric and eccentric strength variables were related in order to have a better picture in relation to rehabilitation and possible injury prevention. We studied the relationship between isokinetic concentric and eccentric

peak torque, total work, and average power of knee extension and knee flexion at 60°/sec and 120°/sec in 42 young Chinese adults (22 males, age = 27 ± 6.9 years; 20 females (age = 24.9 ± 5.05 years) using the Cybex 6000 isokinetic dynamometer. Repeated analysis of covariance was used to compare the means between concentric and eccentric variables adjusted by limb dominance, speed of testing, and the muscle groups tested. A highly significant correlation was found between all concentric and eccentric variables, with correlation coefficients (*r*) ranging from 0.67 to 0.93. All but two of the eccentric variables were significantly greater than the concentric variables. Concentric and eccentric knee flexion to knee extension (HQ) ratios were poorly correlated, with *r* ranging from 0.359 to 0.645. Although there is an acceptably high correlation between isokinetic concentric and eccentric strength variables of knee flexion and extension in young healthy individuals, we recommend measuring concentric and eccentric strength to plan a proper rehabilitation program and to assess muscle groups in a given contraction mode.

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*Journal of Orthopaedic and Sports  
Physical Therapy.*

**Drechsler WI, Knarr JF, Snyder-Mackler L. A comparison of two treatment regimens for lateral epicondylitis: a randomized trial of clinical interventions. *J Sport Rehabil.* 1997;6:226-234.**

Eighteen subjects participated in a randomized controlled clinical trial to compare the effectiveness of two physical therapy treatments for tennis elbow. The subjects were divided into two groups: In the neural tension group (NTG), the head of the radius was mobilized and specific physical therapy mobilizations were used to address hypomobility of the radial nerve. The standard treatment group (STG) received ultrasound, transverse friction massage, and stretching and strengthening exercises for the extensors of the wrist. All subjects were treated twice weekly for 6 to 8 weeks. Follow-up data were ob-

tained at 3 months post-treatment. Subjects who received radial head mobilization improved over time ( $P < .05$ ) while those who did not receive radial head mobilization did not improve. Results of the NTG treatment were linked to the radial head treatment, and isolated effects of the NTG treatment could not be determined. There were no long-term positive results in the STG.

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*Journal of Sport Rehabilitation.*

**Johnson U. A three-year follow-up of long-term injured competitive athletes: influence of psychological risk factors on rehabilitation. *J Sport Rehabil.* 1997;6:256-271.**

The rehabilitation of 77 competitive athletes with long-term injuries was followed for 2 to 3 years from the time of the injury with the aim of identifying potential risk factors in rehabilitation. Seven athletes not returning to competitive sport despite favorable physical records were compared with 5 athletes who returned despite unfavorable records and with 65 athletes whose rehabilitation met expectations. Twelve tests were employed on four different occasions. The results suggested that being younger, being female, and having had no previous experience with injury characterized the nonreturning athlete. An insufficient mental plan for rehabilitation and a predominantly negative attitude toward it, as well as restricted social contacts with fellow athletes and a low mood level, appeared to accompany a problematic and prolonged rehabilitation. It was concluded that the nonreturning, long-term injured athlete can be identified as early as the beginning of the rehabilitation process.

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*Journal of Sport Rehabilitation.*

**Holcomb WR. A practical guide to electrical therapy. *J Sport Rehabil.* 1997;6:272-282.**

Electrical therapy is a popular therapeutic modality for the management and

rehabilitation of athletic injuries. Electrical stimulation is commonly used to elicit muscle contraction, reduce edema, and control pain. However, electrical therapy can also be a tremendous challenge for clinicians. The purpose of this paper is to present current and accurate information that will serve as a guide in the use of electrical therapy for the effective management of athletic injuries. With an understanding of the basic current types provided by various electrical stimulators and the modifications of the currents that are available, electrical therapy becomes an invaluable tool for injury management and rehabilitation.

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*Journal of Sport Rehabilitation.*

**Riemann BL, Guskiewicz KM. Assessment of mild head injury using measures of balance and cognition: a case study. *J Sport Rehabil.* 1997;6:283-289.**

Mild head injury (MHI) represents one of the most challenging neurological pathologies occurring during athletic participation. Athletic trainers and sports medicine personnel are often faced with decisions about the severity of head injury and the timing of an athlete's return to play following MHI. Returning an athlete to competition following MHI too early can be a catastrophic mistake. This case study involves a 20-year-old collegiate football player who sustained three mild head injuries during one season. The case study demonstrates how objective measures of balance and cognition can be used when making decisions about returning an athlete to play following MHI. These measures can be used to supplement the subjective guidelines proposed by many physicians.

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*Journal of Sport Rehabilitation.*

**Taylor DC, Arciero RA. Pathologic changes associated with shoulder dislocations: arthroscopic and physical examination findings in first-time, traumatic anterior dislocations. *Am J Sports Med.* 1997;25:306-311.**

This prospective observational study was performed on young patients, less than 24 years old, with first-time, traumatic anterior shoulder dislocations. These patients were offered either arthroscopic or nonoperative treatment. Fifty-three patients chose nonoperative treatment. Sixty-three patients elected to have arthroscopic procedures. The average patient age was 19.6 years. There were 59 men and 4 women. All procedures were performed within 10 days of dislocation. All 63 patients had hemarthrosis. Sixty-one of 63 (97%) patients treated surgically had complete detachment of the capsuloligamentous complex from the glenoid rim and neck (Perthes-Bankart lesion), with no gross evidence of intracapsular injury. Of the other two patients, one had an avulsion of the inferior glenohumeral ligament from the neck of the humerus, and one had an interstitial capsular tear adjacent to the intact glenoid labrum. Fifty-seven patients had Hill-Sachs lesions; none were large. There were six superior labral anterior posterior lesions, two with detachment of the biceps tendon. There were no rotator cuff tears. Of the 53 nonoperatively treated patients, 48 (90%) have developed recurrent instability. In this population, the capsulolabral avulsion appeared to be the primary gross pathologic lesion after a first-time dislocation. These findings, associated with the 90% nonoperative recurrence rate, suggest a strong association between recurrent instability and the Perthes-Bankart lesion in this population.

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**Gatt CJ Jr, Hosea TM, Palumbo RC, Zawadsky JP. Impact loading of the lumbar spine during football blocking. Am J Sports Med. 1997;25:317-321.**

The purpose of our study was to determine the impact force to the lumbar spine when football players hit a blocking sled. We quantified the loads at the L4-5 motion segment throughout the blocking sequence. Five Division I-A college football linemen were subjects

for our study. Kinematic data were obtained while the subjects hit a blocking sled instrumented with a force plate. Three plane forces were then calculated from these data. The average impact force measured at the blocking sled was  $3013 \pm 598$  N. The average peak compression force at the L4-5 motion segment was  $8679 \pm 1965$  N. The average peak anteroposterior shear force was  $3304 \pm 1116$  N, and the average peak lateral shear force was  $1709 \pm 411$  N. The magnitude of the loads on the L4-5 motion segment during football blocking exceed those determined during fatigue studies to cause pathologic changes in both the lumbar disk and the pars interarticularis. These data suggest that the mechanics of repetitive blocking may be responsible for the increased incidence of lumbar spine injury incurred by football linemen.

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**Swenson EJ Jr, DeHaven KE, Sebastianelli WJ, Hanks G, Kalenak A, Lynch JM. The effect of a pneumatic leg brace on return to play in athletes with tibial stress fractures. Am J Sports Med. 1997;25:322-328.**

A total of 18 competitive and recreational athletes were enrolled in a randomized, prospective study looking at the effect of pneumatic leg braces on the time to return to full activity after a tibial stress fracture. All patients had positive bone scans and 15 had positive radiographic findings by week 12. There were two treatment groups. The traditional treatment group was treated with rest and, after 3 pain-free days, a gradual return to activity. The pneumatic leg brace (Aircast) group had the brace applied to the affected leg and then followed the same return to activity guidelines. The guidelines consisted of a detailed functional progression that allowed pain-free return to play. The brace group was able to resume light activity in 7 days (median) and the traditional group began light activity in 21 days (median). The brace group returned to full, unre-

stricted activity in 21 to 22 days, and the traditional group required  $77 \pm 7$  days to resume full activity. The Aircast pneumatic brace is effective in allowing athletes with tibial stress fractures to return to full, unrestricted, pain-free activity significantly sooner than traditional treatment.

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**Borsa PA, Lephart SM, Irrgang JJ, Safran MR, Fu VH. The effects of joint position and direction of joint motion on proprioceptive sensibility in anterior cruciate ligament-deficient athletes. Am J Sports Med. 1997;25:336-340.**

We studied a group of anterior cruciate ligament-deficient athletes to identify whether joint position and direction of joint motion have a significant effect on proprioception. Twenty-nine anterior cruciate ligament-deficient athletes were tested for their threshold to detect passive motion at both  $15^\circ$  and  $45^\circ$  moving into the directions of both flexion and extension. The single-legged hop test was used to identify function in the deficient limb. Results demonstrated statistically significant deficits in threshold to detect passive motion for the deficient limb at  $15^\circ$  moving into extension. For the deficient limb, threshold to detect passive motion was significantly more sensitive moving into extension than flexion at a starting angle of  $15^\circ$ ; at a starting angle of  $15^\circ$  moving into extension threshold was significantly more sensitive than at a starting angle of  $45^\circ$  moving into extension. We conclude that in deficient limbs proprioception is significantly more sensitive in the end ranges of knee extension ( $15^\circ$ ) and is significantly more sensitive moving into the direction of extension. To effectively restore reflex stabilization of the lower limb we recommend a rehabilitation program emphasizing performance-based, weightbearing, closed kinetic chain exercise for the muscle groups that act on the knee joint.

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# B ook Reviews

## *Time-Saving Training for Multisport Athletes*

Richard Niles

Human Kinetics, Champaign, IL

1997

182 pages

ISBN: 0-88-11-538-6

Price: \$16.95

The purpose of this book is to explain the proper techniques for those individuals beginning multisport or triathlon training, and it offers information about energy systems in very general terms. The chapter on threshold training has sound principles and is easy to understand. Chapter 3, "Time to Prevent Training Losses," does a very good job of explaining how to scientifically increase performance without overtraining. Heart rate is explained with a helpful section on target heart rate, as well as monitoring heart rate during exercise. However, the strength training section should be expanded, since it contains only a few lower-extremity exercises and two upper-extremity exercises. There are illustrations on strength training identifying muscles used during each exercise.

The chapter "Time Management: The Weekly Schedule" discusses setting safe and efficient weekly training schedules for individuals limited by time. The author has designed very good model training programs that are restricted to swimming, biking, and running. He sets upper limits and spaces multisport training throughout the week. There is also a section on form and factors that can affect times and performance, again restricted to swimming, biking, and running. Correcting improper form is also discussed.

I would recommend this text to persons beginning multisport activity or as a supplement to an exercise science curriculum. This text is well written, with an emphasis on proper training. It is easy to read and does not require a background in exercise physiology to comprehend the material. The cost is reasonable for the material covered.

Sally A. Perkins, ATC/L  
Southern Illinois University  
Carbondale, IL

## *NBA Power Conditioning: 122 Exercises and Drills from the Experts*

National Basketball Conditioning Coaches Association

Human Kinetics, Champaign, IL

1997

205 pages

ISBN: 0-88011-687-0

Price: \$17.95

Even though many different ideas and approaches exist to improve athletes' strength and conditioning, athletic trainers, coaches, and players are always looking for new programs and new ideas. This text reflects the combined effort of many of the NBA's strength training professionals. Its objective is to take young basketball players through the entire spectrum of a strength and conditioning program in an easy-to-understand format. Filled with numerous examples and illustrations, the book presents a standard, common-sense approach.

The text is divided into four parts. Part I, "Power Preparation," provides an introduction to activities designed to ready the athlete for exercise. Stretching and warm-up are reviewed, with a brief background on the physiology of each. Many different stretching methods are discussed, and they are accompanied by 20 pages of illustrations, covering each area of the body. A nutrition plan, tips for a healthy diet, and weight gain and fat loss are also discussed. This section concludes with a chapter on cardiovascular conditioning that includes numerous conditioning drills and an off-season program.

Part II, "Power Base Strength," begins with abdominal exercises and then moves on to the basics of strength training, including instructions, with illustrations of both free weight and machine exercises, along with basic guidelines for structuring a weight training workout. Strength training programs for different times of the year are presented, and sample workout cards are provided.

Part III, "Power in Motion," consists of chapters on plyometric training (including medicine ball drills), speed training (including numerous running drills),

and agility training (combining basketball skills with conditioning drills).

Part IV, "Power Rating and Programming," contains a series of tests to evaluate the player's level of strength conditioning and individual physical abilities. These tests can be used to evaluate and monitor the player's progress and rate it on a performance scale.

The text does provide a general overview of strength training, power development, and cardiovascular conditioning for basketball. It contains brief explanations and applications of these components of physical performance. It does not include any specific basketball coaching fundamentals, but those are not within the scope of this text.

One highlight is the section on testing. Athletes are always looking for methods to determine how they "measure up" to others, and this book provides a mechanism for rating individual performance. However, these tests are not standardized or referenced, and I found the power rating system biased toward smaller athletes. There are no normalizations for body mass and size.

In my opinion, at \$17.95 this book is moderately priced and a useful guide to the young player or beginning coach.

Tim Garl, MPA, ATC  
Indiana University  
Bloomington, IN

## *Treat Your Own Back*

7th edition

Robin McKenzie

Spinal Publications, Waikanae,  
New Zealand

1997

80 pages

ISBN: 0-9597746-6-1

Price: \$10.00

*Treat Your Own Back*, authored by Robin McKenzie, an internationally known clinician, speaker, and author on the management and prevention of spinal injuries, was first published in 1980. Emphasizing a self-help approach, the book is an excellent resource on back injury prevention and management. Well

organized and easy to read with minimal technical terminology, it uses a variety of very effective techniques to reinforce important points and to allow the reader to determine if he or she understands the material. The material offers practical application to a variety of readers. The photographs depicting proper and improper posture, correct and incorrect sitting and standing techniques, and the seven exercises that are the core of the treatment program are excellent.

The first two chapters give an overview of the extent of back injuries in society plus a nontechnical review of the spine and low back pain. The key point of these initial chapters, which is effectively reinforced throughout the book, is that prevention and management of low back pain/injury is the responsibility of the individual. The author concludes that many people with back pain do not take responsibility; instead they rely on therapeutic techniques that may produce short-term relief, but not permanent relief. A particularly useful section of chapter 2 lists symptomatology that indicates and contraindicates the use of the McKenzie approach with specific patients. The series of questions provided could easily be integrated into the athletic health care provider's differential evaluation of the athlete with low back pain.

To take responsibility for the prevention and management of low back problems, the individual needs to understand the common causes of low back pain. Chapter 3 provides the reader with a comprehensive overview of mechanisms associated with low back pain onset and recurrence. These include sitting or standing for prolonged periods; working in stooped positions; lifting, lying and resting; and coughing and sneezing. The photographs in this chapter are excellent in depicting correct and incorrect techniques and postures.

Chapters 4 to 6 present the series of seven exercises that make up the sequential treatment program. McKenzie feels that much low back pain is the result of spinal tissue distortions from postures and techniques that decrease the lordotic curve. The book emphasizes that, from management and prevention perspectives, maintaining proper lumbar lordosis is the key. The four extension exercises

(three prone and one standing) and three flexion exercises are effectively presented through photographs and written descriptions. The exercises are sequential, and each time a new exercise is presented, it is done in the context of the previous exercises. This approach to presenting the exercises makes comprehension of the sequence and rationale very easy.

Chapter 7 presents special considerations when dealing with low back patients who are pregnant, elderly, or athletes. Chapter 8 provides a brief discussion of other traditional and non-traditional approaches to managing low back pain, including medications, heat/cold, acupuncture, chiropractic, and bedrest. The discussions of these approaches are very superficial. Including them for any reason other than to note their existence adds little to the book.

Chapter 9 ("First Aid for Low Back Pain") not only provides excellent closure to the topic, but also includes a helpful one-page resource with photographs for use by the health care practitioner and the individual who develops sudden low back pain. Called the "Panic Page," it contains a concise description of how to deal with the sudden onset of acute low back pain.

*Treat Your Own Back* is an extremely valuable resource that can be used by health care practitioners and educators and individuals with low back pain. The book could be used in the treatment setting as an instant resource, easily understood by the practitioner and patient. Athletic trainers and physical therapists may wish to make it mandatory reading for their patients as part of the treatment program and home exercise component of the treatment plan. The book's length, organization, and graphic presentations make it easy reading.

The book should be required reading for any student studying therapeutic exercise. For the student with an adequate background in spinal anatomy and biomechanics, the text brings the topic of low back pain prevention and management to a very practical and "hands-on" level.

Charles J. Redmond, ATC, PT  
Springfield College  
Springfield, MA

## **Fundamentals of Sports Injury Management**

### **Fundamentals of Sports Injury Management Student Workbook**

Marcia K. Anderson, Susan J. Hall (book)

Malissa Martin, Marcia K. Anderson, Susan J. Hall (workbook)

Williams & Wilkins, Baltimore, MD  
1997

450 pages (book), 209 pages (workbook)

ISBN: 0-683-30001-6 (book), 0-683-30345-7 (workbook)

Price: \$39.95 (book), \$16.95 (workbook)

*Fundamentals of Sports Injury Management* (text and student workbook) is the latest offering from Anderson and Hall, following their well-designed *Sports Injury Management* 1995 text. The primary goal of *Fundamentals of Sports Injury Management* remains the same as it was in *Sports Injury Management*: that is, to integrate basic medical concepts and related scientific information to provide a foundation in the prevention, recognition, assessment, management, disposition, and rehabilitation of sport-related injuries and illnesses. However, the difference between the two texts is that, according to the authors, *Fundamentals of Sports Injury Management* is designed as an introductory text for courses in coaching, exercise science, health education, health fitness, physical therapy, recreation, physical education, and youth sports.

The overall content of *Fundamentals of Sports Injury Management* is very similar to *Sports Injury Management*. Section I deals with the foundations of sports injury management. Topics included are sports injury management and the athletic trainer and the mechanics of tissue injury and healing. Section II, "Sports Injury Management," covers emergency procedures, sports injury assessment, therapeutic exercise and therapeutic modalities, protective equipment, and protective taping and wrapping. Sections III, IV, and V cover injuries to the lower extremity, the upper extremity, and the axial region, including the face, throat, thorax, and viscera. Each of these sections contains an anatomy review, description of major muscle actions, injury prevention guidelines, common injuries, assessment techniques, and

rehabilitation techniques. Section VI deals with special conditions (eg, those affecting the reproductive system) that may be related to sports.

The excellent pedagogic features of the original text are retained in *Fundamentals of Sports Injury Management*. These include learning objectives, thought questions, marginal definitions and tips, tables, field strategies, and a summary for each chapter. Following the suggestion of a previous review in the *Journal of Athletic Training*, the authors have incorporated key terms at the beginning of each chapter. All of these features make this text very easy to read and comprehend. I found the thought questions, and their accompanying answers later in each section, to be a very valuable pedagogic tool because they applied the text material to real-life situations. The liberal use of tables and field strategies also serves to reinforce the material found in the text, again in a very practical sense.

The *Fundamentals of Sports Injury Management Student Workbook* is an outstanding adjunct to the text. The learning objectives and key terms mirror those of the text for each chapter. The use of a variety of student learning exercises in the anatomy, kinematics, taping, protective equipment fitting, and assessment laboratories provide the student with practical applications for their ad-

vancing knowledge. In addition, the use of problem-solving skill applications lessons and multiple choice questions allows students possessing different learning strategies to assess their mastery of the material. Immediate feedback by way of the correct answers to all learning exercises at the end of each chapter also serves to enhance student learning.

My only reservations relative to this text concern its stated mission to serve non-athletic training students. Many sections of the new text are still written as if addressing athletic trainers or students of athletic training, specifically many of the thought questions and the athletic trainer interviews at the beginning of each section. This may confuse other readers as to whom the text is truly written for, or it may allow the reader to assume that by mastering this text, he or she is an "athletic trainer."

The field strategy on the prevention and management of blisters, found in the new text and not in the old, is particularly troublesome. Considering that some, including athletic trainers, feel that the puncture and drainage of blisters is beyond the scope of athletic trainers, why is this section included here and not in the text for athletic trainers?

In addition, many field strategies found in the previous text are not included in the *Fundamentals of Sports Injury Management*. Because these are

excellent methods and guidelines in athletic injury management to provide the non-athletic trainer, I would suggest the authors incorporate more of these in a future edition.

The text dialogue is modified in the new text, making it less technical (or confusing for the non-athletic training student) while still conveying the meaning of the material. This makes these sections much easier to read and leads the reader to the point more quickly, an advantage, I feel, for the non-athletic training student. The section on the application of taping and wrapping is excellent; I wish it had been included in the version for athletic training students.

I could see how it would be very difficult for the authors to create a textbook for non-athletic training students after their successful previous textbook. Deciding how much material to include, how much to omit, and how to present it (without creating a similar book) would be a daunting task. Despite the shortcomings I noted above, I feel that *Fundamentals of Sports Injury Management* and the *Student Workbook* would be appropriate for a course in the prevention and care of athletic injuries, with an audience of students preparing for careers other than athletic training. It would be equally appropriate for professionals in the careers stated by the authors.

Daniel Sedory, MS, ATC  
University of New Hampshire  
Durham, NH

# V video Reviews

## *Teaching Flexibility*

Human Kinetics, Champaign, IL

1997

51 minutes

ISBN: 0-88011-776-1

Price: \$24.95

*Teaching Flexibility* is a newly released video that addresses the various aspects of stretching for health and performance. The overall production and presentation of the material is of high quality, with both the audio and video portions being clear and concise. Information is organized in a logical and comprehensible manner, with smooth and easy-to-follow transitions between focus areas. The use of a variety of models and examples for demonstrations is helpful for the viewer.

Qualified sports professionals (certified athletic trainers, certified strength and conditioning specialists, physical therapists, etc) should find the information in *Teaching Flexibility* to be a review, while individuals beginning the study of human performance may find the material especially useful. Basic concepts of flexibility training for both healthy and injured clients are detailed. Stretching principles and factors affecting joint range of motion are described, although briefly. A variety of different joint flexibility tests is presented, with good visual and verbal explanations of each. The final section of the video offers the "Human Kinetics Stretch Routine," which involves 14 stretching exer-

cises for the enhancement of range of motion for the major joints of the body.

For the relatively inexpensive price of \$24.95, *Teaching Flexibility* is a good supplement to an in-depth study of stretching for health and performance. It would be a good supplement for undergraduate students in a fitness and conditioning or therapeutic exercise class. In order to consider *Teaching Flexibility* as a more primary source of information or for more advanced undergraduate students, Human Kinetics should include more material on the theories and principles of stretching and offer a greater variety and number of stretches.

*Robert D. Kersey, PhD, ATC, CSCS*

California State University

Fullerton, CA

flexible, and it's important to start early. This video is designed to help you learn how to stretch effectively and safely. It features a variety of stretching techniques, including static stretching, dynamic stretching, and proprioceptive neuromuscular facilitation (PNF) stretching. The video also includes tips on how to stretch correctly and avoid injury.

**MEET THE EXPERTS**  
The video features three experts in the field of stretching: Dr. Robert D. Kersey, ATC, CSCS, a certified athletic trainer and strength and conditioning coach; Dr. Michael J. Kellis, ATC, CSCS, a certified athletic trainer and strength and conditioning coach; and Dr. James M. Hartman, ATC, CSCS, a certified athletic trainer and strength and conditioning coach.

**WHAT'S INSIDE**  
The video includes a variety of stretching techniques, including static stretching, dynamic stretching, and proprioceptive neuromuscular facilitation (PNF) stretching. It also includes tips on how to stretch correctly and avoid injury.

**WHO IS IT FOR?**  
The video is designed for anyone who wants to improve their flexibility and reduce the risk of injury. It is suitable for athletes, fitness enthusiasts, and anyone who wants to stay healthy and active.

**WHAT'S INCLUDED?**  
The video includes a DVD and a booklet containing tips on how to stretch safely and effectively.

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# C current Literature

Clint Thompson, MS, ATC

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(Revised January 1998)

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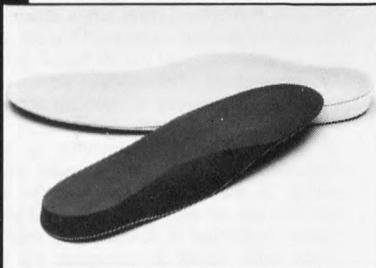
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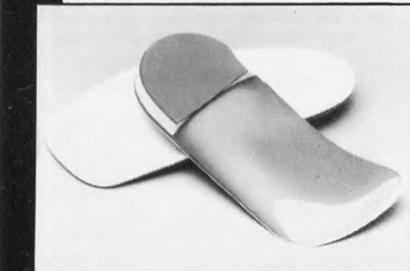
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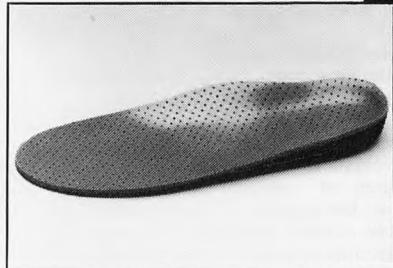
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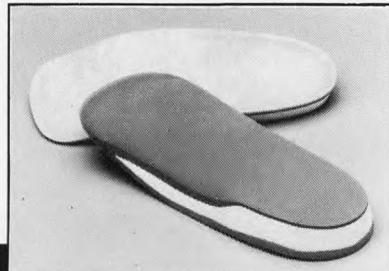
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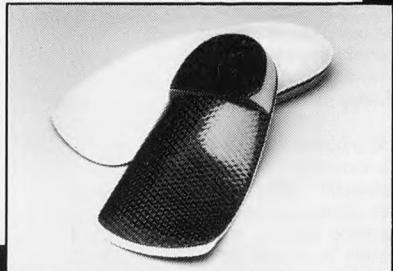
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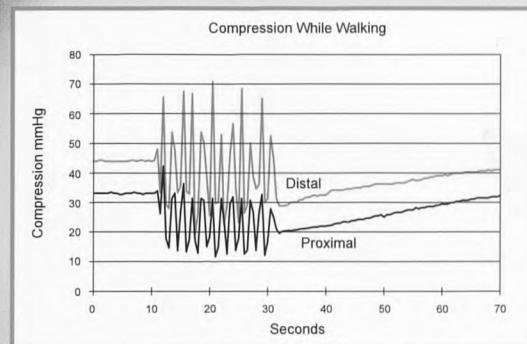
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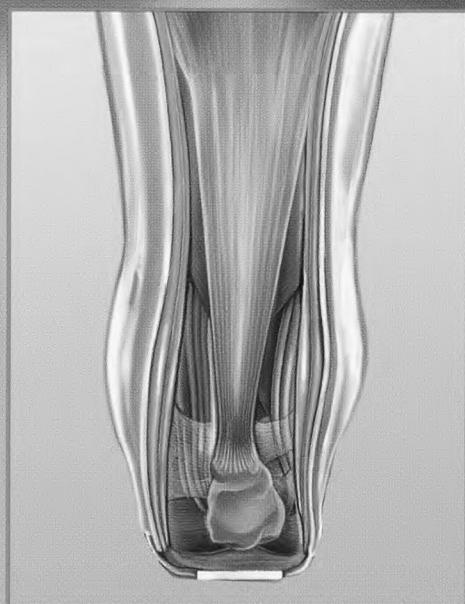
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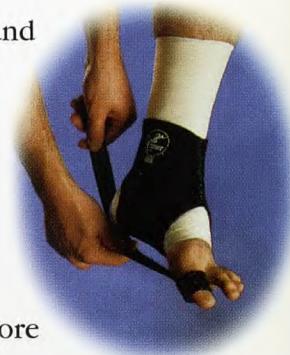
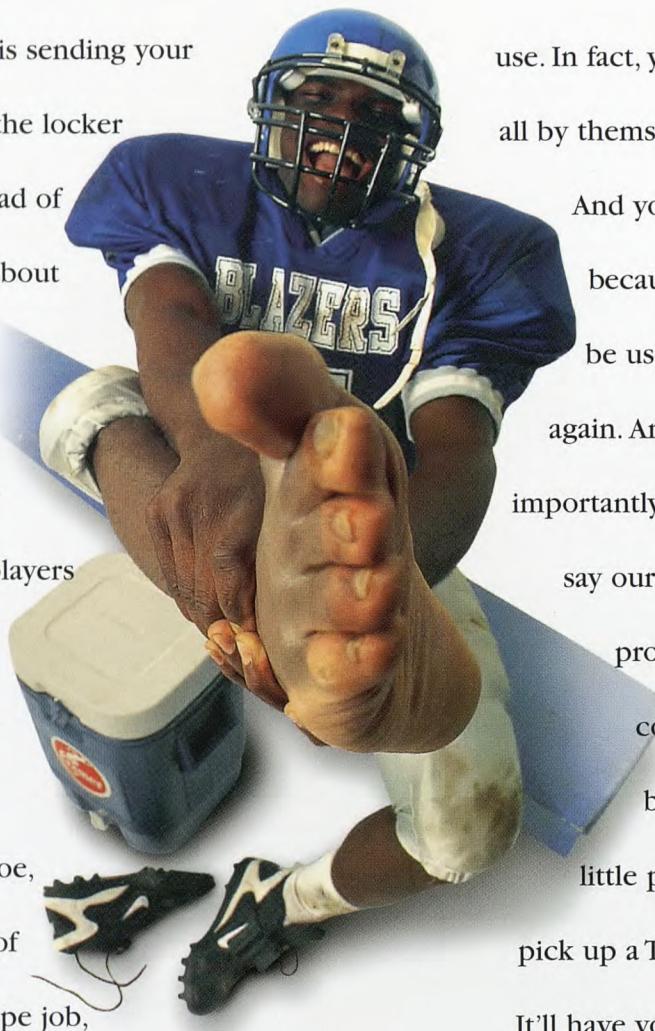
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The Turf Toe Brace protects like a tape job. It fits snugly around the ankle, heel and toe, preventing hyperextension of the great toe. But unlike a tape job, this brace is lightweight and easy to



use. In fact, your players can slip it on all by themselves. □ You save time. And your team saves money because each Turf Toe Brace can be used again and again. And most importantly, athletes say our new product is more comfortable than even the best tape job. □ Get your little piggies to market today and pick up a Turf Toe Brace from Cramer. It'll have your athletes crying "wow, wow, wow!" all the way home.



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