

# JOURNAL OF ATHLETIC TRAINING

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# JOURNAL OF ATHLETIC TRAINING

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Volume 31, Number 2, April-June

## Original Research

- Functional Outcome Measures for Knee Dysfunction Assessment**  
Douglas R. Keskula, Jewell B. Duncan, Virginia L. Davis, and Paula W. Finley . . . . . 105
- Functional Performance Following an Ice Immersion to the Lower Extremity**  
Kevin M. Cross, Rick W. Wilson, and David H. Perrin . . . . . 113
- Chronic Brachial Plexopathies and Upper Extremity Proprioception and Strength**  
C. Buz Swanik, Tim J. Henry, and Scott M. Lephart . . . . . 119
- The Effect of Icing with the Pro-Stim Edema Management System on Cutaneous Cooling**  
William R. Holcomb, Brent C. Mangus, and Richard Tandy . . . . . 126
- Effect of Prophylactic Knee Bracing on Balance and Joint Position Sense**  
Thomas W. Kaminski and David H. Perrin . . . . . 131
- The Stretching Window Part Two: Rate of Thermal Decay in Deep Muscle Following 1-MHz Ultrasound**  
Shannon Rose, David O. Draper, Shane S. Schulthies, and Earlene Durrant . . . . . 139
- Various Treatment Techniques on Signs and Symptoms of Delayed Onset Muscle Soreness**  
Dawn T. Gulick, Iris F. Kimura, Michael Sitler, Albert Paolone, John D. Kelly IV . . . . . 145

## Literature Review

- Sport, Exercise, and the Common Cold**  
Thomas G. Weidner and Thomas L. Sevier . . . . . 154
- The Importance of State Regulation to the Promulgation of the Athletic Training Profession**  
Maria N. Rello . . . . . 160

## Case Reports

- Positive Drug Screen for Benzodiazepine Due to a Chinese Herbal Product**  
Patricia L. Eachus . . . . . 165
- Pneumothorax—A Medical Emergency**  
Ronald D. Cvengros and James A. Lazor . . . . . 167

## Clinical Techniques

- Adaptation of a Foot Plate for Use in an Isokinetic and Isotonic Leg Press**  
Herbert K. Amato and Lonnie A. Smith . . . . . 169
- The Foot and Ankle: An Overview of Arthrokinematics and Selected Joint Techniques**  
Janice K. Loudon and Stephanie L. Bell . . . . . 173
- The "Tape Cast" Functional Taping for the Injured Athlete**  
James L. Thornton and Jeffrey A. Webster . . . . . 179

## Departments

- Letters to the Editor . . . . . 101
- Abstracts . . . . . 182
- New Products . . . . . 184
- Current Literature . . . . . 187
- 1996 Request for Proposals NEW-Education Grants! . . . . . 188
- Authors' Guide . . . . . 189
- CEU Quiz . . . . . 190
- Advertisers' Index . . . . . 192



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**Response to "An Alternative Material for Silicone Casting" by James M. Sabo**

We would like to commend Dr. Sabo for his recent contribution to *Tips from the Field*, "An Alternative Material for Silicone Casting" (*JAT*, 1995;30:345-348). As researchers in the area of playing cast fabrication, we are always interested to read of new methods of casting. We would like to remind Dr. Sabo and the readers that a new rule for playing cast usage in high school football was established in 1994 by the National Federation of State High School Associations. This rule, which allows for playing casts of various materials as long as they are covered by at least 1/2" closed-cell foam padding, is included in an article that appeared previously in this journal (*JAT*, 1994;1:37-43). The high school rule further stipulates that the athlete present written verification from a physician that the cast is necessary to protect an injury. We should emphasize that these rules apply only to high school football. Although it is our practice to use two separate casts (one for playing

and one for daily wear), some physicians prefer to use one, nonremovable cast. In this case, if the athlete is cleared to compete, simply applying foam over the cast is now legal in high school football. As always, before fabricating any type of playing cast, it is always a good idea to check the rules of the particular sport.

Please also note an error in the references. We believe that the author T. Malone should have been included in the first reference to Bassett et al.

Again, we commend the author for presenting this unique and cost-conscious method of playing cast fabrication. Clearly, creativity and experimentation in the training room will continue to play a significant part in improving our care of athletes and stretching our limited resources.

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**Author's Response**

I appreciate Mr. DeCarlo and Ms. Malone pointing out the high school rule on the soft cast. I was made aware of this rule after the article went to print. Also, there was an error in the reference section, T. Malone should be included in the first reference.

In addition, over the past several months I have received several comments on this article. A unique comment was to rub an ice cup over the last layer of silicone (while wet). This will smooth out all rough areas of the cast, but does not assist in curing the silicone. I tried this technique just recently, and it works great.

*James M. Sabo, EdD, ATC*  
Salem-Teikyo University  
Salem, WV 26426

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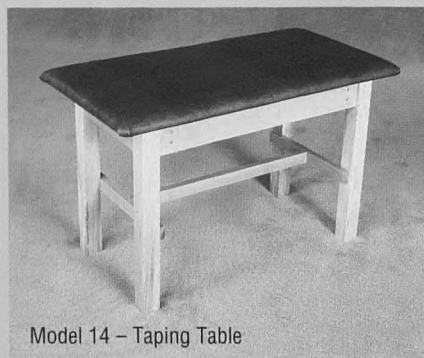
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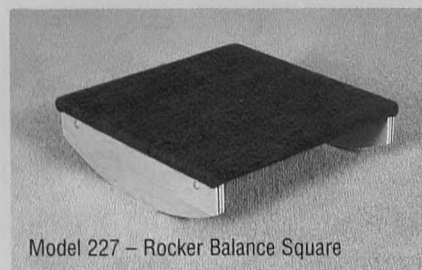
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# Functional Outcome Measures for Knee Dysfunction Assessment

Douglas R. Keskula, PhD, PT, ATC; Jewell B. Duncan, MD;  
Virginia L. Davis, MEd, PT, ATC; Paula W. Finley, PT

**ABSTRACT:** Maximizing the functional abilities of the individual is the primary objective of any therapeutic intervention. Functional outcome data are valuable to those involved in the care of the athlete because such data provides information that helps facilitate the clinical decision-making process and, therefore, helps insure a safe and efficient return to athletics. Functional outcome measures also provide useful data for assessing therapeutic intervention efficacy. The clinician/researcher must

consider various factors when selecting an appropriate outcome measure, such as: the patient population, pathology, specific test parameters, psychometric properties, and practicality of the measure. The primary purpose of this paper is to provide the reader with guidelines for either assessing existing measures or developing new measures of functional outcomes for use in clinical practice and research.

The purpose of health care intervention is to restore the functional abilities of the individual within the limits imposed by injury or disease. Functional limitation or dysfunction represents the individual's inability to perform specific tasks and activities otherwise considered normal.<sup>11</sup> A functional outcome is a predicted result of care that is meaningful and practical to the athlete and sustainable beyond the rehabilitation environment.<sup>20,21</sup> In the athletic population, treatment goals are directed toward safely and efficiently returning the individual to participation in athletics.

Functional outcome data is important to health care consumers, providers, and insurers for several reasons. First, improvement in impairments such as range of motion and strength do not always lead to functional improvement.<sup>20,21</sup> Athletes must meet criteria to progress through the rehabilitation program. However, success during an early phase of rehabilitation does not insure that the athlete will successfully participate in functional activities. The only way to determine the athlete's ability is to conduct a functional trial. The clinical decision-making process must include a mechanism to assess and report functional outcomes to insure safe return to athletic participation.

Functional outcome measures provide data to assess treatment outcomes. The continual evolution of health care delivery and reimbursement requires greater justification for third party payers. Stewart<sup>21</sup> suggests that functional outcome is the key to justification of treatment and successful reimbursement. Functional outcome data may also facilitate the assessment of the efficacy of therapeutic intervention, leading to more efficient and more effective treatment. Functional outcomes not only assess benefits but also provide cost-benefit data.<sup>9</sup>

Rehabilitation of the lower extremity is frequently encountered in sports medicine. There are several assessment tools available to the clinician/researcher to measure and report change in the status of an individual with lower extremity dysfunction. Tegner et al<sup>23</sup> categorized these dimensions as patient symptoms, clinical exam, activity grading, and performance testing. There are advantages and limitations to each measure used independently or in conjunction with other measures. Determination of the appropriate outcome measure(s) may be contingent on the patient population, pathology, specific test parameters, psychometric properties, and practicality of the measure.

The purpose of this paper is to provide the reader with guidelines for the assessment of existing or development of new measures of functional outcomes for use in clinical practice or research for the assessment of knee dysfunction. Suggestions for the documentation of functional outcomes in sports medicine are presented.

## CONSIDERATIONS IN THE SELECTION OF FUNCTIONAL OUTCOME MEASURES

The clinician/researcher must consider the psychometric properties of the measurement tool when selecting a functional outcome measure. Reliability and validity are important considerations in the selection of a clinical test. These attributes applied to data acquisition serve to facilitate the clinical decision-making process. Additional considerations for test selection include the practicality of the measure.

Reliability is the degree to which a measure is consistent and free from error. Clinicians need to be concerned with the reliability of measures with respect to time and the evaluator. The assumption is that variations between measures are attributed to changes in the variable being measured. However, random measurement error may contribute to this variation, reducing the reliability of the test. There are several sources of measurement error that diminish the reliability of testing. These factors may include flaws with the measurement tool, inherent instability of the variable being measured, and errors

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made by the examiner.<sup>16</sup> There are limited reports of reliability of functional measures for the lower extremity.<sup>4,15,19</sup>

A reliable measure is not necessarily a valid one. The validity of a test examines whether the test measures what it is supposed to measure. In addition, the clinician must consider if the test is valid for the intended purpose. An outcome measure designed for patients with a total knee replacement may have questionable validity for patients with anterior cruciate ligament (ACL) reconstruction. There are several reports addressing the validity of functional measures for ACL patients<sup>17,24</sup> and total hip and knee replacement patients.<sup>15,19</sup>

A test should possess the ability to discriminate between the presence or absence of problems. The ability of a test to determine a positive test when the problem is present (true positive) is defined as sensitivity.<sup>16</sup> A negative test, when the problem is absent (true negative), is defined as specificity.<sup>16</sup> Both of these dimensions are desirable characteristics of a test. However, there is an inverse relationship between the two dimensions (sensitivity increase results in specificity decreasing). The dimension of the test should reflect the consequences of decisions made based on the test data. Combining several tests to assess function may serve to minimize any trade-offs between specificity and sensitivity.<sup>16</sup>

The practicality of functional outcome measures employed in the clinical/research setting is an important consideration. Jette<sup>10</sup> describes the following factors: the method of administration, time required to administer the tests, equipment required, special training for the examiners, and the nature of the scoring system. Selection or development of an evaluative tool will depend on all these factors. In addition, the intended purpose of the data should be considered. Whether the data will be used primarily for clinical or research purposes may influence the decision to select a functional measure. For example, comparison of data across several investigators or clinical sites requires the use of standardized assessment tools to create valid comparisons.

## FUNCTIONAL OUTCOME MEASURES

A variety of measures have been established for a range of lower extremity problems. Oberg et al<sup>15</sup> provides a comprehensive review of instruments across a range of dysfunctions. Many authors describe activity rating scores<sup>8,13,22</sup> and performance testing<sup>2,12,23</sup> for use in assessing lower extremity dysfunction following knee ligament injury. Activity rating scales solicit qualitative and quantitative subjective information from the patient such as functional/recreational abilities, pain, swelling, instability, and level or intensity of activity. Performance tests are objective measures of unilateral, bilateral, and sport-specific activity.

### Activity Rating

Activity grading scores may be used to compare several points in time (ie, preop to postop or pretreatment to posttreatment). Draper and Ladd<sup>6</sup> used the Lysholm scale to assess knee function and activity levels of patients with ACL-reconstructed knees. The athlete/patient responds to items on a questionnaire.

Scores are calculated and recorded. The following examples are representative of activity rating scales used in the sports medicine literature to assess knee dysfunction resulting from ACL injury and/or surgery. The reader is encouraged to consult original reports for specific information.

**Lysholm Score.**<sup>22</sup> Patients/athletes rate eight dimensions and are assigned point values with a possible total score of 100 points. The dimensions assessed and maximal point values are as follows: limp (5 points), support (5 points), locking (15 points), instability (25 points), pain (25 points), swelling (10 points), stairs (10 points), and squatting (5 points). Quality dimensions for each category generally range between no problem to consistent limitation. For example, the range of points for stair climbing and squatting is 0 points for impossible and a maximal point value of 10 points for no problem with activity.

**Activity Score.**<sup>22</sup> Patients/athletes rate activity level on a scale of 0 to 10. Levels 6 through 10 describe recreational to competitive sports participation in activities requiring acceleration/deceleration and cutting (ie, soccer, basketball, hockey, and tennis). Levels 3 through 5 identify heavy vocational requirements and competitive recreational activities requiring straight plane activities (ie, cycling, jogging, and cross-country skiing). Levels 0 through 3 describe sick leave or disability pension secondary knee problems through light work/ambulatory requirements.

**Subjective Knee Score Questionnaire.** Wilk et al<sup>24</sup> used a questionnaire adapted from the work of Noyes et al<sup>13</sup> to study patients with ACL-reconstructed knees. Patients responded to questions regarding symptoms and sport activities pertaining to their knee. Categories along with maximum point values included: pain (20 points), swelling (10 points), stability (20 points), overall activity level (20 points), walking (10 points), stairs (5 points), running (10 points), and jumping and twisting activities (5 points). Levels within each category are based on scales with a range of abilities. For example, in the running category, 10 points are awarded for normal, unlimited, and fully competitive running, while 2 points are awarded for severe problems with only a few steps. Patients also rated their overall knee function on a scale of 1 to 100.

Several dimensions contribute to the construct defined as function. Factors that impact functional performance may include overall endurance, sport-specific skill, and psychological elements, in addition to the specific knee impairments. These factors may be hard to assess in the structured clinical setting and require the actual participation of the activity. Tegner and Lysholm<sup>22</sup> suggested that activity rating scores provide a good overall picture of knee function without restriction. Seto et al<sup>18</sup> reported that activity scores of patients with an ACL reconstruction were positively correlated with the ability to participate in sports. Activity scales provide both the clinician and the athlete the opportunity to assess the spectrum of knee performance in an unstructured environment. This data is an important component of the functional abilities of the individual.

The activity rating scales listed are based on scales with a range of abilities. For example, the Lysholm scale has four levels to describe the swelling dimension: none (10 points), on



severe exertion (6 points), on ordinary exertion (2 points), and constant (0 points). The range of responses increases the sensitivity of the scale. The implications of swelling on severe exertion are different from swelling that is constant. Properly designed scales may provide qualitative and quantitative data about several aspects of knee function. Activity scales provide useful information regarding the functional status of the individual related to knee problems. The clinician must consider the level or intensity of the activity. Performance of certain functional abilities may suggest no limitations in the capabilities of the knee. However, the activity level may be decreased when compared to premorbid abilities, hiding the knee limitations.<sup>13,22</sup> Comparisons of functional status must be made at comparable levels of activity to be valid.

The appropriate selection of activity scales may be determined by the stage of the rehabilitation program. Risberg and Ekeland<sup>17</sup> reported high functional performance as determined by the Lysholm Score. However, 55% of the ACL patients tested had limitations performing strenuous activities. Data obtained from the Lysholm Scale appears to have limited ability predicting performance of activities such as running, jumping, and twisting. Based on this finding, the authors recommend the use of the Lysholm Score in the early phase of the rehabilitation program. Any scale should be examined for content validity before implementation; ie, it should contain the dimensions you wish to assess.

## Performance Tests

Lower extremity dysfunction may be evaluated using unilateral and/or bilateral performance tests. Contrasts between the involved/uninvolved extremity, pretreatment/posttreatment, or normative data are possible. The following examples are representative of performance tests used in the sports medicine literature to assess knee dysfunction resulting from ACL injury and/or surgery. Summaries are presented and the reader is encouraged to consult the original reports for specific information.

**Single-Leg Hop for Distance.**<sup>2,12</sup> The athlete stands on one limb, hops as far as possible, and lands on the same limb. The distance obtained for each extremity is measured and used for comparison.

**Timed Hop.**<sup>2,12</sup> The athlete stands on one limb and then hops a distance of 6 m. The time is measured for each extremity and used to determine the symmetry index.

**One-Legged Vertical Jump.**<sup>2</sup> The athlete's bilateral standing reach is determined. The athlete performs a vertical jump and lands on the same extremity. The height is measured and recorded.

**Triple Hop for Distance.**<sup>12</sup> The athlete stands on one limb and performs three consecutive hops, landing on the same foot. The distance is measured for each extremity and used to determine the symmetry index.

**Cross-over Hop for Distance.**<sup>12</sup> The athlete hops three times on one limb over a 15-cm-wide center strip. The distance for each extremity is measured and used for comparison.

Bilateral lower extremity performance tests provide baseline data to assess change between test sessions. Normative data

may also be available for contrast. Comparisons between uninvolved and involved limbs may be possible by considering the leg on which the athlete pivots to change direction. The following are some examples of bilateral functional measures for the lower extremity.

**Shuttle Run.**<sup>2</sup> The athlete completes two laps running around cones placed 6 m apart with the uninvolved leg on the inside. The test is repeated with the involved leg on the inside. In a variation of this test, the athlete runs, then stops, pivots on the uninvolved limb, and returns to the starting point. The same procedure is followed for the involved lower extremity. For both tests, Barber et al<sup>2</sup> recommends two laps with the time recorded in seconds and comparisons made.

**Running in a Figure Eight.**<sup>17,23</sup> The athlete runs in a figure eight of a predetermined distance. Tegner et al<sup>23</sup> employed a 20-m course, while Risberg and Ekeland<sup>17</sup> used circles with a diameter of 4 m. The time is recorded in seconds.

**Running Up and Down a Staircase.**<sup>23</sup> The athlete runs up and down a staircase one time, one step at a time. The time is recorded in seconds. Risberg and Ekeland<sup>17</sup> reports a variation of this, referred to as the stairs hopple test. This test is modified to be a unilateral test. The athlete hops up and down a staircase on the uninvolved, followed by the involved, lower extremity. The time for both tests is recorded in seconds. The stair hopple test allows comparisons between uninvolved and involved extremities.

All tests listed have minimal equipment needs and space requirements. The equipment required for the tests outlined are a stopwatch, cones, and tape. Space and surface requirements vary with the desired test and outcome. More complex systems interfaced with computers designed to assess functional performance are being used in the clinic and in research. One example is the CYBEX Fastex System (Division of Lumex, Jericho, NY), which enables the clinician to objectively assess a variety of unilateral and bilateral lower extremity parameters, such as reaction time, ground force time, transit speed stabilization time, ground time, and total movement time.

Functional or performance tests provide objective assessment of components of the athlete's ability in a structured, controlled setting. Skills assessed may include running, jumping, and cutting activities. The clinician must consider the stage of rehabilitation, status of the patient, surgical restrictions, and measurement outcome when selecting various tests. Data from the tests may then be used to identify problems or limitations. Patient goals are determined and the plan is designed to address appropriate goals. Data may be used to augment the decision about return to activity. To be valid, performance tests should correspond with the functional demands during rehabilitation through return to activity.

The clinician has the option of unilateral and bilateral lower extremity tests. Generally, the athlete's ability to perform unilateral tests is limited in the early phase of rehabilitation. Risberg and Ekeland<sup>17</sup> examined unilateral and bilateral tests to assess functional demands of patients with ACL-reconstructed knees. The bilateral tests (figure eight and stair running) were correlated with the daily life function and the unilateral tests (triple jump and stair hopple test) correlated with the strength and stability function. The daily life function

represents the early phase of the rehabilitation sequence. The Lysholm score correlated with the bilateral tests supporting the ability of bilateral tests to assess the daily life function.<sup>17</sup>

Tegner et al<sup>23</sup> reported that several bilateral tests (turn-running component of the figure eight, stair running, and slope running) place greater demands on the knee. The authors reported only 35% to 46% of ACL-deficient patients were able to perform normally on these activities when compared to uninjured subjects. No difference was present in the straight-running segment or single-leg hopping. Methodological differences in the performance of the figure eight places different demands on the knee. A lazy figure eight (large diameter circles) does not require cutting as in a less circular pattern, thereby placing less demands on the knee.

The figure eight may be an appropriate assessment tool at different stages of the rehabilitation program. Progression of activities from a lazy figure eight with no cutting may be useful in the early phase of rehabilitation. Performance on a course with less of a circular (tear drop pattern) requires the athlete to quickly pivot and turn. This activity is a common component of many sport skills and is appropriate in the later stages of rehabilitation.

The clinician must be concerned with substitution and compensatory actions during the measurement of clinical parameters. Data obtained when the athlete substitutes may be of limited value in defining functional limitations. Barber reported that ACL-deficient patients compensated during the shuttle run by running at half speed and guarding both lower extremities. The ability to detect functional limitations was diminished because of the compensation.

Unilateral lower extremity tests were highly correlated with strength and stability dimensions described by Risberg and Ekeland.<sup>17</sup> The sensitivity of the four tests used by Noyes et al<sup>12</sup> (single-leg hop for distance, timed hop, triple hop for distance, and crossover hop for distance) was not sufficient to detect specific components dysfunction. However, the tests were able to identify asymmetry between involved and uninjured lower extremities. Unilateral test data serves to provide confirmatory information, enhancing the clinical picture.<sup>12</sup>

Unilateral leg tests provide the opportunity to compare the uninjured and injured limbs. Time or distance data may be compared between uninjured and injured lower extremities. The symmetry index provides a useful guide to determine abnormal limb symmetry.<sup>2,12</sup> To determine the symmetry index, the mean value for the injured extremity is divided by the mean for the uninjured extremity and multiplied by 100. Barber et al<sup>2</sup> reported 91% to 92% of normal subjects tested (the single-leg hop for distance and the one-leg hop for distance) obtained symmetry index scores of 85%. A symmetry index less than 85% may be considered abnormal.<sup>2,12</sup> The ability of performance tests to determine abnormal lower extremity symmetry does not appear to be affected by gender or limb dominance.<sup>2</sup>

Barber et al<sup>2</sup> and Noyes et al<sup>12</sup> reported a higher percentage of abnormal scores when two unilateral tests were combined compared to a single test (60% vs 42% to 50%) when assessing athletes with ACL-deficient knees. Wilk et al<sup>24</sup> reported similar percentages in ACL-reconstructed patients performing three sim-

ilar tests. Noyes et al<sup>12</sup> assessed combinations of four tests (single-leg hop for distance, timed hop, triple hop for distance, and crossover hop for distance) and reported no difference in abnormal scores between the combinations. The clinical implications are that any combination of a minimum of two unilateral tests are necessary to determine lower extremity asymmetry.

Performance tests are performed in a controlled environment with minimal distractions. A limitation of performance tests is that the data do not provide a comprehensive picture of the athlete's overall abilities or limitations. Barber et al<sup>2</sup> reported that over half of ACL-deficient patients had normal scores on the one-leg hop test but reported limitations with sport activities. Athletes with normal performance test results may be at risk for limitations in performing more complex activities in an uncontrolled setting. Data from the clinical exam and activity rating scores should be combined to provide a comprehensive picture of the functional status of the athlete.

Intrarater and/or interrater reliability of data obtained from performance tests is an important consideration for the clinician. Booher et al<sup>4</sup> examined the reliability of three single-leg hop tests (hop for distance, 6-m hop for time, and 30-m agility hop) on 18 healthy subjects. Intraclass correlation coefficients (ICCs) ranged from .77 to .99, suggesting good reliability within this investigation. Oberg et al<sup>15</sup> reported gamma coefficients for interrater reliability ranging from .99 to 1.0 for total knee and hip patients. Shields et al<sup>20</sup> reported intratester reliability coefficients of .79 to .90 and intratester reliability coefficients of .48 to .78 for total hip and knee patients. However, reliability is specific to examiners and patient population. Examiners must adhere to the basic principles of test administration to maximize reliability.

Several sources of error can be controlled, thereby improving reliability of functional outcome performance tests. Appropriate calibration and maintenance of the equipment may serve to minimize measurement error due to mechanical problems. If the measure of interest is error-prone, a decision may be made as to the value of its use.<sup>16</sup> Careful planning, clear operational definitions, and standardization of test procedures can minimize the effect of additional sources of measurement error.<sup>16</sup> For example, appropriate practice/test trials and rest intervals must be established.

Based on research, there are several useful tests to assess components of function in ACL patients. Performance measures may be employed throughout the rehabilitation program based on abilities and goals of the patient. An example of a sequence over a rehabilitation program is as follows: 1) low-level bilateral test such as walking, lazy figure eight, and straight running; 2) unilateral activities such as single-leg hop for distance, timed hop, triple hop for distance, and crossover hop for distance; and 3) sport-specific skills that may include cutting, pivoting, and running at full speed.

The clinician/researcher must obtain a variety of information to accurately identify patient problems and set realistic goals. Data will enable the clinician to progress the athlete safely and efficiently through a rehabilitation program. Various assessment tools are available to the clinician. Careful selection of the appropriate dimensions to measure provides a clear and accurate clinical picture. It is beyond the scope of this paper to discuss all



aspects of the clinical exam. Due to the emphasis on return to function, several components of the clinical exam are discussed in the context of the relationship with functional outcomes.

## THE RELATIONSHIP BETWEEN IMPAIRMENTS AND FUNCTION

The Nagi<sup>11</sup> conceptual scheme for disability would classify symptoms and clinical signs as impairments that contribute to functional limitations. Impairments such as pain, instability, or decreased range of motion and strength may contribute to the inability of the athlete to run, cut, jump, or perform other task-oriented activities. The primary concern of the athlete, coach, and parents is not specific to impairments, but rather "can they play?" Several reports in the literature describe the relationship between impairments and functional parameters.<sup>1,3,7,14,17,18,23,24</sup> The relationship between conventionally assessed impairments and function are briefly discussed below.

### Stability

The relationship between functional abilities and knee joint stability is not clearly defined. Risberg and Ekeland<sup>17</sup> reported that the triple jump and the stair hopple test were correlated to instability determined by knee arthrometer measurements. Other researchers report that data obtained from clinical assessment of knee joint laxity does not reliably predict functional stability.<sup>2,7,14,18,23</sup> Noyes et al<sup>14</sup> suggests that the forces placed on the knee during a clinical exam are less than forces acting on the knee during activity. The data obtained from the clinical exam may not represent in vivo stability, thereby limiting validity of the measure to infer functional stability. Several researchers have supported this hypothesis.

Harter et al<sup>7</sup> examined ACL-reconstructed patients and concluded that patients' postoperative perceptions of function were not strongly correlated with elements of the clinical exam (instrumented measurement of ligamentous laxity, knee joint position sense, orthopedic clinical exam, isokinetic muscle testing). Seto et al<sup>18</sup> reported no significant relationship between objective instability and functional activity score in patients with an ACL-reconstructed knee. Barber et al<sup>2</sup> reported no significant relationship between arthrometer measurements and five functional tests (one-legged hop for distance, one-legged timed hop, one-legged vertical jump, shuttle run with pivot, and shuttle run without pivot). Assessment of knee laxity provides information related to the integrity of the ligament. However, clinical laxity tests may be limited in their ability to assess functional stability of the knee. The clinician must limit inferences about function with absence of additional data.

### Isokinetic Testing

Isokinetic dynamometers are frequently employed in the clinical/research setting. The data derived from isokinetic testing provides reliable, objective assessment of a variety of parameters indicative of muscle performance. The relationship between isokinetic test data and functional performance is not

clear. Several researchers report no relationship between isokinetic testing and sport skills.<sup>1,5</sup> Others report correlations between isokinetic data and functional test performance.<sup>2,12,18,24</sup>

Several researchers reported significant relationships between concentric quadriceps peak torque obtained at 60°/s and the single-leg hop test.<sup>2,12</sup> Seto et al<sup>18</sup> reported a significant correlation between quadriceps/hamstring concentric peak torque (obtained at 120°/s and 240°/s) and an activity rating scale in patients with intra-articular ACL reconstructions. Wilk et al<sup>24</sup> reported a significant, positive correlation between concentric peak torque of the quadriceps at test speeds of 180°/s and 300°/s and functional testing. Activity rating scales also correlated with isokinetic measures of quadriceps performance. There did not appear to be a relationship between hamstring peak torque and function.<sup>18,24</sup>

The method of isokinetic data acquisition is an important consideration. Data obtained through reciprocal testing protocols provides appropriate neural input to the lower extremity.<sup>24</sup> Based on the results of this and other studies, measures of quadriceps peak torque obtained through reciprocal testing at test speeds of 180°/s and 300°/s may provide the most valid indicators of functional performance. Measures of acceleration and deceleration may provide additional information.

Additional measures of proprioception<sup>3</sup> and girth<sup>17</sup> have been reported in the literature. Measures of impairments may provide meaningful data about functional status. However, the construct of function is multifaceted and requires assessment across several dimensions to allow valid inferences to be made about functional status.

## DOCUMENTING FUNCTIONAL OUTCOMES

Functional outcome reporting should include information that identifies the tolerance of the individual to the activity, endurance considerations, and the level of desired performance.<sup>21</sup> There are several ways to document functional outcomes related to performance test or specific skill requirements. The following example involving a basketball player returning from ACL reconstruction will illustrate the reporting of functional outcomes at different periods during the rehabilitation process. The functional assessment is presented along with a corresponding goal: a) Single-leg hop for distance: unaffected side 40 inches and affected side 32 inches with pain in the affected knee during landing (symmetry index:  $32/40 \times 100 = 80\%$ ). An example of a 2-week goal could be that the athlete will reach 36 inches (symmetry index: 90%) with the affected extremity while performing the single-leg hop for distance with no pain. b) Figure-eight run: performed an 8-m figure eight with minimal guarding during cutting to the affected side in 10 seconds. An example of a 2-week goal could be that the athlete will perform two consecutive figure eights with no guarding during turning to the affected side in 18 seconds. The basic concepts of documenting functional outcomes and determining appropriate goals may be applied to sport-specific skills. An example of assessment of a basketball layup: limitations and guarding during jumping and landing phase with the involved lower extremity for a single layup. An

## Structure of an Outcome Oriented Clinical Report: An Example of a Program for Post-Op ACL Reconstruction Patients

Strategic program outcomes	Independent ambulation with no deviations in gait on level surfaces and stairs Return to recreational/vocational activities ROM and strength within normal limits
Program-specific data base	Stability (KT-1000, clinical exam) Isokinetic test Performance tests Unilateral +/- bilateral tests as appropriate Sport-specific tests Activity rating scales Functional and sport level
Generic screening data	A/PROM and strength lower extremities—bilateral Gait: Level surfaces and stairs Strength of bilateral upper extremities Skin and soft tissue Pain

example of a 3-week goal could be the athlete will perform 10 consecutive layups with the involved lower extremity with no limitations or guarding. An example of the organizational structure of a functional outcome report for an ACL reconstruction patient is presented in the Table.

## CONCLUSIONS

There does not appear to be a universal measure of function for athletes with lower extremity dysfunction. The clinician should consider choosing tests that assess meaningful, practical, and sustainable functional measures in reliable and practical ways. Functional outcome measures provide the clinician with significant data that contribute pieces of meaningful information to the complex patient puzzle. Functional outcome data, a careful history, thorough physical examination, and consideration of the athlete's goals and expectations are all components of the clinical decision-making process to assure a safe and expedient return to athletic participation.

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# Functional Performance Following an Ice Immersion to the Lower Extremity

Kevin M. Cross, MEd, ATC; Rick W. Wilson, PhD, PT; David H. Perrin, PhD, ATC

**ABSTRACT:** Cryotherapy is a widely accepted component of treatment for acute injuries. It has recently re-entered the later stages of rehabilitation as a contributing modality. Cryotherapy's depressive effects on the body's physiological systems have generated concern among many health care practitioners about its effect on motor activity. This study examined the effects of an ice immersion on three functional performance tests: the shuttle run, the 6-m hop test, and the single-leg vertical jump. Twenty volunteers from Division III soccer and football teams who had not sustained an injury to the lower extremity within the past 6 months were randomly assigned to either an experimental or control group. Subjects in the experimental group performed three trials of each functional performance

test before and after the application of a 20-minute ice immersion (13°C) to the lower leg. Subjects in the comparison group followed the same procedure except that a 20-minute resting period replaced the cold treatment. A mixed design analysis of variance was used to analyze the data. Vertical jump scores decreased in the experimental group ( $41.4 \pm 6.8$  cm to  $39.3 \pm 6.1$  cm) but not in the control group ( $45.2 \pm 5.5$  cm to  $45.7 \pm 5.9$  cm) as a result of the treatment. Shuttle run times decreased in the experimental group ( $6.5 \pm 0.3$  seconds to  $6.7 \pm 0.4$  seconds) but not in the control group ( $6.8 \pm 0.4$  seconds to  $6.8 \pm 0.4$  seconds). Six-meter hop test values were not affected. We suggest that clinicians should carefully consider the immediate effects, potentially, of cold on motor activity.

Since the time of Hippocrates, cold therapy has been documented as beneficial treatment for acute injuries.<sup>22</sup> Due to the depressive effects cold has on many physiological systems, such as the myotatic reflex, nerve conduction velocity, and force production, the practice of applying a cold modality to an injury site before rehabilitative exercises or athletic competition has been questioned.<sup>16,23,24</sup> Much has been written about the effects of cryotherapy on individual physiological systems, such as the nervous system<sup>12,15,16,23-25,35</sup> and the muscular system.<sup>12,16,21,23-26</sup>

Functional performance tests allow the athletic trainer to observe the athlete's performance on physical activities that simulate the muscular and joint stresses encountered during athletic events.<sup>2,10,18-20</sup> Investigators have proposed that many of these tests are reliable indicators of lower extremity function due to their relatively high test-retest intraclass correlations (ICCs) and low standard error of measurements (SEMs).<sup>6,20</sup> These tests may be more useful to the practicing athletic trainer than specific physiological measures because fewer inferences need to be made concerning their effect on performance. In the research setting, recent studies concerning functional bracing have used such testing protocols.<sup>5,11,29</sup> The purpose of this study was to assess the effects of ice immersion to the lower extremity on functional performance.

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Views expressed in this article are those of the authors and do not reflect the official policy of the Department of Defense or other departments of the United States Government.

## METHODS

We used a pretest-posttest design with an untreated control group. Subjects were randomly assigned to one of two conditions: the ice immersion or resting period. Before and immediately following the treatment, subjects performed three functional performance tests: the shuttle run, the 6-m hop test, and the single-leg vertical jump.

To minimize the effects of fatigue and to equalize the diminishing effects of the cold treatment during the testing session, the order that subjects performed the three tests was counterbalanced. Twenty male subjects (age =  $19.3 \pm 1.2$  yr, ht =  $69.0 \pm 2.7$  in, wt =  $168.3 \pm 21.1$  lb) from a Division III college participated in this study. The subjects were volunteers from the college's soccer team and the football team's skill positions. Only those subjects who had not injured either lower extremity within 6 months were permitted to participate in the study. In addition, an informed consent form describing the experimental procedures and potential risks and benefits was read and signed by all of the subjects before participation in the study.

## Procedures

Subjects wore T-shirts, short pants, socks, and tennis shoes. Each rode a stationary bike at a low intensity for 5 minutes as a warm-up and performed one stretch for the quadriceps muscle group, hamstrings muscle group, and the triceps surae. All subjects performed three functional performance tests: shuttle run, 6-m hop, and single-leg vertical jump.

To ensure that the same leg would be used during the single-leg tests, subjects performed three practice trials on each leg for the 6-m hop and single-leg vertical jump. Upon completion of the trials, they were asked to choose the leg that they felt most comfortable with during both tests. The chosen extremity was used for the pretest and posttest trials and received the treatment.

To administer the shuttle run, we placed two strips of tape on the floor 6.1 m apart. Subjects were told to sprint to the line in front of them, touch it with their foot, and sprint back to the starting line twice for a total of 24.4 m.

For the 6-m hop test, two strips of tape were placed on the floor 6 m apart. We asked the subjects to begin on one strip of tape in a crouched position on one foot and hop to the next line as fast as possible on the same foot.

For both the shuttle run and 6-m hop, we asked subjects to begin each trial with one foot on the starting line and to start when they heard the word "go." At this point, we started the stopwatch. Upon completion of the last lap, the trial ended and the clock was stopped. For both tests, before each practice and test trial, we encouraged subjects to complete the test in the minimum amount of time. No encouragement or knowledge of results were given during or after practices or test trials.

The single-leg vertical jump was measured on the Vertec (Sports Imports, Columbus, OH). After we measured subjects' standing reach, we instructed them to begin in a crouched position on one leg under the Vertec's slivers and jump as high as possible off the same leg and knock the slivers backward at the top of their jump. The difference between the height of the subjects' jump and their standing reach was recorded in centimeters as the trial score. Before each trial, we encouraged subjects to give maximal effort and to jump when ready. We gave no encouragement or knowledge of results during or after practice and test trials.

Subjects completed one practice trial and three test trials for each functional performance test during both the pretest and the posttest. They rested 45 seconds between each trial. The three tests required approximately 20 minutes to complete.

Following the pretest session, all subjects reported to the athletic training room and removed the shoe and sock from the foot which they chose to use in the functional performance tests. Those in the control group relaxed in a chair for 20 minutes. Experimental group subjects immersed their leg to the level of the fibular head in a cold whirlpool of 13°C for 20 minutes. We constantly monitored and controlled the water temperature to insure the desired temperature. Additionally, we turned on the whirlpool turbine to negate any possible insulatory effects.

After the 20-minute period, all subjects put their shoes and socks back on and quickly returned to the testing area to perform the posttests. This relocation took approximately 2 minutes. Subjects stretched the triceps surae muscle group three times for 15 seconds using the runner's stretch. The posttest procedures were performed as previously described.

### Statistical Analysis

The average of the three test trials for each functional performance test was used for comparison. A mixed design analysis of variance, with one between subjects' factor (treatment group) and one within subjects' factor (occasion), was used to determine whether an ice immersion would cause significant differences among functional performance scores on the three different functional performance tests. The alpha level was preset at 0.05.

The stability of the measures obtained between trials for each of the functional performance tests was examined using the ICC calculations (formula 2,1) established by Shrout and Fleiss.<sup>33</sup> This method was selected because: 1) each measurement trial was considered a random sample from a larger population of trials, and 2) each measure on each trial was derived from a single value rather than a composite score.<sup>33</sup>

### RESULTS

Mean and standard deviations for the two groups' performances on the three functional performance tests are listed in Table 1. The vertical jump was significantly reduced following cold application [ $F(1,18) = 7.53, p = .01$ ; Fig 1] and the shuttle run times were significantly slower following the cold treatment [ $F(1,18) = 8.17, p = .01$ ; Fig 2]. There were no differences between groups in the hop test [ $F(1,18) = 3.36, p = .08$ ; Fig 3].

The ICC and SEM for each functional performance test are listed in Table 2. The relatively high ICC for each test confirms an acceptable systematic and error variance, which corresponds to the reliability of measures.

### DISCUSSION

Cold's effects on the muscle spindle and the myotatic reflex is of great importance when considering the muscle's physiology. When reductions in intramuscular tissue temperature occur, the neuronal discharge and sensitivity of the muscle spindles are impeded.<sup>12,16,23-26</sup> Additionally, even if stimulation from the muscle spindle activates the reflex arc, the neuronal message for increased muscle excitability may be inhibited due to a significant decrease in the motor end plate's potential.<sup>23</sup>

Mecomber and Herman<sup>25</sup> clinically validated these findings by noting a decrease in the amplitude of action potentials, twitch contraction, and nerve conduction time following maximal tendon taps of precooled Achilles tendons. Consequently, the resultant force development within the muscle and the myotatic reflex's protective mechanism may be negatively influenced.

For more practical application, muscle strength following a cold treatment has also been investigated. Conflicting results regarding the effects of cold on isometric strength have been reported by investigators.<sup>3,4,7,22,27,28</sup> Significant decrements in muscle function have been reported, however, when isokinetic devices, which more accurately quantify muscle performance, are used to assess cryotherapeutic effects on muscle function.<sup>21</sup>

**Table 1. Performance Scores for the Single-Leg Vertical Jump, Shuttle Run, and the 6-m Hop Test (Mean  $\pm$  SD)**

	Experimental		Comparison	
	Pretest	Posttest	Pretest	Posttest
Vertical jump (cm)	41.44 (6.80)	39.33 (6.14)	45.17 (5.45)	45.72 (5.89)
Shuttle run (s)	6.54 (.27)	6.71 (.39)	6.78 (.38)	6.75 (.43)
Hop test (s)	2.07 (.16)	2.17 (.14)	2.11 (.22)	2.11 (.19)



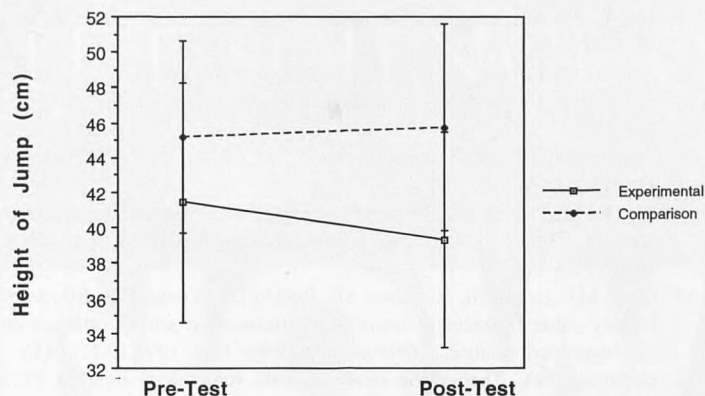


Fig 1. Grouping by occasion interaction for the single-leg vertical jump.

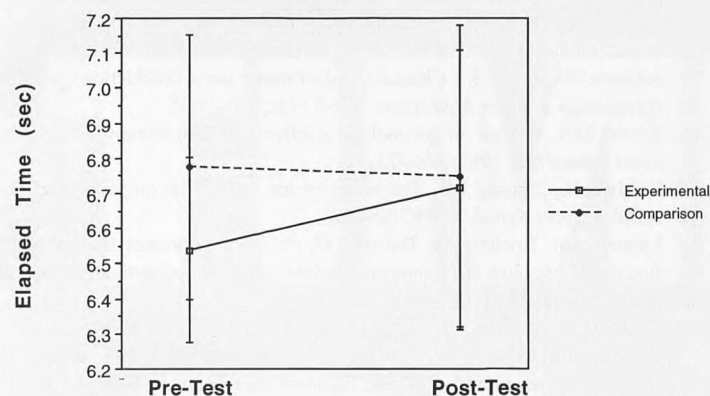


Fig 2. Grouping by occasion interaction for the shuttle run.

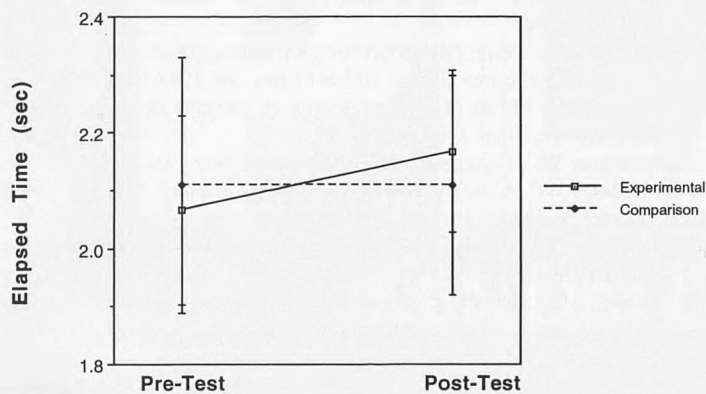


Fig 3. Grouping by occasion interaction for the six-m hop.

Table 2. ICCs and SEMs for the Single-Leg Vertical Jump, Shuttle Run, and the 6-m Hop Test

	ICC	SEM
Vertical jump	0.83	2.15 cm
Shuttle run	0.90	0.10 s
Hop test	0.76	0.09 s

Muscle contraction speed and force-generating capacity<sup>4</sup> are reduced by cold. Davies and Young<sup>8</sup> noted that, when the intramuscular tissue temperature of the triceps surae was reduced 8.4°C by a cold immersion, the time to peak tension and half-relaxation were significantly increased. Also, the tetanic tension at an electrically stimulated frequency of 40 Hz, the maximal voluntary contraction, and the peak and average

power output were significantly reduced. These performance detriments were attributed to a loss of electrically evoked force generation and contractile capacities.<sup>8</sup>

The positive dependence of the velocity of adenosine triphosphate (ATP) splitting on muscle temperature may also be a factor in the decreased maximal muscle activity.<sup>9</sup> Our selection of 45 seconds of rest between trials appeared to permit subjects to sufficiently recuperate. However, due to the negative effects of cold treatments on ATP resynthesis, subjects' energy supply in the treated extremity may not have had adequate time to rebuild.

To determine when an athlete may begin playing after an injury, manufacturers of several examination devices, such as isokinetic equipment, have introduced normative data produced by their devices for reference. These same norms have been used to assess the effects of cold therapy on various physiological mechanisms, such as force production.<sup>21</sup> Unfortunately for the practicing athletic trainer, recent research has questioned if a significant relationship exists between measurements obtained from these devices and an athlete's functional ability.<sup>2,19,20,34</sup> As a result, many functional performance tests have been developed to help determine an athlete's functional ability.

The vertical jump is a time-honored mode of determining an athlete's functional ability.<sup>1</sup> It has been specifically used to assess an athlete's anaerobic power and to screen participants for athletic or other physically demanding activities.<sup>13,32</sup> This test is particularly useful for measuring the triceps surae's power output as this muscle group is a primary power source, second to the hip extensors, for vertical displacement.<sup>31</sup>

In the present study, we wanted to isolate the treated extremity to control for external factors such as overcompensation with the nontreated leg. As a result, we elected to have the subjects perform a single-leg vertical jump instead of the standard double leg. This choice of methodology is supported by Risberg and Ekeland<sup>30</sup> who suggested that two-leg tests are associated with the ability to perform daily functions, whereas single-leg tests are more closely associated with the functional stability encountered during more demanding activities.

Our findings of a decrease in jumping height in the experimental group following the cold treatment was congruent with those of Davies and Young.<sup>8</sup> Many physiological effects had the potential of negatively affecting the experimental group's performance. As previously discussed, impairment of the muscle spindle's ability to invoke the myotatic stretch reflex during the preparatory crouch may have decreased the amount of "recoil" energy which could be elicited.

Also, we observed that, following the cold treatment, subjects in the experimental group often had difficulty maintaining their balance on the treated extremity. Thus, we feel the subjects' support bases were not always stable before their trial jumps. This apparent loss of stability is difficult to explain considering the recent research which denies a significant loss of proprioception following a cold treatment.<sup>14,17</sup> Nevertheless, a variety of factors potentially created an environment unsuitable for maximal power output during this test.

We feel that the 6-m hop test did not permit an accurate analysis of the elapsed time differences between the experi-

mental and comparison groups. No significant decrement in performance was statistically found; however, we believe that this may be due in part to the hop test's low statistical power of 0.411. It is our impression that the primary cause of this low power was the short duration of each trial that averaged 2.11 seconds. Thus, we suggest that 6 m may not be an adequate distance to effectively assess functional performance by the hop test for time.

According to Risberg and Ekeland,<sup>30</sup> the shuttle run is not a very reliable method of assessing functional stability and muscle strength, because it uses both the injured and noninjured (treated and nontreated) extremities. However, we found that, following the treatment, the experimental group finished the trials at a significantly slower time than the comparison group, as did Bergh and Ekblom<sup>4</sup> who reported a positive relationship in their subjects' sprinting performances and muscle temperatures. Again, previous discussions of cold's negative influences on muscle contractility may explain this detriment in performance.

When referring to this study, readers should note the limitations of the subject sample and the treatment application. Subjects were selected from a healthy population of athletes who had not injured either lower extremity within the past 6 months. Obviously, members from this population rarely receive cold treatments before activity. Thus, these findings may not apply to an injured population who receive cold treatments on a daily basis.

Also, immersion of a joint and large muscle group in cold water before vigorous activity may not be deemed applicable to a sports environment; submersion tanks are rarely present along the sidelines of playing facilities. It is common to apply a cold treatment only to a joint and the immediate surrounding area that will not affect the musculature. Future research should attempt to define the effects of a more common cold application on functional performance. Nevertheless, our findings of decreased performance following a lower extremity ice immersion should not be undervalued. Athletic trainers should carefully consider the possible consequences of cold therapy before returning treated athletes to competition.

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# Chronic Brachial Plexopathies and Upper Extremity Proprioception and Strength

C. Buz Swanik, MS, ATC; Tim J. Henry, MS, ATC; Scott M. Lephart, PhD, ATC

**ABSTRACT:** Brachial plexopathies, where traction or compressive forces disrupt motor and sensory nerve conduction, are the most common nerve injuries in collision sports. Athletes frequently do not report these episodes, however, predisposing the brachial plexus to recurrent trauma. The purpose of this study was to identify how multiple injuries to the brachial plexus affects shoulder strength and proprioception. Ten male intercollegiate football players with at least three unilateral episodes of brachial plexopathies were tested an average of 10 weeks after the most recent episode. The uninvolved shoulder was used as the control. Isometric peak torque was assessed for shoulder abduction, external

rotation, and elbow flexion. Proprioception was measured under two conditions: threshold to detection of passive motion and reproduction of passive positioning. Dependent *t* tests revealed significant mean differences ( $p < .05$ ) between the involved and uninvolved extremity for abduction peak torque, overall mean peak torque, and one out of four conditions of threshold to detection of passive motion conditions. This was in the neutral position moving into external rotation. In addition, subjects with greater numbers of episodes exhibited larger strength deficits. The results of this study emphasize the need for timely re-evaluation of athletes with chronic brachial plexopathies.

Brachial plexopathies are injuries to the nerves of the brachial plexus.<sup>19</sup> These lesions occur frequently in collision sports such as football, hockey, and wrestling.<sup>1,19,22,29,30</sup> In collegiate football, studies have shown that approximately 50% of the players report at least one episode per season.<sup>23,26</sup> Many of these athletes (87%) complain of recurring incidents.<sup>26</sup> The competitive nature of athletics and the "play with pain" philosophy may give rise to gross under-reporting of these injuries.<sup>26,30</sup> Athletes often continue to participate without notifying medical personnel of their symptoms.

Symptoms of brachial plexopathies include: transient burning, stinging, and/or muscle weakness throughout the involved upper extremity.<sup>1,10,24,27</sup> Several mechanisms for producing this injury have been suggested. The most prevalent is a force that causes lateral flexion of the cervical spine and concomitant shoulder depression to the contralateral side.<sup>1,10,26,30,31</sup> The interval between the cervical spine and shoulder increases, placing traction on the brachial plexus.<sup>5</sup> Likewise, a blow to the supraclavicular region may cause damage by compressing the underlying nerves. These lesions frequently reside in the upper trunk as identified by electromyography (EMG) studies and clinical evaluations.<sup>10,19,27</sup> The anatomical location of the upper trunk, both superior and superficial, makes it more vulnerable to compression and traction forces.<sup>15,27</sup>

Research has evaluated some of the effects of these lesions on the efferent (motor) pathways. It has been suggested that a chronic syndrome can develop from repeated brachial plexopathies.<sup>22,30</sup> However, the consequences of this syndrome on the neuromuscular system have not been documented. Moreover,

the effects of brachial plexopathies on shoulder proprioception have not been studied.

The purpose of this study was twofold: 1) to investigate the effects of repeated brachial plexopathies on the proprioception pathways in the shoulder, and 2) to assess how multiple injuries to the brachial plexus influences muscular strength. It was hypothesized that proprioception and strength would be deficient in the affected shoulder when compared to the healthy shoulder. Furthermore, subjects with a greater number of episodes would exhibit larger proprioception and strength deficits in their affected shoulders.

## METHODS

This was a retrospective study that used the subject's contralateral healthy limb as an internal control for comparison. A certified athletic trainer identified and evaluated subjects by excluding cervical radiculopathies, neuropathies, and orthopedic injuries. Before participation, all subjects read and signed a medical history questionnaire and consent form approved by the University of Pittsburgh Biomedical Institutional Review Board. The experimental group consisted of 10 male, division I football players (age =  $20.4 \pm 1.5$  years) with unilateral grade 1 brachial plexopathies. Grade 1 injuries or neuropraxias, display symptoms for only a few minutes.<sup>1,5,10</sup> All subjects experienced at least three episodes during the 1994 season with a mean of  $15.3 \pm 13.5$  over the course of their career and were tested ( $\bar{x} = 10.3 \pm 3.2$  weeks) after the most recent episode. The dependent variables assessed were shoulder proprioception and isometric strength. The same examiner conducted random order testing during a single session.

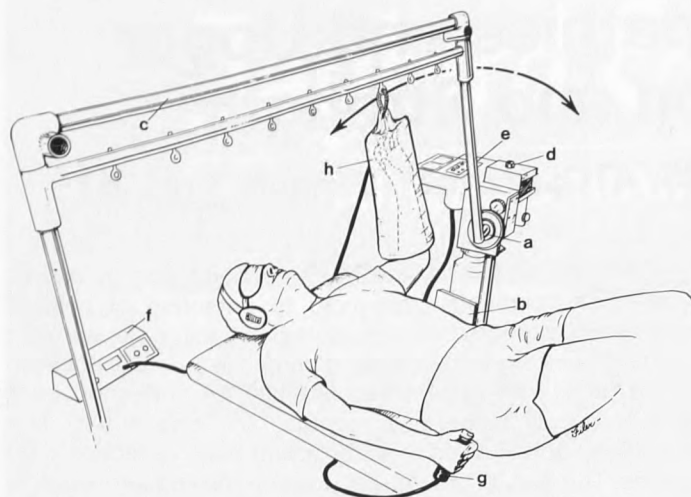
## Proprioception Assessment

Proprioception was measured with a proprioception testing device (Fig 1). Previous studies on the proprioception testing device revealed a test-retest reliability of  $r = .92$ .<sup>18</sup> The subject

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**Fig 1. Proprioception testing device:** a, rotational transducer; b, motor; c, moving adapter; d, control panel; e, digital microprocessor; f, pneumatic compression device; g, handheld on/off switch; and h, pneumatic compression sleeve. (From: Lephart SM, Kocher MS. The role of exercise in the prevention of shoulder disorders. In: Matsen FA, Fu FH, Hawkins RJ. *The Shoulder: A Balance of Mobility and Stability*. Rosemont, IL: American Academy of Orthopaedic Surgeons; 1993:611. Reproduced with permission from the American Academy of Orthopaedic Surgeons.)

was positioned supine with the shoulder abducted and elbow flexed to 90°. The forearm was placed in a pneumatic sleeve, which was attached to the drive shaft on the proprioception testing device. A head set and blindfold were fitted to eliminate auditory and visual cues.<sup>16</sup> Proprioception was measured as the threshold to detection of passive motion and reproduction of passive positioning.<sup>4,16,17,18</sup> Threshold to detection of passive motion is believed to selectively activate the quick-adapting mechanoreceptors responsible for sensation of joint motion or kinesthesia.<sup>4,9,17,18</sup> Reproduction of passive positioning stimulates the slow-adapting mechanoreceptors that mediate joint position sense.<sup>4,9,17,18</sup> The starting position, direction of movement, and shoulder side were randomized.

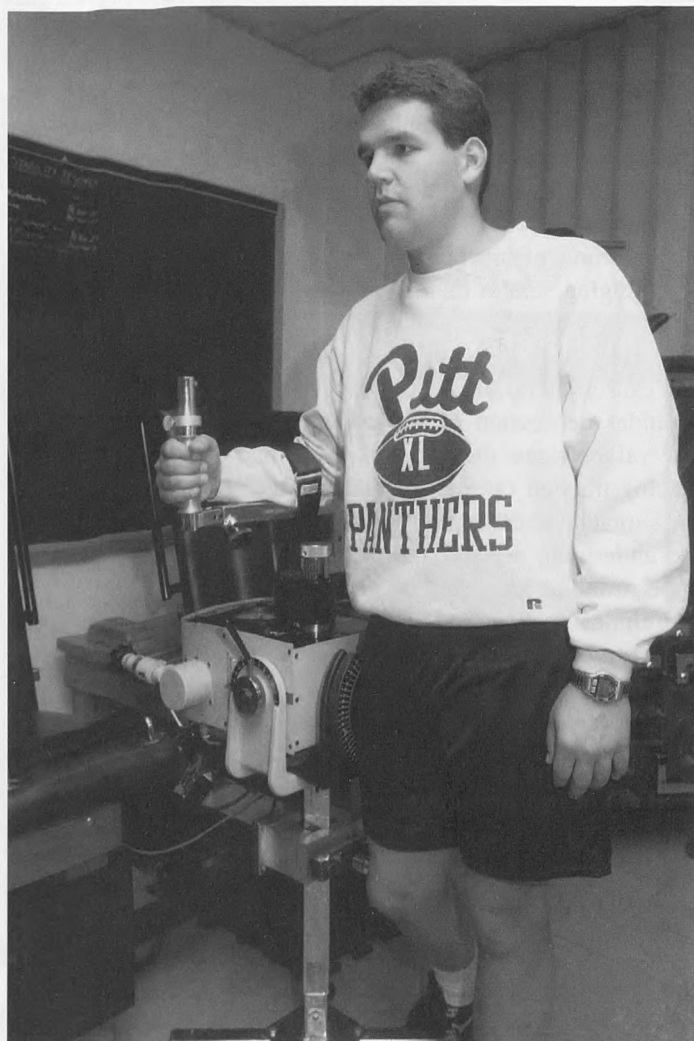
Threshold to detection of passive motion was initiated after three practice attempts. The subject signaled he was ready, and within the next 10 seconds the proprioception testing device passively rotated his arm at a velocity of 0.5°/s. Upon perceiving motion, the subject disengaged the device by pressing a handheld switch and the degree of rotation was recorded. Three trials were performed, moving into both external and internal rotation.<sup>4,16,17</sup>

Reproduction of passive positioning was also tested after three practice attempts. The subject's shoulder was rotated from two reference positions to a randomized angle in both external and internal rotation. The velocity of rotation was varied to nullify time cues. Subjects were allotted 10 seconds to concentrate on the presented angle; the arm was then passively moved back to the reference position. The subject used an on/off switch to passively reproduce the presented angle.<sup>4,16,17</sup> The difference between the presented angle and the reproduced angle was recorded in degrees.

## Strength Assessment

Strength was measured using the Cybex II Isokinetic Dynamometer (Lumex, Inc, Ronkonkoma, NY), which has proven to be reliable and was calibrated before beginning the study.<sup>21</sup> Muscular assessments of isometric peak torque were recorded for shoulder abduction, external rotation, and elbow flexion. Each test position included a warm-up, followed by three isometric trials. All trials consisted of a 3-second maximum voluntary contraction and a 10-second rest between trials, during which the force curves were scrutinized for the sincerity of effort.<sup>7,8,14</sup> The same procedure for each of the three strength conditions was repeated for the opposite upper extremity.

Shoulder external rotation was tested in a standing position. The subject's arm was at his side with 90° of elbow flexion. A hand grip and VELCRO® straps secured the forearm to the dynamometer, while permitting shoulder rotation (Fig 2).<sup>6,7,14</sup> Shoulder abduction was measured in a seated position, with the trunk reclined 40°. The torso was secured by VELCRO straps while the subject grasped an adapter connected the dynamometer. This arrangement restricted motion to shoulder abduction (Fig 3).<sup>7,20,21</sup> Elbow flexion strength was tested with the



**Fig 2. Isometric shoulder external rotation test position on the Cybex II dynamometer.**



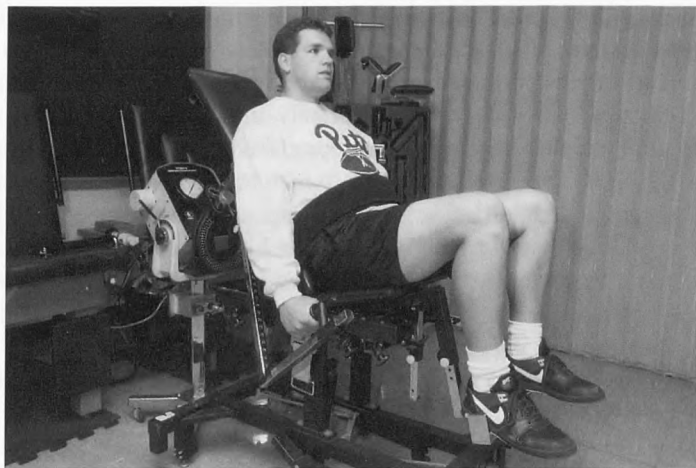


Fig 3. Isometric shoulder abduction test position on the Cybex II dynamometer.

subject lying supine, arm abducted 45° and resting on a pad. The subject's torso was secured with VELCRO straps while he grasped an adapter connected to the dynamometer (Fig 4).<sup>7,13</sup>

## RESULTS

Dependent *t* tests were used to determine the mean differences between the involved and uninvolved shoulders. All values are reported as means and standard errors. Analysis revealed that shoulder abduction strength of the involved shoulders ( $\bar{x} = 87.6 \pm 7.6$  ft/lb) was significantly less ( $p < .05$ ) than the uninvolved shoulders ( $\bar{x} = 101.4 \pm 7.4$  ft/lb). In addition, the mean of the three combined strength scores was significantly less ( $p < .05$ ) for the involved side ( $\bar{x} = 59.1 \pm 4.0$  ft/lb) when compared to the uninvolved limb ( $\bar{x} = 66.3 \pm 3.5$  ft/lb). The mean peak torque values for external rotation and elbow flexion were not significant ( $p < .05$ ; Fig 5).

The involved shoulders also demonstrated a significantly longer ( $p < .05$ ) threshold to detection of passive motion in the neutral position moving into external rotation for the involved arm ( $\bar{x} = 1.9^\circ \pm 0.26^\circ$ ) as opposed to the uninvolved shoulder ( $\bar{x} = 1.45^\circ \pm 0.22^\circ$ ). All other conditions for proprioception were not significant ( $p > .05$ ).

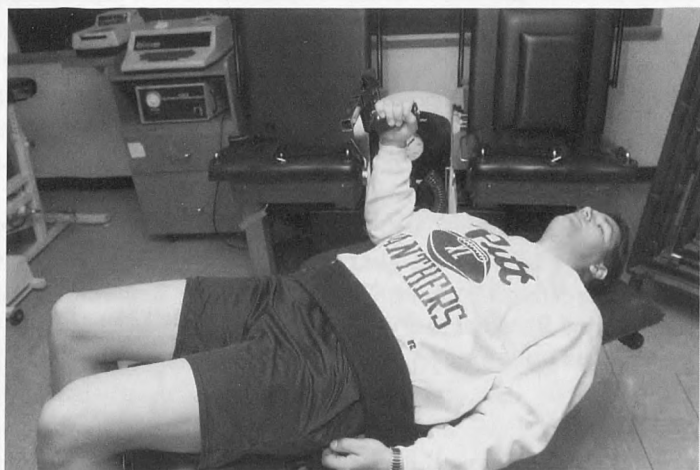


Fig 4. Isometric elbow flexion test position on the Cybex II dynamometer.

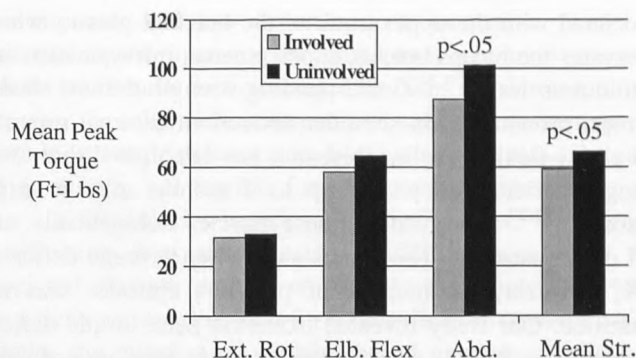


Fig 5. Mean peak torque (ft/lb) of the involved vs uninvolved shoulders for external rotation (Ext Rot), elbow flexion (Elb Flex), abduction (Abd), and mean of the three strength conditions (Mean Str).

Pearson's product moment correlation was used to determine the relationship between the number of episodes and peak torque deficits in the involved and uninvolved upper extremities. There was a strong relationship ( $r = .80$ ,  $p < .003$ ) between the strength deficits of the involved limbs, and the number of career episodes reported (Fig 6). The threshold to detection of passive motion and reproduction of passive positioning conditions were not significant in relation to the number of episodes.

## DISCUSSION

The results of proprioception testing suggest that repeated, grade 1 plexopathies have little effect on threshold to detection of passive motion and reproduction of passive positioning. The mean isometric strength values appear to indicate deficits under all three conditions tested, but only abduction strength reached a significant level. The most remarkable finding in this data was that subjects with increased numbers of brachial plexopathies also demonstrated less isometric peak torque in their involved shoulder. Evidence of this effect until now has been anecdotal.

### Isometric Strength

Complaints of transient muscle weakness are common among athletes with brachial plexus lesions. These deficits are

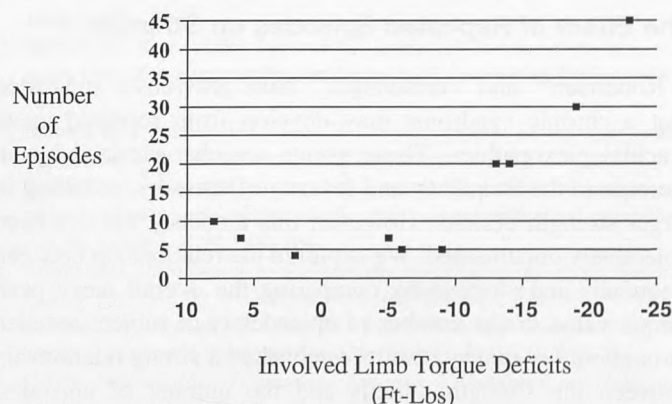


Fig 6. Strong relationship ( $r = .80$ ) between the strength deficits of the involved limbs and the frequency of brachial plexopathies reported by subjects.

associated with the upper trunk of the brachial plexus, which innervates the biceps brachii, supraspinatus, infraspinatus, and deltoid muscles.<sup>17,20,24</sup> Corresponding strength deficits should be most pronounced in shoulder abduction, external rotation, and elbow flexion. In fact, research has established that these strength deficits can persist up to 4 months after a single episode.<sup>10,23,27</sup> Speer<sup>27</sup> tested these muscles isokinetically, at 3 to 5 days postinjury. His results showed an average deficit of 14%; however, the number of previous episodes was not quantified. Our study revealed isometric peak torque deficits for an average of 10.3 weeks postinjury, but corroborated those reported by Speer.<sup>27</sup> The involved upper extremities were 13% weaker for elbow flexion, and abduction peak torques were 14% less than the uninvolved shoulders. These results were expected and concur with Archambault's<sup>1</sup> statement that the deltoid is often the last to recover full strength, although the mechanism is not understood.

There was no apparent strength deficit in external rotation torque values. This discrepancy with previous literature may be due to methodology. Cahalan<sup>6</sup> found that peak torque for external rotation is generated at 90° of abduction, whereas our testing protocol adhered to those suggested by the manufacturer<sup>7</sup> and employed by Murray,<sup>20</sup> who tested external rotation in the neutral position. Moreover, Kuhlman<sup>14</sup> reported the rotator cuff muscles account for only 50% to 75% of external rotation strength; consequently, subjects with strength deficits in their rotator cuff could compensate by recruiting additional muscles. Although individual subjects did present with deficits in external rotation, the procedure used in this study may not have accurately isolated and measured the strength of the supraspinatus and infraspinatus muscles.

Upon reviewing the data, a trend was found within the strength deficits. Each subject appeared to exhibit strength deficits in two of the three conditions. This can be explained by the variability of mechanisms and locations of each injury within and between subjects. For this reason, the three mean peak torque values for each strength condition was averaged and also found to be significantly different ( $p < .05$ ) between the involved and uninvolved shoulders. This value by no means represents cumulative shoulder strength, but rather a general assessment of the three conditions tested in this study.

### The Effect of Repeated Episodes on Strength

Robertson<sup>23</sup> and Vereschagin<sup>30</sup> have previously suggested that a chronic syndrome may develop from repeated acute brachial plexopathies. These events are characterized by an increase in the frequency and severity of episodes, resulting in larger strength deficits. However, this tendency has not been objectively documented. We explored the relationship between frequency and strength by comparing the overall mean peak torque value to the number of episodes each subject recalled throughout his career. Results established a strong relationship between the strength deficits and the number of episodes. Multiple episodes of grade 1 plexopathies may cause scarring of the epineurium and adjacent tissue. Because this scar tissue is less elastic, it is more susceptible to repetitious trauma. For

each injury, the athlete's symptoms are transient, but strength deficits remain between episodes.

The impact of these strength patterns on shoulder stability and coordination are not completely understood.<sup>17</sup> It is believed that these muscles (the posterior rotator cuff, deltoid, and biceps) create force couples, which have an integral role in the dynamic stabilization of the glenohumeral complex.<sup>4,16,17</sup> Lesions to the upper trunk of the brachial plexus may disrupt this mechanism by impairing efferent motor control. This creates a muscle imbalance in the shoulder, increasing the susceptibility to acute and chronic musculoskeletal injuries of the shoulder (Fig 7).<sup>4,16,17</sup>

### Proprioception

Despite the pronounced effect of these lesions on motor neurons, sensory fibers appear relatively unaffected.<sup>10</sup> Athletes typically experience only a few minutes of paresthesia with a grade 1 plexopathy.<sup>10,12</sup> The reason efferent fibers sustain more damage than afferent fibers is not understood. Leffert<sup>15</sup> suggests that large, myelinated afferent fibers can diffuse traction and compression forces more so than smaller efferent fibers. However, proprioception depends on both the afferent and efferent pathways.<sup>9,17</sup> Mechanoreceptors in cutaneous, muscular, and articular structures transduce mechanical deformation of tissue into electrical signals.<sup>5</sup> The brachial plexus transmits this proprioceptive (afferent) information to the central nervous system.<sup>4,9,17</sup> The appropriate response is then transmitted back through the plexus along the efferent (motor) pathway. Deafferentation of the proprioception receptors can disrupt motor coordination and/or joint stabilization.<sup>2,4,9,17</sup> However, studies have demonstrated a strong compensatory mechanism for joint motion and position sense.<sup>2,3,17</sup> We hypothesized that lesions to the brachial plexus would disrupt the afferent-efferent proprioception loop.

Sainburg et al<sup>25</sup> studied patients with proprioceptive deafferentation resulting from sensory neuropathies. They found a

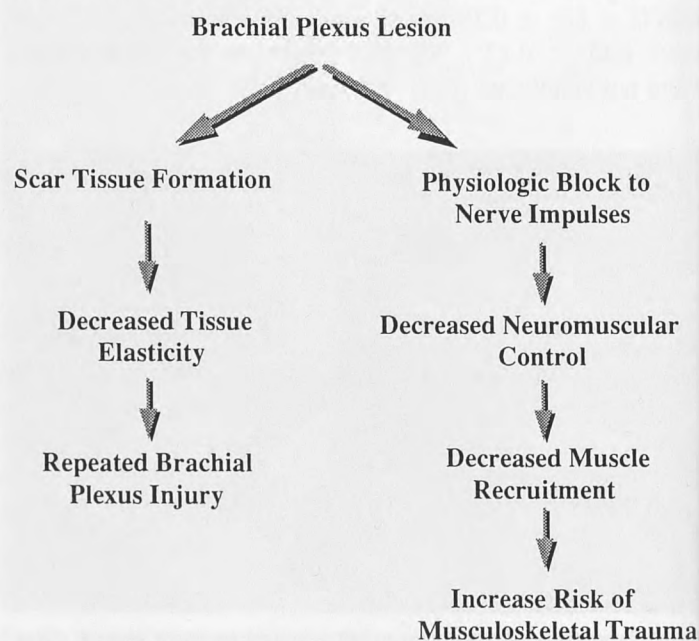


Fig 7. Chronic brachial plexopathy injury paradigm.



large variability in the timing of agonist/antagonist muscle activation, which resulted in the loss of motor coordination and joint position sense. In contrast, our study revealed minimal deficits in proprioception. The transmission of joint motion and position information does not appear to be affected by grade 1 lesions to the upper trunk of the brachial plexus. Although threshold to detection of passive motion in the neutral position with external rotation was significantly less in the involved shoulder, no distinct trends were observed. Several arguments can explain these findings.

It is possible that only the efferent pathway is disrupted, as supported by the strength deficits. However, conduction velocity throughout the proprioception loop remains sufficient to compensate for any loss. Likewise, the quantity of proprioceptive information obstructed by a lesion may be negligible in comparison to the amount transmitted to the central nervous system.

Training has also been shown to enhance proprioception.<sup>2-4,11</sup> Subjects in this study were participating in either rehabilitation, weight training, or full practice sessions and were tested on average 8.6 weeks after the most recent episode. Proprioceptive deficits may be present during the initial phase, but resolve with time and continued activity. Therefore, proprioception testing at 72 hours postinjury may provide more insight on the effect of lesions to the afferent-efferent loop.

### Clinical Implications

Clinical evaluation is crucial for locating and classifying lesions within the brachial plexus. Athletes with lesions to the upper trunk present unilateral, circumferential burning and stinging sensations, which do not correspond to dermatomes.<sup>10,21,29</sup> Complaints of point tenderness in the supraclavicular fossa (Erb's point) are common.<sup>10</sup> However, limitations in cervical strength and range of motion are not present, unlike injuries to the nerve root.<sup>10,19,23</sup> Transient weakness in the upper extremity may be immediate or delayed 72 hours.<sup>1,23,27</sup> Subjects in this study all complained of immediate but transient muscle weakness lasting 3 to 5 minutes. Muscle weakness and abnormal EMGs cannot persist longer than 4 weeks if a lesion is to be classified as grade 1.<sup>19,27</sup> EMG studies and nerve conduction velocity tests are more accurate assessments of brachial plexus lesions, but do not appear abnormal until demyelination occurs approximately 2 weeks postinjury.<sup>27,28</sup> In addition, these tests do not correlate with strength or functional tests that clinicians frequently rely on to determine if an athlete is able to participate.<sup>27,28</sup>

The chronic syndrome develops from repeated episodes and is the responsibility of both the athlete and medical personnel. Subjects in this study reported only 52% of their episodes to athletic trainers or coaches, confirming research by Sallis et al<sup>26</sup> who observed that 50% of these chronic injuries go unreported. This statistic is particularly disturbing considering the persistent deficits in strength. Speer<sup>27</sup> also suggested that athletes participating on the collegiate level sustain more brachial plexopathies than athletes in lower levels of competition. In this study, 63% of these episodes occurred during the athlete's most recent collegiate season. The concentration of

these injuries and low reporting rate can most likely be attributed to the intensity of competition and motivation of athletes to continue participating. Clinicians are also at fault for returning the athletes to competition without considering the delay in strength deficits and EMG abnormalities. Because EMG testing is not feasible for all of these injuries, clinicians must classify injuries based on physical exams. The current classification does not consider multiple episodes or the associated strength deficits revealed in this study. This evidence demonstrates the need for a classification strategy which includes the duration of symptoms and number of episodes. However, without examining athletes between each episode, clinicians cannot differentiate the pathoetiology responsible for strength deficits.

### CONCLUSION

A trend in strength deficits was identified in subjects with repeated episodes of grade 1 brachial plexopathies, but only one was statistically significant. It has been suggested that repeated episodes cause an increase in the frequency and severity of these lesions. Our results support this allegation. Greater strength deficits were observed in subjects with more episodes. Four tests of reproduction of passive positioning were not different between groups; however, threshold to detection of passive motion was significantly different in neutral position moving into external rotation. Three other conditions of threshold to detection of passive motion were within normal limits.

The results of this study stress the importance of timely re-evaluations for athletes with chronic brachial plexopathies. Clinicians should place emphasis on the athlete's previous history, because strength deficits may not appear for 72 hours and EMG analysis is not effective until 2 weeks after a grade 1 brachial plexopathy.<sup>1,10,26</sup> Information from this study can assist in determining the participation status of athletes with chronic episodes. Although athletes do not always report episodes or display functional deficits, continued participation with these lesions predisposes the upper extremity to recurrent brachial plexopathies and/or musculoskeletal trauma.

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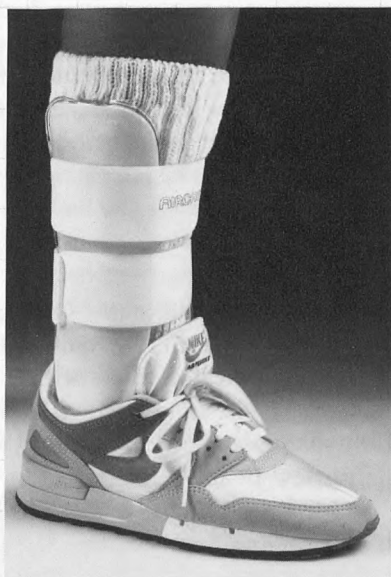


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4. 1985. Pre-inflated Aircell. Makes adjustment unnecessary—but possible. Patent 4,628,945
5. 1985. Duplex Aircell. Graduated compression, enhanced pulsation, edema control. Patent 5,125,400
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# The Effect of Icing with the Pro-Stim Edema Management System on Cutaneous Cooling

William R. Holcomb, PhD, ATC; Brent C. Mangus, EdD, ATC;  
Richard Tandy, PhD

**ABSTRACT:** The simultaneous administration of ice, compression, and electrical stimulation is a technique sometimes used to control the magnitude and duration of edema. The Pro-Stim Edema Management System (TKO, Inc, Alameda, CA) was developed to make this simultaneous treatment both simplistic and more effective. The system is designed to be more effective because the stimulating electrodes are incorporated into the fabric of the ice pack thus providing little insulation to cold. The purpose of our study was to test the effectiveness of icing with Pro-Stim on cutaneous cooling by comparing it to ice bag application with conventional stimulator electrodes. Twelve subjects received the ice portion of the two experimental conditions for 30 minutes. Cutaneous temperatures were monitored at two sites: one under the electrode and one away from

the electrode (centered between the stimulating electrodes). Temperatures were recorded via surface probes interfaced to digital thermometers each minute for 5 minutes before and after icing and during the 30 minutes of ice application. Temperature data were analyzed with three-way factorial analysis of variance with repeated measures. The administration of ice decreased the temperature for all conditions. However, the temperature under the electrode with Pro-Stim was significantly lower during the treatment period than the temperature under the electrode with the conventional system. Thus, Pro-Stim provides more cooling of the entire treatment area. Further research should include an investigation of the effect of the Pro-Stim Edema Management System on cooling while using electrical stimulation.

The simultaneous administration of ice, compression, and cathodal direct current electrical stimulation is a technique sometimes used to control the magnitude and duration of edema.<sup>17,20</sup> Conventional application involves placing electrical stimulator electrodes over the site of edema, placing an ice bag over the electrodes, and securing the bag with an elastic wrap. Pro-Stim Edema Management System (TKO, Inc, Alameda, CA) was developed to make this simultaneous treatment both simplistic and more effective. The Pro-Stim system (Fig 1) consists of an ice pack that is made of a thin porous material on the interface side to allow cold penetration and a thick cloth material on the outside to provide insulation. Electrodes are incorporated into the bag with leads that can be connected to an electrical stimulator. Reusable ice cubes are frozen and added to the pack, which can then be sealed with VELCRO®. The pack containing the ice and electrodes is then placed over the area of edema and secured with a specialized elastic wrap that will adhere to the outer surface of the pack. After treatment, the ice cubes are returned to the freezer for reuse. A variety of pack sizes are available to accommodate the body part being treated.

The Pro-Stim system is more convenient than the conventional system, because the electrodes are a part of the pack and the compression wrap adheres to the pack. In addition, the fluid in the ice cubes is contained and can't escape from the pack during the treatment. We consider the system to be more

effective because the electrodes are incorporated into the fabric of the pack and, therefore, provide little insulation from the cold. Therefore, the entire treatment area, both under and away from the electrodes, should experience more consistent cooling. The purpose of this study was to compare cutaneous cooling with the Pro-Stim Edema Management System to the conventional method of ice and electrical stimulation application.

## METHODS

Twelve college-age students (age =  $21.8 \pm 1.2$  yr, ht =  $66.7 \pm 3.7$  in, wt =  $142 \pm 26.2$  lb) from university athletic training education classes volunteered to participate in the study. We informed subjects of the associated risks and they signed a consent form that met the requirements of the University Institutional Review Board.

Subjects received the ice portion of the Pro-Stim and conventional methods described earlier. We used a within subjects design for testing, and the order of treatments was randomly selected. A minimum of 48 hours and a maximum of 7 days were allowed between treatments. The electrical stimulator electrodes were placed on the thigh of each subject, but stimulation was not used as a part of this study.

Subjects reported to the Sports Injury Research Center where we placed them in a semirecumbent position on a standard exam table. Subjects exposed their right thigh and rested comfortably for 10 minutes to allow the skin temperature to stabilize. Room temperature was maintained at 24°C. We marked the midline of the thigh at 6 cm, 12 cm, and 18 cm above the superior pole of the patella. We then affixed two Physitemp (Physitemp Instruments, Clifton, NJ) skin surface probes (model SST-1), interfaced to two Physitemp digital monitoring thermometers (model TH-8), over the marks 6 cm

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**Fig 1. The Pro-Stim Edema Management System including a 32- x 24-cm pack with six equally spaced 10- x 7.5-cm electrodes with leads, reusable ice cubes, and elastic wrap.**

and 12 cm above the patella. Temperature readings were allowed to stabilize for 5 minutes before treatment.<sup>19</sup> We then applied the ice treatment and recorded the temperature each minute for 30 minutes (Fig 2). After 30 minutes, we removed the ice and made recordings for an additional 5 minutes. We then removed the surface probes and cleaned them with a solution containing Cidex (Surgikos Inc, Arlington, TX) liquid sterilization.<sup>12</sup>

The ice packs were prepared during the 5-minute pretest. The Pro-Stim pack was filled with 1 kg of ice and sealed. The pack was then placed lengthwise on the thigh with one end adjacent to the superior pole of the patella. This placement ensured that one surface temperature probe was under the stimulator electrode, and one surface probe was under the pack and away from the stimulator electrodes. We then secured the pack with the compression wrap.

The conventional method used the standard carbon-rubber electrodes (7.5-cm diameter) provided with an Intellect High Voltage Stimulator (model 150; Chattanooga, Corporation, Chattanooga, TN). Two electrodes were centered over the marks 6 cm and 18 cm above the patella. A plastic bag was

filled with 1 kg of ice and sealed. We placed the bag over the stimulator electrodes and secured it the same way as the Pro-Stim pack. Once again, this arrangement ensured that one surface temperature probe was under the stimulator electrode, and one surface temperature probe was under the ice bag and away from the stimulator electrodes.

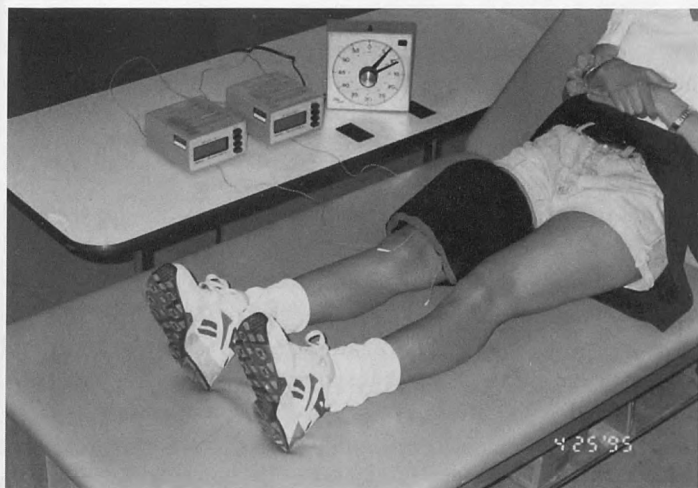
We analyzed the data with a three-way cooling condition (Pro-Stim or conventional) by location (under the electrode or away from the electrode) by time (1-minute intervals) ANOVA with repeated measures. Due to concerns about violating the sphericity assumption, the Huynh-Feldt<sup>6</sup> adjustment to the degrees of freedom for the within-subjects effects and interactions was used. Three separate ANOVAs were performed, one for each of the following time periods: 1) at 1-minute intervals for the 5 minutes immediately preceding ice application; 2) seven measurements at 1, 5, 10, 15, 20, 25, and 30 minutes following ice application; and 3) at 1-minute intervals for the 5 minutes immediately following ice application. A *p* value of .05 or less was accepted as significant.

## RESULTS

Average temperatures before the application of ice, and at the time of the greatest treatment effect, are reported in the Table. Skin temperatures were similar before the experiment for both treatment conditions [ $F(1,44) = 3.19, p = .08$ ] and both locations [ $F(1,44) = 0.94, p = .34$ ]. With the application of ice, the temperatures dropped rapidly and continued to decrease throughout the treatment period. The lowest average temperature was recorded 30 minutes after the application of ice for each condition and location. Temperature readings throughout the treatment for each condition and location are shown in Fig 3. [The temperatures, away from the electrode for both conditions and under the electrode for the Pro-Stim system, each showed a similar decline throughout.] However, the temperature under the electrode with the conventional system showed a lesser decline. Conditions [ $F(1,44) = 19.24, p = .0001$ ] and location [ $F(1,44) = 14.13, p = .0005$ ] were different. There was, however, also a significant condition by location interaction [ $F(1,44) = 17.42, p = .0001$ ]. The temperature away from the electrode was significantly lower than under the electrode with the conventional system [ $F(1,44) = 31.46, p < .05$ ]. The Pro-Stim treatment provided equivalent cooling over time both at and away from the electrode [ $F(1,44) = .08, p > .05$ ].

**Average Temperatures (°C) Prior to Application and at the Time of the Greatest Treatment Effect [Mean (SD)]**

Treatment	Temperature	
	Preapplication	Lowest
Pro-Stim		
Under electrodes	31.7 (1.7)	13.6 (2.8)
Under pack	32.2 (1.7)	14.4 (1.8)
Conventional		
Under electrodes	32.4 (1.2)	19.4 (2.3)
Under pack	32.7 (1.1)	14.2 (3.1)



**Fig 2. Measuring temperature during the application of ice with the Pro-Stim Edema Management System.**

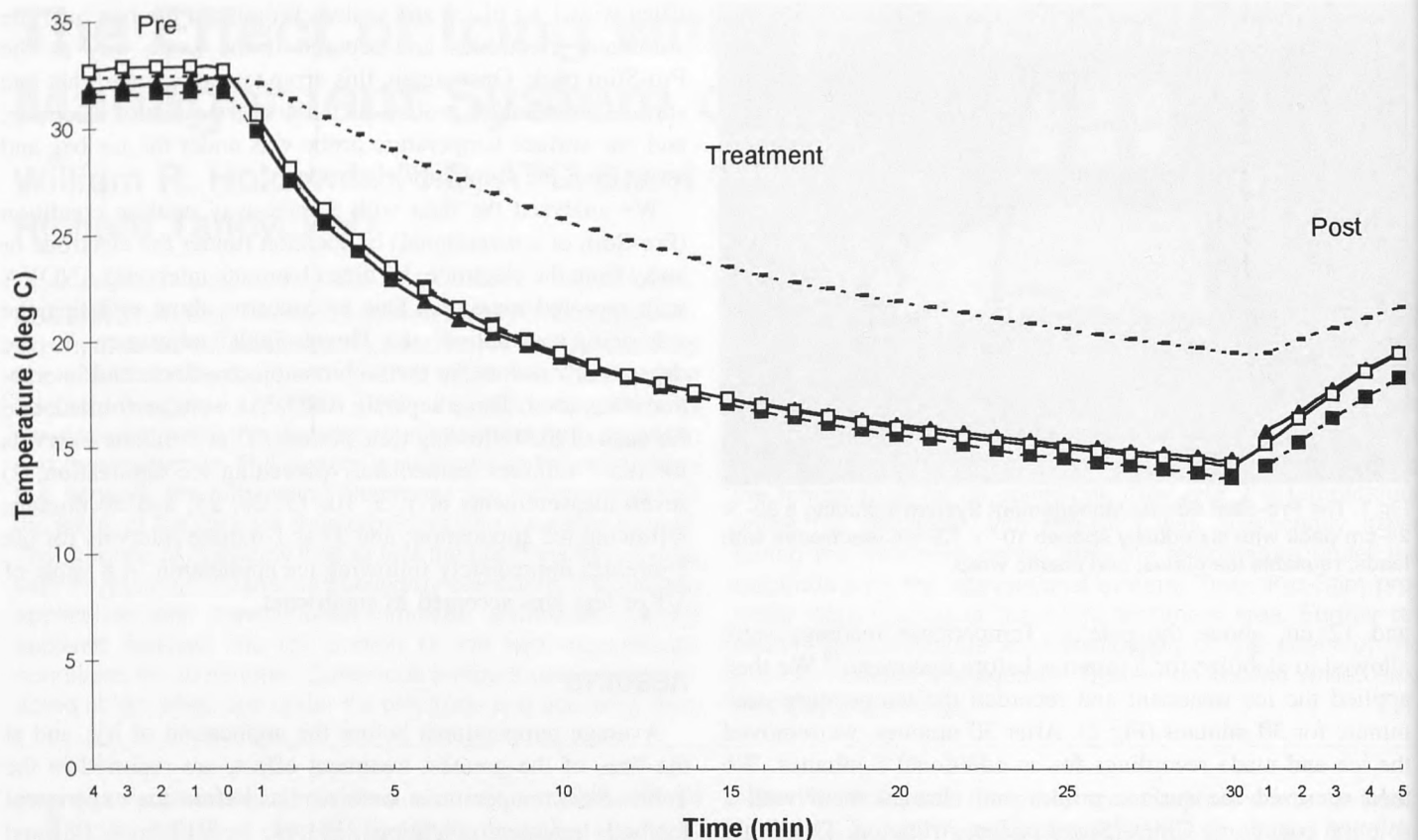


Fig 3. Average skin surface temperatures vs time during five minutes pre- and postapplication and during 30 minutes of ice application. ■, under the electrode with Pro-Stim; ▲, away from the electrode with Pro-Stim; dashed line, under the electrode with the conventional system; □, away from the electrode with the conventional system.

Temperatures recorded following removal of the ice treatments were similar to the ice treatment period [ $F(1,44) = 11.35, p = .002$ ]. There was a difference between the cooling effects of the Pro-Stim and the conventional ice treatment. However, there was also a condition by location interaction [ $F(1,44) = 13.91, p = .0005$ ]. Follow-up tests ( $\mu = .05$ ) indicated no difference in the cooling effect of the Pro-Stim pack and the conventional ice pack away from the electrode [ $F(1,44) = 0.06, p > .05$ ]. However, temperatures were colder under the electrode with the Pro-Stim system than the conventional method [ $F(1,44) = 26.19, p < .05$ ] during all five post-treatment measurements.

## DISCUSSION

The results of this study showed that the Pro-Stim system allows a more thorough cooling than does the conventional system while also permitting compression and electrical stimulation. Each of these treatments is known to have a positive effect on acute injury. Cryotherapy lowers tissue temperature which lowers metabolism and decreases secondary hypoxic injury.<sup>9</sup> Decreasing tissue temperatures will decrease blood flow to the injury by increasing blood viscosity and causing vasoconstriction of the vessels supplying the injured area.<sup>4,14,18</sup> Compression increases external pressure on the tissues, which decreases leakage from the vessels and encourages lymphatic drainage.<sup>3,7,21</sup> Cathodal direct current electrical stimulation is thought to reduce edema by decreasing microvascular perme-

ability to plasma proteins. Therefore, the osmotic gradient usually lost during the inflammatory response is maintained and fluids will not escape into the extracellular tissue.<sup>1,15,20</sup> In addition, blood cells and plasma proteins are negatively charged and will be repelled from the cathode.<sup>15</sup> The movement of these particles away from the site of injury creates a gradient allowing fluid movement.

These edema management techniques have been shown effective in a number of animal models and in some studies with human subjects. McMaster and Liddle<sup>8</sup> found that ice significantly reduced edema in rabbit forelimbs subjected to a crushing injury. Hocutt et al<sup>5</sup> used cryotherapy to speed the rate of recovery from ankle sprains where edema reduction is beneficial. Ice combined with compression has been found to significantly reduce artificially induced edema in humans,<sup>16</sup> and ice in combination with direct current stimulation has significantly reduced edema in acute lateral ankle sprains.<sup>13</sup> Edema reduction via electrical stimulation has also been tested in animal models. The most common protocol used cathodal monophasic stimulation with a frequency of 80 to 120 pps, an intensity equal to 90% of motor threshold, for 30 minutes. This protocol was found to significantly reduce edema in frogs and rats with both impact and hyperflexion injuries.<sup>1,2,10,11</sup>

We studied the effect of the Pro-Stim system on the ability to lower the surface temperature across the entire treatment area. We believe that a decrease in surface temperature corresponds to a temperature reduction in the subcutaneous tissue being treated. Therefore, we believe the Pro-Stim system



will provide better cooling than ice bags with electrical stimulation electrodes and should be used in the management of acute edema.

## ACKNOWLEDGMENTS

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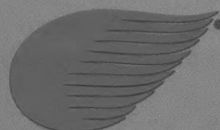
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# Effect of Prophylactic Knee Bracing on Balance and Joint Position Sense

Thomas W. Kaminski, PhD, ATC; David H. Perrin, PhD, ATC

**ABSTRACT:** Prophylactic knee braces are designed to prevent and reduce the severity of ligamentous injuries to the knee. Conflicting evidence is reported concerning their efficacy. The purpose of this study was to determine the effect of prophylactic knee bracing on the proprioceptive parameters of balance and joint position sense. Active and passive joint position sense were assessed using the Cybex II + Isokinetic Dynamometer (Cybex Division of Lumex, Inc, Ronkonkoma, NY). Sway index and center of balance were assessed using the Chattecx Dynamic Balance System (Chattanooga Group, Hixson, TN). Thirty-six male subjects were measured with and without prophylactic knee braces. Joint position sense was measured in degrees of error from four preselected target angles. Sway index and center of

balance measures were recorded in centimeters under the following platform conditions: stable, plantar flexion/dorsiflexion, and inversion/eversion. Separate repeated measures ANOVAs were performed to determine if there were differences between the braced and unbraced conditions for center of balance, sway index, and joint position sense. Center of balance with the platform moving in a dorsi/plantar flexion direction was improved while wearing the knee braces. In addition, differences in both center of balance and sway were recorded across the three platform conditions with and without knee bracing. Bracing did not affect joint position sense. The results of this study suggest that prophylactic knee braces have very little impact on proprioceptive feedback mechanisms.

Knee injuries continue to plague the athletic population, especially in the sport of football. Advances in the treatment and rehabilitation of sport-related knee injuries have hastened recovery time and subsequent return to sport. However, prevention of knee injuries remains elusive despite attempts to limit the frequency of these disabling conditions. Prophylactic knee braces are designed to prevent and help reduce the frequency and severity of knee injuries and are used primarily in football. Despite the inconsistencies regarding their purported effectiveness, many clinicians still advocate their use.

Researchers have conducted several epidemiology studies to determine the effectiveness of prophylactic knee bracing on knee injury prevention. Some reported reduction of knee injuries<sup>1,31</sup>; others reported an increase in knee injuries<sup>20,27</sup>; and still others reported no effect.<sup>9</sup> A number of studies have been focused on the effect of prophylactic knee bracing on performance.<sup>6,10,15,24,26,29</sup> The primary emphasis of these studies has been on the muscle performance parameters of speed, strength, endurance, and agility. Proprioception is a parameter that has recently received considerable attention in sports medicine literature. Several recent reports have assessed the proprioceptive benefits of neoprene sleeves and elastic bandages.<sup>4,22,25</sup> The importance of this neuromuscular mechanism in injury and reinjury pathology is not clearly understood. We found no studies examining the effect of prophylactic knee braces on proprioception.

Proprioception is the ability to acknowledge input from various mechanoreceptors in muscles, tendons, and joints.

Information from mechanoreceptors is then conducted along large-diameter myelinated nerve fibers that have high conduction velocities. It is processed by the central nervous system.<sup>2</sup> The majority of sensory inputs from the joint mechanoreceptors are processed through the dorsal root spinal ganglion, ascend through the posterior spinal cord, and are conducted to the cerebral cortex.<sup>14</sup> The central nervous system ultimately communicates by indicating where the limb is in space. Proprioception can be assessed by measuring kinesthesia (perception of movement) and joint position sensibility (perception of joint position). Traditionally, this has been done in an open kinetic chain using the methods of threshold to detection of passive motion or joint position sense. The knee has served as the primary test limb for most studies.<sup>3,17,22,25</sup> Closed kinetic chain assessment of proprioception can be performed by examining balance control. Somatosensory information from the feet in contact with the support surface is the preferred sensory input for the control of balance in the healthy athlete.<sup>30</sup> Center of balance data can be considered a proprioceptive measurement as assessed in the closed kinetic chain.<sup>19</sup> Normal center of balance can be defined as the point between the feet where the ball and heel of each foot has 25% of the body weight. The purpose of this study was to determine the effect of prophylactic knee bracing on the proprioceptive parameters of balance and joint position sense.

## METHODS

Thirty-six healthy male subjects (age =  $21.7 \pm 5.5$  yr, ht =  $69.9 \pm 2.6$  in, wt =  $166 \pm 19.8$  lb) volunteered to participate in this study. Subjects were injury-free and had no previous exposure to prophylactic knee bracing. Each read and signed a consent form approved by a University Committee for the Protection of Human Subjects. Subjects reported for testing barefooted and wearing running shorts. We tested subjects

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under both the braced and unbraced conditions on the same occasion. The order of testing was randomly assigned according to either joint position sense testing or balance testing. We used a counterbalance scheme to delineate the order of each evaluation within each of the two test sequences. The scheme used for balance testing included consideration for bracing, stance, and platform movement. The joint position sense counterbalance protocol considered the factors of bracing, type of repositioning, and target angle.

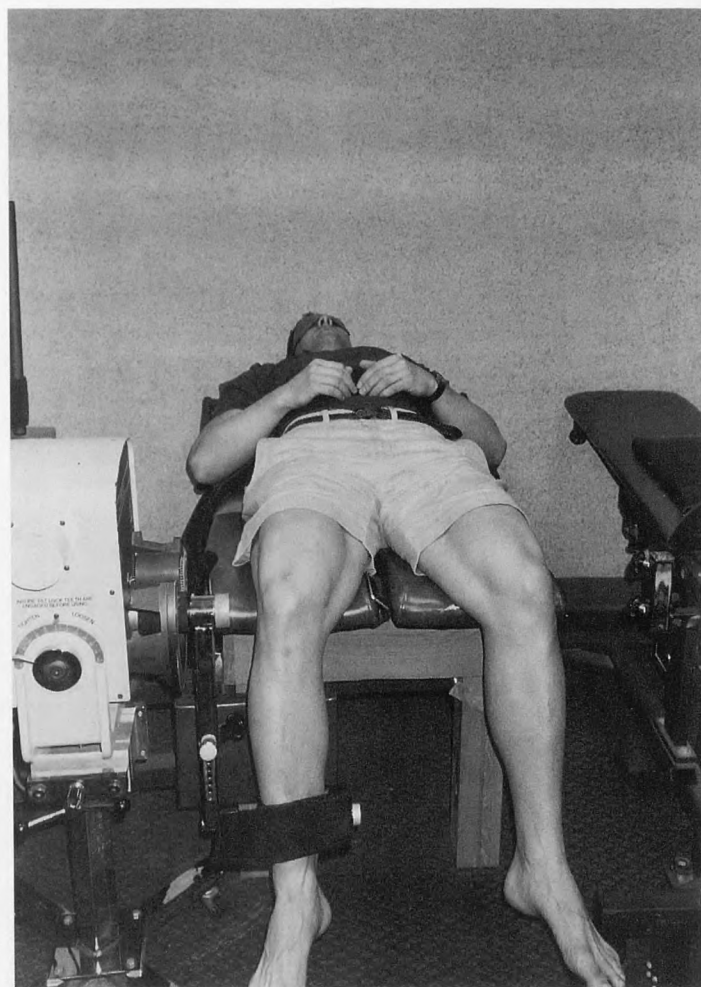
### Bracing

The McDavid Knee Guard (M-202; McDavid Knee Guard Inc, Chicago, IL) was chosen for use in this study. This is a popular, commercially available prophylactic knee brace used by many intercollegiate and interscholastic football programs. The knee brace features a geared polycentric hinge with a reversible hyperextension stop that allows for bilateral fitting. The brace is held in place by neoprene wrap-on cuffs with an extra VELCRO® strap over the calf cuff to prevent slippage. Each brace was fitted and applied according to the manufacturer's guidelines. The brace was worn unilaterally on the dominant leg for single-leg balance assessments and joint position sense evaluations. The brace was worn bilaterally for the braced double-leg balance assessments. Dominance was determined by asking subjects to identify the leg they would use to kick a ball.

### Assessment of Joint Position Sense

The Cybex II + Isokinetic Dynamometer (Cybex Division of Lumex, Inc, Ronkonkoma, NY) was used to assess joint position sense. The reproduction of passive positioning is defined as the ability to reproduce a position in which the joint has been previously placed.<sup>3,13</sup> The Cybex II + has a built-in electrogoniometer that can be conveniently used to assess this parameter of proprioception. The Cybex II + computer monitor allowed for a constant monitoring of joint range of motion in degrees. We positioned the subjects supine on the Cybex II + test table (Fig 1). In this position the hip was at approximately 0° of extension, and the knee joint was flexed at approximately 90°. A stabilizing strap was placed across the subject's chest. The shin pad strap was reversed and positioned behind the calf at a level just above the malleoli. This position helped to minimize any extraneous cutaneous feedback from the lower limb. We blindfolded the subjects to eliminate any visual cues. The velocity of the dynamometer arm remained constant at 12.5°/s. This coincides with the weigh-limb button on the Cybex II + remote digital speed control.

Using a 4 × 4 balanced Latin square, we randomized the order of target angle presentation. This enabled us to insure that, first, every target angle occurred in each of the four presentations and, second, that each angle preceded every condition as many times as it followed that condition. Starting from a position of approximately 90° of knee flexion, we zeroed the Cybex II + goniometer. This was considered the starting point for each of the evaluations. We then passively extended the subject's leg forward to one of



**Fig 1. Subject positioning on the Cybex II + Isokinetic Dynamometer for joint position testing.**

four preselected target angles. The selected target angles were 15°, 25°, 35°, and 75°. These angles were selected to stimulate different joint mechanoreceptors at both the extreme and midpoint of the range of motion. Once the target angle was reached, the limb was maintained at that position for 5 seconds. The subject then returned his limb to the starting position (zero point on the Cybex II + goniometer reading). After a brief pause, we asked the subjects to actively reposition their limb to the previously placed angle. Subjects verbally indicated to the examiner when they felt that they had achieved the repositioned angle, and the joint angle data were extracted from the Cybex II + computer. We determined the error score by taking the difference between the actual and repositioned joint angles. Absolute values of the four joint angle error scores were then summed together. We used the average of these four scores as the error score for each subject.

We also examined passive repositioning, in an attempt to examine differences between active and passive judgments on joint position sense. In this procedure, we passively repositioned the limb in place of active repositioning by the subject. The procedure was identical with active reposition testing in all other respects.



## Assessment of Balance

Each subject was assessed for closed kinetic chain balance using the Chattecx Dynamic Balance System (Chattanooga Group, Hixson, TN). The moderate to strong reliability of this machine has been previously reported.<sup>7,21,23</sup> All balance tests were performed with the eyes open and the subjects barefooted. The subjects were tested under single-leg and double-leg stance conditions. In addition, subjects were tested using three different platform movements: stable (no movement), dynamic plantar flexion/dorsiflexion, and dynamic inversion/eversion. The exact sequence for stance, platform, and brace conditions was randomized and counterbalanced according to a Latin square. This was done in an attempt to eliminate both learning and order effects.

Each balance evaluation included a 20-second practice trial followed immediately by a 20-second test trial. We chose this time sequence to equate to the common subjective Romberg balance test. A brief rest period was allowed during the foot (force) plate change period. All manufacturer's safety guidelines were followed during each test. For the single-leg assessments, subjects stood on their dominant legs with their arms at their side and their opposite knees bent at a 45° angle (Fig 2). They looked straight ahead at an "X" marked on the wall. If a touch down occurred at any time during the test trial,

the entire trial effort was repeated. The same procedure was used for both the braced and unbraced conditions.

Sway index values were calculated for each stance, platform, and brace condition. Sway index is a numerical value in centimeters of the standard deviation of the time and distance the subject spends away from his/her center of balance. This is sometimes referred to as the dispersion index. Center of balance measures were calculated by using the Pythagorean Theorem (distance formula) for the hypotenuse of a triangle. The  $x$  and  $y$  coordinates generated from the device were used in the formula  $\sqrt{x^2 + y^2}$  to determine the corresponding hypotenuse distance. This represents the distance subjects maintained their center of gravity away from their base of support.

## Statistical Analysis

We used the SPSS Release 4.1 Statistical Package to analyze the data. Sway index, center of balance, and joint position sense error scores served as the dependent measures. A two-factor repeated measures ANOVA was used to determine if any differences existed between the braced and unbraced conditions for all three dependent measures. For the measures of sway index and center of balance, the within-subject factors included bracing (braced vs unbraced) and platform movement (stable, plantar flexion/dorsiflexion, and inversion/eversion). Separate analyses were performed for both the single-leg (dominant) and double-leg stances. For the measure of joint position sense error scores, the within-subject factors included bracing (braced vs unbraced) and motion (active vs passive).

## RESULTS

Knee bracing improved center of balance under one dynamic condition during the double-leg stance [ $F(2,70) = 3.88, p = .03$ ; Fig 3]. Tukey post hoc tests revealed that there was a significant difference between the mean values for the dorsi/plantar flexion motion during the braced and unbraced conditions (Table 1). In addition, center of balance was worse in the unbraced group during double-legged stance dorsi/plantar flexion movement than during inversion/eversion movement. Knee

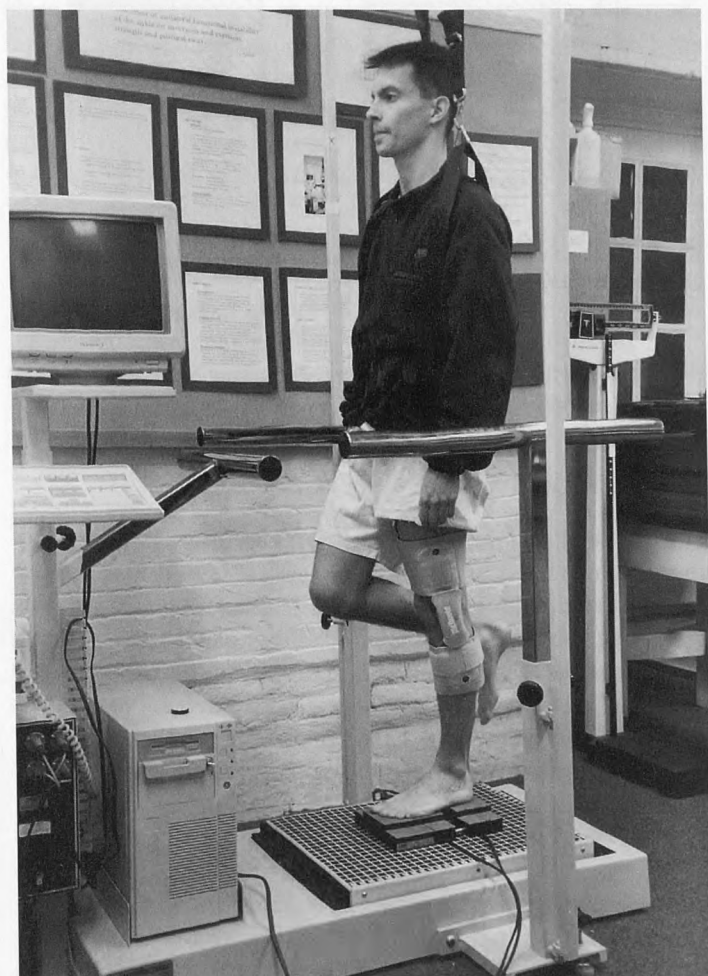


Fig 2. Subject positioning on the Chattecx Dynamic Balance System for the single-leg (dominant) stance test.

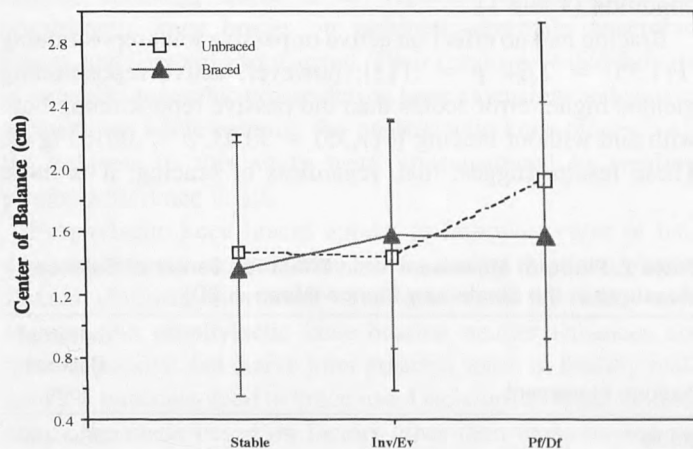


Fig 3. Graph of significant interaction for the center of balance scores in the double-leg stance during stable, inversion/eversion, and plantar flexion/dorsiflexion platform conditions.

**Table 1. Center of Balance (cm) and Sway Index (cm) Between Braced and Unbraced Conditions (Mean  $\pm$  SD)**

Platform Condition	Unbraced (cm)	Braced (cm)
Double-leg center of balance		
Stable	1.47 $\pm$ .74	1.36 $\pm$ .81
Inversion/eversion	1.44 $\pm$ .86	1.59 $\pm$ .73
Dorsi/plantar flexion	1.93 $\pm$ 1.00	1.57 $\pm$ .85
Single-leg center of balance		
Stable	1.30 $\pm$ .73	1.26 $\pm$ .67
Inversion/eversion	.96 $\pm$ .66	1.14 $\pm$ .86
Dorsi/plantar flexion	1.05 $\pm$ .71	1.17 $\pm$ .74
Double-leg sway index		
Stable	.32 $\pm$ .16	.34 $\pm$ .18
Inversion/eversion	1.19 $\pm$ .49	1.14 $\pm$ .37
Dorsi/plantar flexion	1.10 $\pm$ .38	1.09 $\pm$ .48
Single-leg sway index		
Stable	.69 $\pm$ .21	.70 $\pm$ .23
Inversion/eversion	.87 $\pm$ .18	.83 $\pm$ .20
Dorsi/plantar flexion	1.14 $\pm$ .28	1.14 $\pm$ .31

bracing had no effect on the other double-leg dynamic or static conditions.

There was no difference in center of balance between the braced and unbraced groups during the single-leg stance while on a stable or dynamic platform [ $F(2,70) = .76, p = .5$ ; Table 1]. There were differences in center of balance, however, between the three platform conditions when both the braced and unbraced groups were combined [ $F(2,70) = 3.19, p = .05$ ; Table 2]. Tukey post hoc tests indicated that the center of balance scores during the stable platform condition were significantly higher than those during the inversion/eversion platform movement.

Subjects swayed more while the platform was moving in either the dorsi/plantar flexion direction or inversion/eversion during both the single-leg [ $F(2,70) = 72.38, p < .001$ ; Table 3], and double-leg stances [ $F(2,70) = 121.48, p < .001$ ; Table 3]. There were no differences in sway index, however, between the braced and unbraced groups during either stance condition (Table 1).

Bracing had no effect on active or passive joint repositioning [ $F(1,35) = 2.64, p = .113$ ]; however, active repositioning yielded higher error scores than did passive repositioning both with and without bracing [ $F(1,35) = 30.53, p < .001$ ; Fig 4]. These results suggest that, regardless of bracing, it is more

**Table 2. Platform Movement Main Effect for Center of Balance Measures in the Single-Leg Stance (Mean  $\pm$  SD)**

Platform Movement	Center of Balance (cm)
Stable	1.28 $\pm$ .69
Inversion/eversion	1.05 $\pm$ .77 <sup>a</sup>
Dorsiflexion/plantar flexion	1.11 $\pm$ .72

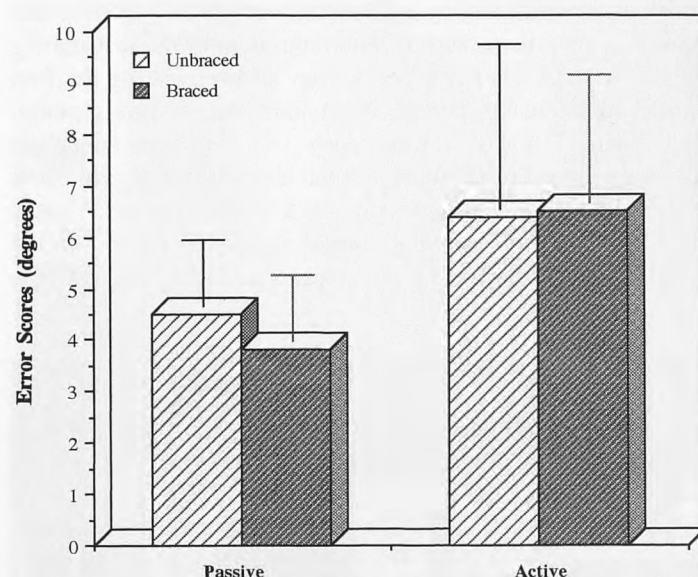
<sup>a</sup> Significantly different from stable platform condition.

**Table 3. Sway Index During Single-Leg and Double-Leg Stance for Three Platform Movement Conditions (Mean  $\pm$  SD)**

Platform Movement	Sway Index (cm)
Single-leg stance	
Stable	.69 $\pm$ .22
Inversion/eversion	.85 $\pm$ .19 <sup>ab</sup>
Dorsiflexion/plantar flexion	1.14 $\pm$ .29 <sup>a</sup>
Double-leg stance	
Stable	.33 $\pm$ .17
Inversion/eversion	1.17 $\pm$ .43 <sup>a</sup>
Dorsiflexion/plantar flexion	1.10 $\pm$ .43 <sup>a</sup>

<sup>a</sup> Significantly different from stable platform condition.

<sup>b</sup> Significantly different from dorsi/plantar flexion platform condition.



**Fig 4. Joint position error scores during passive and active modes of repositioning.**

difficult for subjects to reposition their lower limb actively than when someone assists with that repositioning.

## DISCUSSION

Harrison et al<sup>16</sup> reported no differences in postural sway of the dominant and nondominant legs or between the ACL-reconstructed legs and the opposite unaffected leg during single-leg standing. They concluded that the single-leg standing balance test may only be appropriate for conditions in which balance is greatly affected.<sup>16</sup> As expected, our subjects swayed more when the balance platform was undergoing movement, either in the dorsi/plantar flexion direction or inversion/eversion. This is consistent with the findings of Hertel,<sup>19</sup> who theorized that the platform movement forces a change in the muscles that are used to maintain balance. This change in muscle activation then leads to an increase in postural sway.

We had hypothesized that the braced condition would enhance the ability to reproduce both active and passive joint position sense. However, there was no interaction between the



bracing and motion conditions, which is inconsistent with others who have reported enhancement in kinesthesia via the use of bracing and wrapping. Lephart et al<sup>22</sup> reported that kinesthesia (threshold to detection of passive motion) was improved in post-anterior cruciate ligament reconstructed subjects while wearing neoprene sleeves. They suggested that the sleeves augmented afferent input by providing increased cutaneous stimulation.<sup>22</sup> An elastic bandage around the pathological knee improved the performance of patients when applied to a joint with poor joint position sense (ie, osteoarthritic or soon after joint replacement), but not when applied to their uninjured knee.<sup>4</sup> In a more recent study, Perlau et al<sup>25</sup> reported that knee joint proprioception was improved while wearing an elastic bandage in a group of uninjured subjects. Wrapping and bandaging apparently stimulates the skin during joint motion and increases the pressure on the underlying musculature and joint capsule.<sup>25</sup> Afferent feedback from a number of receptors located in the skin, muscles, ligaments, and joint capsule contribute to the overall proprioceptive mechanism at the knee joint.<sup>2,8</sup> Most of the cutaneous receptors respond to changes in movement and are rapidly adaptive.<sup>14</sup> It is theorized that wraps will provide the most potential for increased proprioceptive feedback during joint motion, and less of a benefit during stable positions.

We believe the differences in our findings may be because the neoprene wraps holding the prophylactic knee braces in place do not completely encircle the knee joint, thus interrupting enhancement in cutaneous stimulation. Most commercially available prophylactic knee braces are held in place by either neoprene or elasticized wraps that are secured to the thigh and calf region of the leg. It seems apparent from our findings that this configuration does not enhance joint position sense. The impact of securing the braces in place by a wrapping or bandage that completely covers the knee joint on kinesthesia is unknown. Further study on the effects of securing knee braces in place by taping or complete neoprene sleeves is warranted. Furthermore, we may attribute the different results in our study to the fact that we used healthy subjects with no history of knee problems. Barrett et al<sup>4</sup> suggested that wearing a bandage improves joint position sense in knees in which proprioception is impaired. Our subjects did not have a history of such joint position deficits.

Our findings suggest that passive knee joint position sense is significantly better (less error) than active knee joint position sense. This is consistent with Gross,<sup>13</sup> who demonstrated that passive judgments were significantly better than active judgments of ankle joint position in control subjects without ankle sprains. Gross<sup>13</sup> hypothesized that muscle receptors are involved more significantly in the perception of joint movement than in the perception of joint position. Muscle receptors are viewed as mechanoreceptors with frequencies of discharge that increase in response to stretch.<sup>11,12</sup> This helps to explain why the error scores for active joint positioning were higher (significantly greater) than the error scores for passive joint positioning in our study. The processing and interpretation of additional input from muscle afferent and efferent structures may have resulted in the increase in error for the active movements, while the reduction of this processing may have

enhanced the passive motions.<sup>13</sup> Bernier<sup>5</sup> recently conducted a study examining the effects of training on joint position sense in subjects with functionally unstable ankles. Our study is consistent with her findings in that all three of her study groups had significantly higher error scores with active repositioning versus passive repositioning. Our results are also consistent with the work of Rymer and D'Almeida,<sup>28</sup> who examined the effects of muscle contraction on joint position sense. They stated that if muscle receptor afferents contribute to joint position sense, then the competing effects of externally versus internally (fusimotor) imposed changes provide a potential source of conflicting information.<sup>28</sup> This, in turn, can lead to errors in perceived limb position.

Previous research has studied the effects of prophylactic knee bracing on functional and muscular performance.<sup>6,10,18,24,26,29</sup> The true effect of these protective devices on performance is still debatable. If one considers closed chain assessment of balance a marker of functional performance, then our results are consistent with those showing no deficits in performance due to prophylactic knee bracing. Hansen<sup>15</sup> showed no deficits in isokinetic muscle performance while wearing prophylactic knee braces. Several early studies using the Arco Brace (the precursor to the McDavid Knee Guard) indicated that this prophylactic knee brace had no effect on running speed and agility (A Johnson, unpublished data, 1969 and TL May, unpublished data, 1981).<sup>18</sup> A similar study by Clover (unpublished data, 1983) showed no decline in running speed while wearing the Anderson Knee Stabler. Our findings conflict with others who have reported significant deficits due to brace wearing. Prentice et al<sup>26</sup> reported that forward running speed was decreased while wearing prophylactic knee braces. This study was conducted on male subjects unaccustomed to knee brace use. Fujiwara et al<sup>10</sup> studied the effect of bracing with regard to previous exposure to brace wear. They found that 40-yard dash times were faster while not wearing the brace. They also found significant differences between experienced and nonexperienced users for 40-yard dash times, backward running times, and square cone agility drills.<sup>10</sup> They suggested that familiarization with bracing may be an important consideration for those wishing to wear prophylactic knee braces. Recently, Borsa et al<sup>6</sup> reported on the effect of prophylactic knee braces on isokinetic strength, anaerobic power, and forward sprint speed. Their results revealed deficits in strength, anaerobic power during knee extension, and slower sprint times while wearing the prophylactic knee braces.<sup>6</sup> All the subjects in this study were unaccustomed to wearing prophylactic knee brace.

Prophylactic knee braces appear to improve center of balance measures in a double-leg stance during the dorsiflexion/plantar flexion platform movement. The results of this study also suggest that prophylactic knee bracing neither enhances nor inhibits passive and active joint position sense in healthy male subjects unaccustomed to brace use. Decisions to brace athletes should be made based on factors other than those having the potential to impact on proprioceptive feedback mechanisms. Future research should focus on the effect of prophylactic knee bracing on other proprioceptive and kinesthetic measures.

## ACKNOWLEDGMENTS

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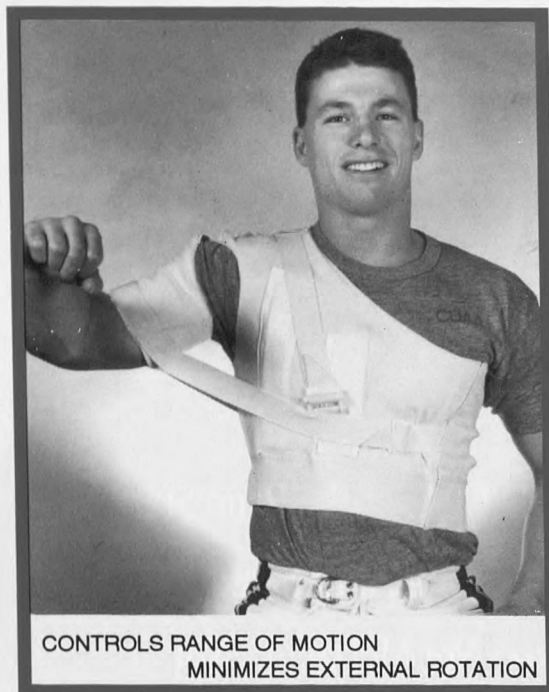


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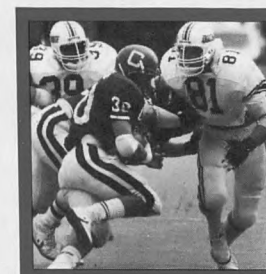
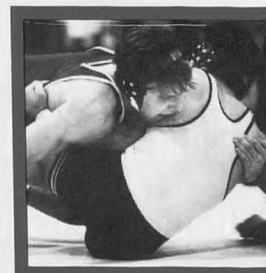
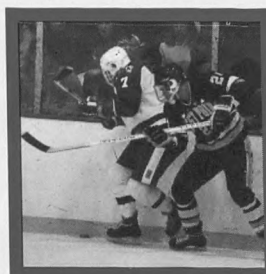
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# The Stretching Window Part Two: Rate of Thermal Decay in Deep Muscle Following 1-MHz Ultrasound

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Shane S. Schulthies, PhD, PT, ATC; Earlene Durrant, EdD, ATC

**ABSTRACT:** Thermal ultrasound can be effective in increasing extensibility of collagen, thus aiding joint mobilization and stretching. In 1995, we reported on the rate of temperature decay following 3-MHz ultrasound in subcutaneous tissues. We repeated that study at 1-MHz frequency to see if the stretching window is different for deep muscle. Twenty subjects had two 23-gauge thermistors inserted 2.5 cm and 5 cm deep into their triceps surae muscle. We administered 1-MHz continuous ultrasound at 1.5 W/cm<sup>2</sup> until the tissue temperature increased 4°C (vigorous heating). Immediately following the treatment, we recorded the rate at which the temperature dropped at 30-second intervals. We ran a stepwise nonlinear regression analysis to predict temperature decay as a function of time

following ultrasound treatment. There was a significant nonlinear relationship between time and temperature decay. At 2.5 cm, the average time for the temperature to drop each degree was: 1°C = 2:34; 2°C = 6:35; 3°C = 12:10; and 4°C = 21:14. At 5 cm, the average time for the temperature to drop each degree was: 1°C = 2:31; 2°C = 6:50; 3°C = 14:32; and 4°C = 27:49. Based upon prior research, thermal decay of 1-MHz ultrasound was slower than 3 MHz, and the deeper tissue cooled at a slower rate than superficial tissue following 1-MHz ultrasound. The data illustrated that the stretching window was open longer for deep-seated structures than for superficial ones.

Many clinicians recommend ultrasound for pain relief,<sup>17,22</sup> wound healing,<sup>8-10</sup> increasing local blood flow,<sup>1,2</sup> increasing tendon extensibility,<sup>3,11,15</sup> and treating other soft tissue injuries.<sup>4</sup> When attempting to increase range of motion, clinicians often heat the tissue with ultrasound in order to increase the compliance of the soft tissues involved. Vigorously heating the tissue will affect the viscoelastic properties of collagen before initiating manual therapy. Studies indicate that simultaneously heating and stretching provides the best results for permanent elongation and that the optimal time to stretch the tissue is at the peak of heating.<sup>11,15</sup> Heating to this level also effectively enables the tissue to avoid damage from the applied load.<sup>19,20</sup> Ultrasound is the ideal method to achieve this higher temperature because it heats the deeper tissues without heating or burning the superficial structures.<sup>14</sup>

During the past two decades, the application of therapeutic ultrasound has increased dramatically. Even though the use of ultrasound is on the rise, there are still misconceptions regarding ultrasound therapy. Perhaps two of the most crucial misconceptions about ultrasound use center around how long it takes to reach an optimal heating zone during ultrasound application and how long after a treatment the tissue retains its heat.

In 1995, we determined that it took 3 to 4 minutes to reach a therapeutic level of heating with 3-MHz ultrasound<sup>6</sup> and 10 minutes to heat tissues using 1-MHz ultrasound.<sup>7</sup> In another 1995 study, we reported rate of temperature decay following 3-MHz ultrasound and labeled this time period the "stretching window."<sup>7</sup> We defined the "stretching window" as the time during which the tissue temperature is ideal to apply stretching and joint mobilization procedures to efficiently increase collagen extensibility. We hypothesized that the stretching window might be different following 1-MHz ultrasound, because this frequency focuses on deeper tissue than the 3-MHz frequency. The deeper tissue should retain heat longer since the overlying structures insulate and serve as a barrier to escaping heat. If this were the case, clinicians would then have more time following ultrasound therapy to perform manual therapy on athletes with deep-seated injuries. Therefore, we studied the rate of temperature decay following 1-MHz ultrasound treatments to determine the "stretching window" for this ultrasound frequency.

## METHODS

Eleven males and 9 females (20 ± 2.1 years) volunteered to participate in the investigation. Each participant signed a consent form after being informed about the possible risks of participation in such a project. We paid each subject a \$20 honorarium for participation. Approval for the study was granted by the University Human Subject's Institutional Review Board.

We used the Omnisound 3000 (Physio Technology Inc, Topeka, KS) ultrasound unit, which operated at a frequency of 1.0 MHz ± 10%. The transducer head contained a lead

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zirconate titanate crystal. The beam nonuniformity ratio of the crystal was 1.8:1, which ensured superior beam uniformity for fast, effective heating with no hot spots. The transducer head was 5 cm in diameter and the effective radiating area was 4.5 cm<sup>2</sup>, which indicates that nearly all of the surface was transmitting the beam. The ultrasound unit was recently calibrated.

To measure temperature changes in the muscle, we used 23-gauge thermistors (Phystek MT-23/5; Physitemp Instruments, Clifton, NJ) coupled to a monitor (BAT-10; Physitemp Instruments) that gave a digital readout of temperature in degrees centigrade. According to the manufacturer, the accuracy of temperature recordings of the probe is within 0.1°C and the monitor is also accurate to within 0.1°C. Our coupling medium was Ultra Phonic ultrasound transmission gel (Pharmaceutical Innovations, Newark, NJ) at room temperature (25°C).

The treatment site was the gastrocnemius and soleus muscles of the left leg. This area was two times the size of the effective radiating area of the transducer head and within the recommended treatment size parameters. To ensure that the treatment size was equal for all subjects, we applied a 9- × 5-cm<sup>2</sup> template to the target area. For this study, we measured the temperature change at both 2.5 cm and 5 cm deep, because this is the heating range of 1-MHz ultrasound and the depth of many deep-seated joints.<sup>13</sup>

Each subject assumed a prone position. We then measured and determined the area of greatest girth on the triceps surae muscle to use as a landmark (Fig 1). We shaved this area, cleansed it with a povidine-iodine (Betadine) scrub, and then swabbed it with 70% isopropyl alcohol. Two 0.5-cc injections of 1% lidocaine (Xylocaine) were given subcutaneously to anesthetize the area. The lidocaine did not contain epinephrine, which might inhibit normal vascular response and obscure the results. We inserted one thermistor into each injection site on the medial aspect of the muscle belly, so that they were 2.5 cm and 5 cm beneath the skin. We connected the thermistors to the monitor and measured the temperature until it stabilized (reached its lowest point with no fluctuations for 3 minutes). We recorded this number as the baseline.



Fig 1. The examiner places a caliper on the skin and marks the two depths for the thermistor insertion (2.5 cm and 5 cm).

The goal of the treatment was to raise the temperature to a vigorous heating range and then to measure the rate of temperature decay. To accomplish this, we administered ultrasound at an average intensity of 1.5 W/cm<sup>2</sup> while moving the soundhead back and forth in the template at a speed of approximately 4 cm/s. We monitored the temperature rise during the treatment and recorded when the temperature had increased 4°C in the more superficial probe. After the treatment was completed, we recorded the rate of temperature decay to the nearest 0.1°C every 30 seconds. We recorded the temperature to the pretreatment baseline and continued to record the temperature until it stabilized. We removed the thermistor and placed it in a sterile solution of Cidex (Johnson & Johnson, Arlington, TX) after each subject had completed the temperature decay. We cleaned the area with 70% isopropyl alcohol and excused the subject.

### Statistical Analysis

Peak temperature of each subject was normalized, or averaged, to the same point so that each temperature decay could be analyzed. Means and standard deviation from the temperature decay, measured every 30 seconds, was computed. We performed a stepwise nonlinear multiple regression on the means to predict temperature decay as a function of time.

### RESULTS

At a depth of 2.5 cm, the mean baseline temperature was 34.7° ± 1.1°C. Following the ultrasound treatment, it increased to 38.7° ± 1.6°C, an average of 4.0° ± 1.1°C above the original baseline. Upon reaching the peak temperature height, the tissue took an average of 21.4 ± 4.8 minutes to return to the baseline (Fig 2).

At the 5-cm depth, the mean baseline temperature was 36.1° ± 0.5°C. Following the ultrasound treatment, the tissue tem-

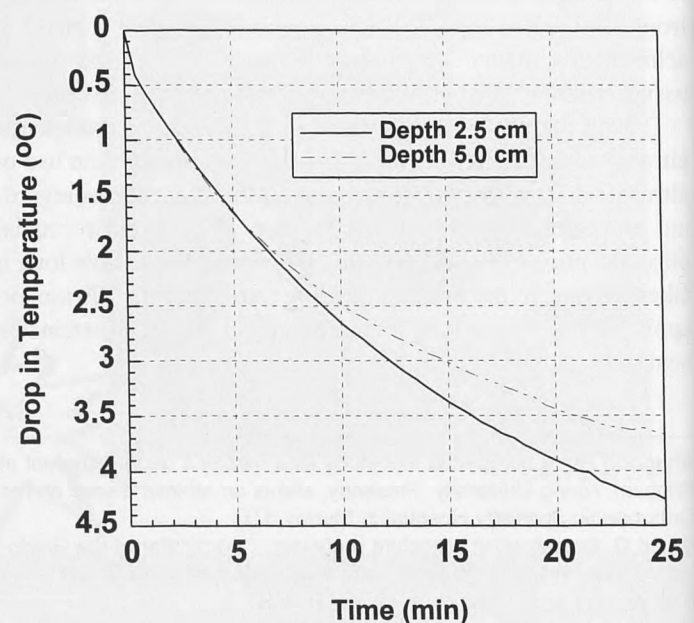


Fig 2. The rate of temperature decay at two depths following 1-MHz ultrasound.



perature increased to  $39.6^{\circ} \pm 1.0^{\circ}\text{C}$ , an average increase of  $3.5^{\circ} \pm 0.8^{\circ}\text{C}$ . Once peak temperature was achieved,  $21.2 \pm 4.6$  minutes were needed for the tissue to return back to its original baseline temperature (Fig 2).

At the 2.5-cm depth, there was a significant relationship between temperature decay and time ( $r^2 = .999$ ,  $\text{SE} = .038$ ), described by the following prediction equation:

$$TD = -0.33362(t) + 0.0102(t^2) - 0.000136589(t^3) - 0.20819,$$

where  $TD$  is temperature decay and  $t$  is time.

At 2.5 cm, the temperature dropped rapidly ( $2^{\circ}\text{C}$  in 6 minutes, 35 seconds) then slowed considerably as it neared the baseline ( $0.5^{\circ}\text{C}$  in the last 5 minutes). The time for the temperature to drop each degree as expressed in minutes and seconds was:  $1^{\circ}\text{C} = 2:34$ ;  $2^{\circ}\text{C} = 6:35$ ;  $3^{\circ}\text{C} = 12:10$ ;  $4^{\circ}\text{C} = 21:14$  (baseline).

At the 5 cm depth, there was also a significant relationship between temperature decay and time ( $r^2 = .997$ ,  $\text{SE} = .046$ ). The prediction equation obtained at this depth was:

$$TD = -0.34396(t) + 0.01383(t^2) - 0.000228247(t^3) - 0.22137,$$

$TD$  = temperature decay and  $t$  = time.

At 5 cm, the temperature also dropped quickly ( $2^{\circ}\text{C}$  in 6 minutes, 50 seconds), then slowed as the temperature reached baseline. The time needed for the temperature to drop each degree as expressed in minutes and seconds was:  $1^{\circ}\text{C} = 2:31$ ;  $2^{\circ}\text{C} = 6:50$ ;  $3^{\circ}\text{C} = 14:32$ ;  $4^{\circ}\text{C} = 27:49$  (beyond baseline).

There was very little difference in the rate of temperature decay for the first  $2^{\circ}\text{C}$  (Fig 2). Then, as time progressed, the deeper tissues (5 cm) cooled more slowly than the more superficial ones (2.5 cm).

## DISCUSSION

It has been suggested that many of the benefits of using ultrasound (increased local blood flow,<sup>1,2</sup> pain relief,<sup>17,22</sup> and increased wound healing)<sup>8-10</sup> are due to heating. There appear to be differing opinions regarding the desired temperature increases needed to enhance extensibility of collagen. Many investigators believe that optimal heating occurs when the tissue temperature rises above  $40^{\circ}\text{C}$ .<sup>9,16</sup> Others are of the opinion that an increase of  $3^{\circ}$  to  $4^{\circ}\text{C}$  above baseline temperature equals optimal heating.<sup>1,6,12</sup> Presently, no research can validate one opinion over another, but it is clear that the more vigorous the heating, the greater the chance is that collagen will elongate.

Neither thermistor depth in our study reached  $40^{\circ}\text{C}$  on an average (2.5 cm =  $38.7^{\circ} \pm 1.6^{\circ}\text{C}$ ; 5 cm =  $39.6^{\circ} \pm 1^{\circ}\text{C}$ ). Perhaps this can be explained by the increase in blood flow created by the thermal effects of ultrasound. The increase in temperature and blood flow engages the body's natural cooling mechanism. Therefore, it may be more difficult to heat muscle tissue as compared to the less vascular tendinous tissue.

We also observed that the baseline temperature of human muscle can vary from  $3^{\circ}$  to  $4^{\circ}\text{C}$  from subject to subject. If an individual's baseline tissue temperature is  $32^{\circ}\text{C}$ , an increase of  $8^{\circ}$  to  $40^{\circ}\text{C}$  is difficult to obtain. Due to these variations in baseline temperature from subject to subject, we believe that optimal heating may occur at less than  $40^{\circ}\text{C}$ .

Abramson et al<sup>1</sup> reported that ultrasound treatments achieving a  $3^{\circ}\text{C}$  increase (from a baseline of  $36^{\circ}\text{C}$  to an increase of  $39^{\circ}\text{C}$ ) produced a marked increase in blood flow to the tissues. Lehmann<sup>12</sup> stated that slightly lower temperature increases of  $1^{\circ}\text{C}$  can reduce mild inflammation and increase metabolism, and that moderate heating (an increase of  $2^{\circ}$  to  $3^{\circ}\text{C}$ ) will decrease pain and muscle spasm. Increasing tissue temperatures higher than  $3^{\circ}$  to  $4^{\circ}\text{C}$  above baseline will increase tissue extensibility, thus enabling the clinician to treat chronic connective tissue problems.<sup>5,12</sup>

Our data provide information on the rate that temperature drops following a 1-MHz ultrasound treatment. Because there was little variation in the rate of temperature decay at the two depths for the first two degrees (critical stretching window), we have taken an average of this rate and displayed it in Fig 3, along with the average heating rates of the two depths. This figure can assist the clinician by illustrating the average rate of temperature decay after 1-MHz ultrasound.

## Heat Then Stretch

An increase in tendon extensibility is more apt to occur when the treatment is used in conjunction with stretching procedures.<sup>3,11,15</sup> This is because collagenous tissue is usually stiff and unyielding, but, once heated, it becomes much more pliable.<sup>11,15</sup> Showing that the same principle applied to muscle as well, Wessling et al<sup>21</sup> found that static stretching following ultrasound increased muscle extensibility by 20% over stretching alone. Therefore, when stress is placed upon heated tissue, greater and more permanent elongation results.

Aside from providing information on the rate of temperature decay after 1-MHz ultrasound, our data also outlined the optimal time to stretch the tissues. Gersten<sup>11</sup> and Lehmann et al<sup>15</sup> have reported that the ultimate time to elongate collage-

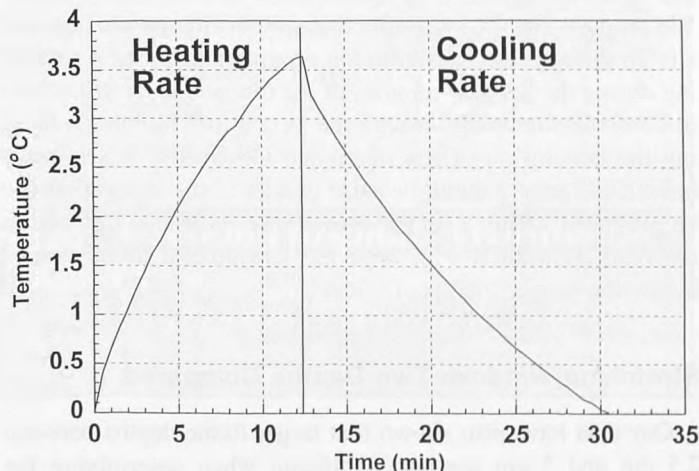


Fig 3. The average rate of temperature increase and decrease for the two depths via 1-MHz ultrasound.

nous tissue is at the peak of heating. With Lehmann's study,<sup>15</sup> this level occurred when the tissue reached a 3° to 4°C increase above baseline temperature. Wessling et al<sup>21</sup> also achieved marked increased in muscle extensibility by performing a 7-minute ultrasound treatment at 1.5 W/cm<sup>2</sup> to an area approximately six times the effective radiating area of the soundhead on the triceps surae muscle. We estimated that Wessling raised the temperature less than 2°C. We based this on our previous study<sup>6</sup> where we raised the temperature 4°C in 10 to 12 minutes at the same intensity, with a treatment size smaller than Wessling's (two effective radiating areas). Therefore, we believe that muscle temperature increases above 3°C, followed by stretching, produce favorable elongation within the tissue.

### Duration of Therapeutic Heat

Just as opinions differ with respect to how warm the tissue must be for optimum stretching, opinions also vary regarding how long the tissue must stay heated. Some report that the temperature must reach and remain between 40° to 45°C for 5 minutes.<sup>9,16</sup> Our data indicated that the temperature drops much faster than this; thus, the stretching window remains open for a short time period. During the ultrasound treatment, at the 2.5-cm depth, the tissue temperature raised  $4.0^\circ \pm 1.1^\circ\text{C}$ . At the conclusion of the treatment, the temperature fell 1°C in only 2 minutes, 34 seconds. At the 5-cm depth, the temperature rose  $3.5^\circ \pm 0.8^\circ\text{C}$ , then decayed 1°C in only 2 minutes, 31 seconds. This demonstrated that the most effective time to encourage range of motion and stretching exercises within rigid tissues is actually less than 3 minutes following ultrasound treatments that raise the temperature  $>3^\circ\text{C}$ . Stretching may be performed at a lower temperature; however, it will not be optimal. Therefore, it is probable that many clinicians perform ineffective heat and stretch therapy.

### Stretch During Heat Application

We theorize that many clinicians wait too long following an ultrasound treatment to begin the stretching process. In the time it takes to remove the coupling agent from the patient and the ultrasound head, the temperature has already begun to drop. We propose that the most effective way to incorporate heat and stretch therapy into rehabilitation programs is to begin stretching during the last few minutes of the ultrasound treatment and to continue stretching through the next 2 to 3 minutes following the conclusion of the treatment. Obviously, this is more beneficial to the patient, because greater tissue elongation can be produced within a longer time frame. This also diminishes the risks associated with applying stress on a tissue cooled below the proper therapeutic level.<sup>19,20</sup>

### Stretching Window: Two Depths Compared

Our data have also shown that target tissue depths between 2.5 cm and 5 cm are not significant when determining the initial rate of temperature decay. Preceding the ultrasound treatment, the deeper tissues recorded a higher baseline tem-

perature than the more superficial tissues ( $36.1^\circ \pm 1.5^\circ\text{C}$  as compared to  $34.7^\circ \pm 1.1^\circ\text{C}$ ). During the treatment, the temperature of the superficial tissues did heat slightly faster than the deeper tissues; however, the time required to drop 1°C was nearly identical at each depth. As time passed, the deeper tissues cooled more slowly than the more superficial ones.

### Stretching Window: 1 MHz and 3 MHz Compared

Perhaps the greatest difference in heating and cooling at various depths occurred between the deeper tissues reported in this study and the more superficial structures commonly treated with 3-MHz ultrasound. In 1995, we published the 3-MHz stretching window.<sup>7</sup> The results indicated that the tissues reached a therapeutic level in a shorter time period and, more critically, decayed significantly faster than our 1-MHz experiments. The temperature with 3 MHz dropped 1°C in 1 minute, 20 seconds compared to our 1°C drop in 2 minutes, 34 seconds using the 1-MHz ultrasound. Therefore, the ideal elongation period was cut nearly in half with the 3-MHz treatment. Clearly then, depth of ultrasound penetration is a crucial factor when determining the time of temperature decay when using a stretching window.

### CLINICAL APPLICATION

Critics of our research pointed to the fact that we only measured rate of thermal increase and decay in muscle. However, Stolov et al<sup>18</sup> have reported that the muscle belly is more extensible than its tendon, with 95% of total elongation occurring within the muscle itself. Therefore, our data are especially beneficial when treating deep muscular conditions of the body, such as piriformis syndrome, chronic hamstring strains, or deep myofascial conditions. With this information, a clinician is better prepared to provide the most beneficial treatment to a patient afflicted with contractures and scar tissue buildup within a muscle. Because this study focuses on the temperature decay characteristics within muscle, further studies may be needed to determine the rate of temperature decay within tendons, joint capsules, and other tissues. This would provide us with a time frame for optimal use of friction massage on these structures.

### ACKNOWLEDGMENTS

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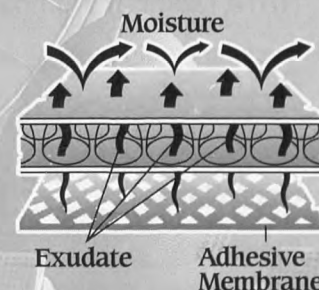
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# Various Treatment Techniques on Signs and Symptoms of Delayed Onset Muscle Soreness

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Michael Sitler, EdD, ATC; Albert Paolone, EdD; John D. Kelly IV, MD

**ABSTRACT:** Eccentric activities are an important component of physical conditioning and everyday activities. Delayed onset muscle soreness (DOMS) can result from strenuous eccentric tasks and can be a limiting factor in motor performance for several days after exercise. An efficacious method of treatment for DOMS would enhance athletic performance and hasten the return to activities of daily living. The purpose of this study was to identify a treatment method which could assist in the recovery of DOMS. In the selection of treatment methods, emphasis was directed toward treatments that could be rendered independently by an individual, therefore making the treatment valuable to an athletic trainer in team settings. DOMS was induced in 70 untrained volunteers via 15 sets of 15 eccentric contractions of the forearm extensor muscles on a Lido isokinetic dynamometer. All subjects performed a pilot exercise bout for a minimum of 9 weeks before data collection to assure that DOMS would be produced. Data were collected on 15 dependent variables: active and passive wrist flexion and extension, forearm girth, limb volume, visual analogue pain

scale, muscle soreness index, isometric strength, concentric and eccentric wrist total work, concentric and eccentric wrist average peak torque, and concentric and eccentric angle of peak torque. Data were collected on six occasions: pre- and post-induced DOMS, 20 minutes after treatment, and 24, 48, and 72 hours after treatment. Subjects were randomly assigned to 1 of 7 groups (6 treatment and 1 control). Treatments included a nonsteroidal anti-inflammatory drug, high velocity concentric muscle contractions on an upper extremity ergometer, ice massage, 10-minute static stretching, topical *Arnica montana* ointment, and sublingual *A. montana* pellets. A 7 × 6 ANOVA with repeated measures on time was performed on the delta values of each of the 15 dependent variables. Significant main effects ( $p < .05$ ) were found for all of the dependent variables on time only. There were no significant differences between treatments. Therefore, we conclude that none of the treatments were effective in abating the signs and symptoms of DOMS. In fact, the NSAID and *A. montana* treatments appeared to impede recovery of muscle function.

Muscle soreness is a common occurrence following unaccustomed physical activity. Muscle soreness has been differentiated into "acute"<sup>27,50</sup> and "delayed onset"<sup>1,3,50</sup> corresponding to the time in which soreness occurs. Delayed onset muscle soreness (DOMS) presents as tenderness to palpation and/or movement<sup>35</sup> and decreases in flexibility and maximal voluntary force production.<sup>5,50</sup> DOMS is believed to result from eccentric muscle activity<sup>5,8,27,43,50</sup> and intense isometric exercise.<sup>11</sup> By impairing function 24 to 48 hours posteccentric muscle activity, DOMS may limit the ability to perform activities of daily living, therapeutic exercise, or sports participation.<sup>24</sup>

No intervention strategies currently exist for preventing DOMS. The only alternative is to treat the signs and symptoms after they occur. Numerous investigators have attempted to identify treatments for DOMS,<sup>7,16,17,24,29–37,55</sup> but none of the studies reviewed addressed all signs and symptoms; the

majority only assessed muscle soreness.<sup>1,29,33,35,37,55</sup> Only eight studies involved the assessment of muscle function.<sup>16,24,29–32,35,36</sup> The purpose of this study was to determine the effect of the nonsteroidal anti-inflammatory drug (NSAID) Daypro (Searle Pharmaceutical, Skokie, IL), high velocity concentric muscle activity, ice massage, static stretching, topical *Arnica montana* ointment (Boiron, Norwood, PA), sublingual *A. montana* pellets (Boiron), and a placebo on the signs and symptoms of DOMS indicated by active and passive range of motion (ROM), forearm girth, limb volume, muscle soreness, and muscle function.

## METHODS

Thirty-five males and 38 females, aged 21 to 40 years, volunteered for this study. Three subjects were lost through attrition. The protocol was approved by the Temple University Institutional Review Board. All subjects gave written informed consent and completed a health questionnaire to screen for high blood pressure, heart disease, diabetes, upper extremity pathology, and medication. We excluded pregnant and nursing women and individuals with a history of liver and kidney dysfunction, peptic ulcer disease, and asthma. All subjects were familiarized with the experimental procedure via one practice session, informed of the possible risks, and instructed to abstain from all vigorous physical activities and from all

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medications 1 week before and during the data collection phase of the study.

## Pilot Study

All volunteers completed a pilot session of 15 sets of 15 repetitions of eccentric wrist extension at a velocity of 30°/s with the nonwriting upper extremity. They rested 1 minute between sets. The exercise was performed on a calibrated Lido isokinetic dynamometer (Loredan Biomedical, West Sacramento, CA) in the eccentric mode. Each subject sat in the manufacturer's recommended position with the shoulder in an anatomically neutral position, the elbow flexed to 90°, and the forearm fully pronated. The subject's limb was passively returned to an extended position after each eccentric contraction to ensure that only eccentric extension was performed. Wrist ROM was limited to 50° flexion and 50° extension. We calculated and recorded total eccentric work. This pilot session was important to confirm the production of muscle soreness. Subjects completed a pain analogue rating 24 and 48 hours postexercise to determine the extent of muscle soreness elicited. If the score on the pain analogue scale was  $\geq 3$  on a scale of 0 to 10, the subject proceeded to the next phase. If soreness was reported to be  $< 3$ , the subject was not permitted to proceed.

## Measurement Procedures

Data collection began a minimum of 9 weeks after the pilot session to minimize or eliminate the "repeated bout effect."<sup>8</sup> Immediately before data collection, all female subjects took a pregnancy test (EPT; Parke-Davis, Morris Plains, NJ). Those who tested positive were not permitted to proceed. The same investigator (DTG) took all measurements throughout the study. Baseline data, identified as "Assessment Time 1," were obtained for all subjects. This included active and passive ROM of the wrist, forearm girth and volume, muscle soreness via a visual analogue pain scale and modified punctate test, and muscle function via isometric force production and isokinetic testing. We obtained two measurements for all variables except the modified Newman punctate test, with the means recorded. The reliability and precision of the measurements were quantified through the calculation of the intraclass correlation (ICC) and standard error of measurement (SEM).<sup>15</sup>

**ROM.** We obtained active and passive wrist ROM via standard goniometry<sup>6,41,46,48,49</sup> with active ROM assessed before passive ROM and extension measured before flexion. All measurements were taken in the seated position with the elbow stabilized in full extension and the forearm pronated. ICC(2,1) = .95 and SEM = .31 for active and passive wrist flexion and extension.

**Edema.** We took forearm circumferential measurements with a Gullick anthropometric measuring tape. This tape measure is equipped with a strain gauge to ensure consistent tension on the tape for reliable measurements. The epicondyles of the humerus were identified with a permanent marker. We placed additional marks on each subject's forearm at 2.5, 5, 7.5, 10, and 12.5 cm distal to each epicondyle. Measurements: ICC(2,1) = .95; SEM = .02 cm.

Upper extremity edema was evaluated with a volumeter (Volumeters Unlimited, Redland, CA), which is an open-water filled plethysmograph. Accuracy of the volumeter has been reported to be within 1% for repeated measures ( $< 25$  mL) with a high correlation ( $r = .97$ ) between volume displacement and circumferential measurements.<sup>45</sup> The subject slowly submerged his/her extremity in the 33°C water bath via a standardized method.<sup>51</sup> The water displaced from the volumeter was carefully collected in a container and measured in a graduated cylinder. Measurements: ICC(2,1) = .95; SEM = 6.27 mL.

**Muscle soreness.** We assessed muscle soreness two ways. The first method was a visual analogue pain scale.<sup>40,47</sup> The visual analogue pain scale consisted of a 10-cm line with descriptors at each end. At the left end there was the number zero with the descriptor *no soreness at all*, and at the right end there was the number ten with the descriptor *soreness as bad as it could be*. The visual analogue pain scale has been used as a valid and reliable measurement for determining the intensity of human pain.<sup>40,47</sup> Only when pain is measured on a ratio scale can a meaningful statement be made about a given percentage of pain reduction.<sup>47</sup> Each subject placed an "x" along a 10-cm line to describe the amount of muscle soreness he/she was presently experiencing with active wrist ROM. The investigator then measured from the no soreness at all end to the "x" (to the nearest 0.1 cm).

The second method of assessing muscle soreness was with a modified Newham punctate technique.<sup>29,43</sup> We invaginated a polyurethane sheet shaped to fit the forearm with 10 punctate sites that spanned the length and width of the wrist extensor musculature. With the elbow flexed to 90°, the forearm pronated, and the wrist placed in the neutral position, we secured the polyurethane sheet to the forearm with VELCRO® straps. The measurement device was a Model 75 force gauge probe manufactured and tested by Technical Products Company (Caldwell, NJ). This device consisted of a blunt 2-mm probe attached to a force gauge with a capacity of 14 lb and a sensitivity range of 4-oz increments. A gradually increasing force was applied to each site. Each subject verbally indicated when the force reached a level of muscle discomfort. We calculated the muscle soreness index by taking the inverse of the amount of force applied to each site and summing the 10 sites. Although an increase in muscle soreness was demonstrated by a decrease in the amount of pressure tolerated by the probe, by inverting the sum of the probe sites, the muscle soreness index would also increase. This inversion of the data eased statistical analysis. The force gauge probe is comparable to weights traceable to the National Bureau of Standards ( $r = .99$ ; ICC(2,1) = .98 and SEM = .03 lb) [unpublished data (1987 to 1991) of Donald C. Meserlian].

## Muscle Function

The MicroFET dynamometer (Hoggin Health Industries, Draper, UT) was used to measure isometric wrist force. The MicroFET dynamometer is a microprocessor-controlled, handheld transducer that measures force in a perpendicular direction. The three strain gauges measure force vectors from three



directions to provide accurate results ( $r > .95$ ).<sup>2</sup> We measured isometric force for wrist extension with the forearm fully pronated and the elbow stabilized at end-range extension. Resistance was applied on the dorsum of the hand via a "break test"<sup>14</sup> and the maximum force generated was measured in pounds. Measurements: ICC(2,1) = .95; SEM = .58 lb.

Using a Lido isokinetic dynamometer in the concentric and eccentric mode at 30°/s, we evaluated isokinetic wrist extension. As per Loredan's recommendations (Personal communication with J Capobianco, September 27, 1993), subjects performed three submaximal repetitions before four maximal contractions with data collected on the second, third, and fourth repetitions. Total work, average peak torque, and angle of peak force generation was obtained for each mode of contraction. The Lido isokinetic dynamometer is both valid and reliable for the torque ( $r = .98$ ) and velocity ( $r = 1.00$ ) studied.<sup>44</sup>

Each subject then repeated the exercise bout described in the pilot session. We calculated and compared total eccentric work with that of the pilot session. Additional work was performed via supplemental set(s) if the total work of the data collection phase was less than that of the pilot session. Immediately following the exercise bout, active and passive wrist ROM, girth, volumetry, soreness assessments, and muscle function measurements were repeated in the identical order of Assessment Time 1. We recorded each series of assessments on a new data sheet to avoid biasing the investigator with previous measurement data. These measurements taken immediately after the exercise session were identified as Assessment Time 2.

## Treatment

We randomly assigned subjects to 1 of 7 groups. To avoid bias they received no information regarding prior research or anticipated treatment effects. Treatment began immediately after Assessment Time 2. The subjects in Group A were given a 1,200-mg dose of the anti-inflammatory medication, oxaprozin (Daypro; Searle Pharmaceutical, Skokie, IL) immediately after the eccentric exercise. A supplemental "loading dose" of 600 mg was taken 12 hours later. Instructions were to take two tablets (600 mg each) every 24 hours for 3 days with precise times written on the tablet containers that the subjects took home. The subjects then rested for 20 minutes.

Subjects in Group B used an upper extremity ergometer at a velocity of 360°/s without resistance for 10 minutes. Verbal feedback assisted subjects in maintaining the desired velocity. Subjects then rested for 10 minutes after this activity.

Group C received an ice massage over the wrist extensors for 20 minutes. During the ice massage the subject was seated, the elbow and wrist in extension, and the forearm pronated. The ice cup was moved in circular motions along the length of the posterior forearm.

Group D executed a static stretch of the wrist extensors in the seated position. The subjects were passively placed in a position of full elbow extension with the wrist pronated and flexed to end range for 10 minutes. The subjects then rested for an additional 10 minutes.

Group E was treated with a homeopathic remedy known as *Arnica montana*. The researcher applied a thin layer (approx-

mately 0.5 g) of 4% topical *A. montana* ointment to the posterior forearm. We instructed subjects to gently smooth a 0.5-g dose of the ointment into the skin every 8 hours, and specific times to apply the ointment were written on the unlabeled *A. montana* tube. The subjects then rested for 20 minutes. Group F was given a sublingual form (6C) of *A. montana*. Subjects took three pellets (50 g each). They received instructions to take three pellets sublingually every 8 hours for the next 3 days with specific times written on the pellet container that they took home. Subjects then rested for 20 minutes.

Group G functioned as the control group and was given a placebo provided by Searle Pharmaceutical. The placebo was identical in appearance to that of the anti-inflammatory tablets (Daypro). Subjects in this group were given two tablets initially and one additional tablet to be taken 12 hours later. Instructions given to the subjects in Group G were identical to that of the subjects in Group A. We reminded all subjects of the potential side effects outlined on the consent form and instructed them to contact the investigator immediately with any problems.

## Follow-Up

We maintained consistency across groups by having each group wait the 20 minutes for reassessment to equate treatment times. All dependent variables were reassessed in the same order with careful adherence to previously stated conditions. This reassessment was identified as Assessment Time 3. Each subject reported back to the clinic at 24 (Assessment Time 4), 48 (Assessment Time 5), and 72 (Assessment Time 6) hours posteccentric activity. The containers of subjects in Groups A, E, F, and G were checked for compliance. When necessary, markings for girth measurements were darkened with the permanent marker for future identification. We reminded subjects to refrain from using any modalities or medications and to minimize their physical activity during data collection.

Data collection concluded when all subjects signed a statement of compliance for the respective intervention. We collected and inspected all containers and weighed and recorded tubes of *A. montana* ointment. Subjects who failed to adhere to the methodology were eliminated from the study and replaced to maintain equal group size of 10 subjects per group.

## Statistical Analysis

ICCs and SEMs were calculated for all dependent variables.<sup>15</sup> Data for each dependent measure were analyzed with  $7 \times 6$  ANOVA with repeated measures over time.<sup>19</sup> Using Newman-Keuls post hoc tests, we determined where significant differences occurred between and within groups ( $p < .05$ ). One-factor ANOVAs were also performed on the differences between Assessment Times 3 and 4, 4 and 5, and 5 and 6 for all dependent variables ( $p < .05$ ).

## RESULTS

All subjects rated their muscle soreness level as 3 or greater (0 to 10 scale) in the pilot study and progressed to the data collection phase. There were no significant differences be-

tween treatment methods for any of the variables assessed. There were significant differences between active wrist flexion ( $F = 10.66, p < .001$ ), passive wrist flexion ( $F = 9.65, p < .001$ ), passive wrist extension ( $F = 13.10, p < .001$ ), muscle soreness index ( $F = 10.89, p < .001$ ), and peak torque angle for concentric ( $F = 3.65, p < .001$ ) and eccentric ( $F = 7.93, p < .001$ ) contractions, indicating that the presence of DOMS impacted these measures. There were no interactions between treatments and assessment times indicating that there were no differences between the effects. In an attempt to analyze all possible differences, one-factor ANOVAs were also performed on the differences between Assessment Times 3 and 4, 4 and 5, and 5 and 6 for all dependent variables ( $p < .05$ ). However, no significant differences were found.

Pearson product moment correlation coefficients for forearm girth and muscle soreness and limb volume and muscle soreness were  $-.98$  and  $-.95$ , respectively. The Pearson product moment correlation coefficients for active wrist flexion and muscle soreness and active wrist extension and muscle soreness were  $-.98$  and  $-.99$ , respectively. In an attempt to simplify the plethora of data, Figures 1 through 4 demonstrate the grand means (ie, general trends) of the treatment groups for the four areas of interest: ROM (Fig 1), edema (Fig 2), muscle soreness (Fig 3), and muscle function (Fig 4).

## DISCUSSION

Because the precise pathology of DOMS is unknown, determining an appropriate course of treatment is difficult. Researchers<sup>7,10,16,17,20,21,24,29-37,39,46,55</sup> have attempted to prevent and treat the various symptoms of DOMS. Based on

previous studies and basic physiology, the six treatment techniques were selected and compared to a placebo (control) to investigate their influence on the symptoms of DOMS.

The method selected for inducing DOMS was deemed successful, because the data for all of the dependent variables differed from Assessment Times 1 to 2. Nine of the 15 dependent variables were significantly different. Once DOMS was induced, none of the treatments significantly influenced ROM, edema, muscle soreness, or muscle function. However, there were many interesting responses to the treatment techniques. The general trends of the dependent variables will be presented first, and the specific responses of each of the treatment groups presented second.

Active wrist flexion and extension followed a similar recovery pattern, but none of the ROM measurements returned to baseline values by Assessment Time 6 (Fig 1). Likewise, the measurements of forearm girth and limb volume data revealed a similar course of recovery after the eccentric muscle activity (Fig 2). The significant increase in girth and volume observed immediately after the exercise was probably a result of increased blood flow to the exercising muscles, a local metabolic response. Increased pressure during the eccentric muscle activity can result in an increased movement of intravascular fluid into the interstitial spaces within the exercised muscle fibers.<sup>7</sup> Neither forearm girth or limb volume significantly increased, however, from Assessment Times 3 to 6. Previous theories<sup>26,27,29</sup> associate the pain of DOMS to the edema within the exercised muscle fibers; however, Buroker and Schwane<sup>7</sup> argued against the hypothesis that pain neurons were physically distorted by edema. They observed that girth measurements of eccentrically exercised limbs did not increase at

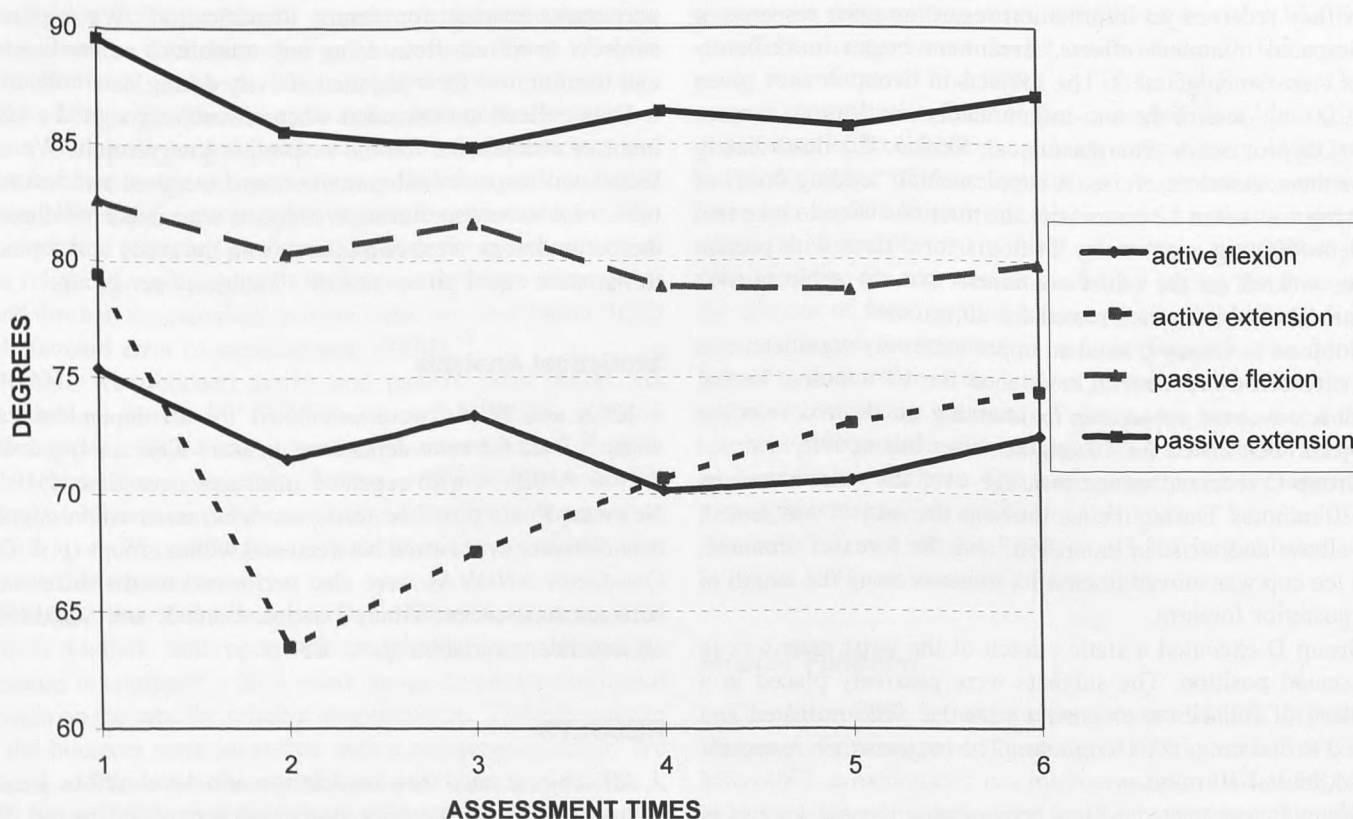


Fig 1. Wrist range of motion grand means.



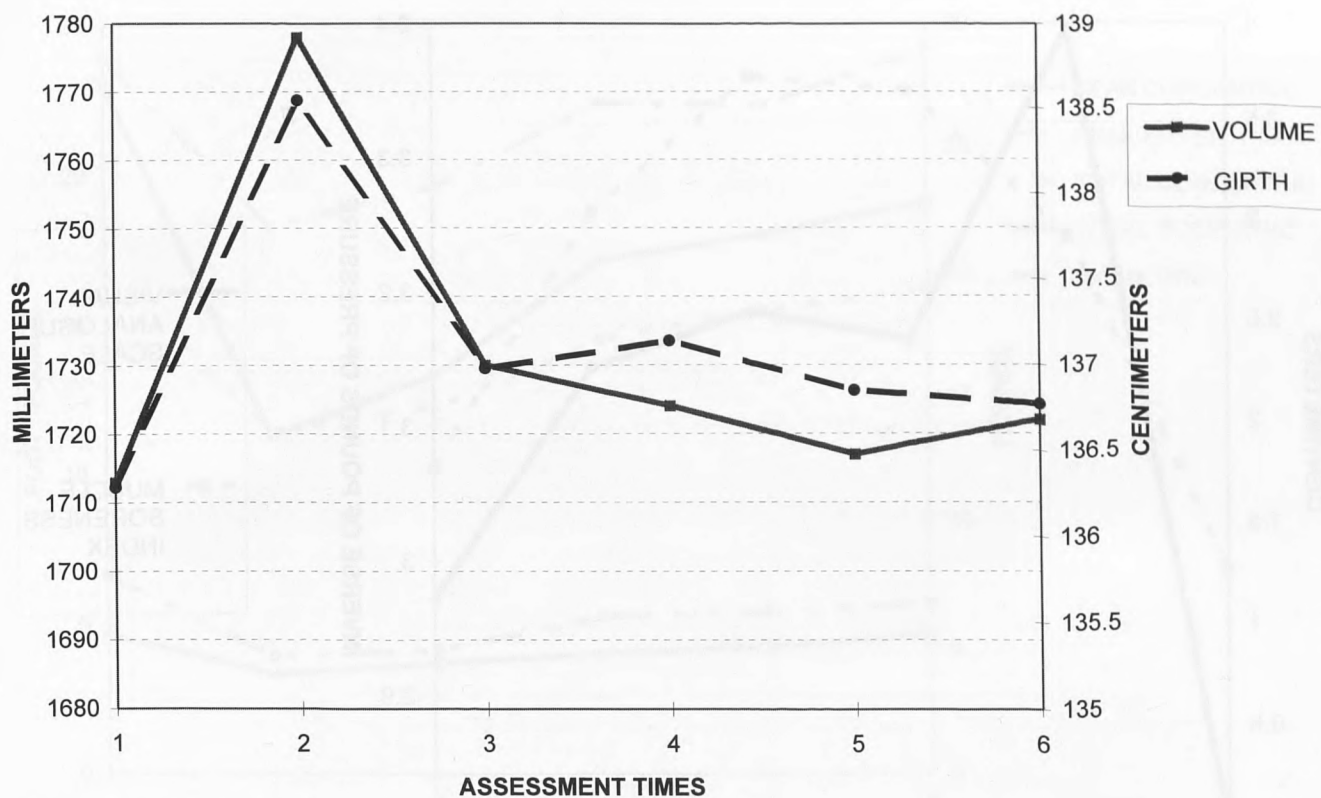


Fig 2. Forearm edema grand means.

any postexercise assessment time. The inverse relationship (ie, negative correlation) of our data supports this conclusion.<sup>7,35</sup>

The visual analogue pain scale data were significantly greater in Assessment Time 2 than Assessment Time 1 and a significant decrease occurred in Assessment Time 3 for all groups (Fig 3). We observed a negative correlation between muscle soreness and active ROM which is consistent with a previous report.<sup>55</sup>

Isometric wrist extension force data for all treatment groups followed a similar recovery pattern toward baseline measurements after DOMS was induced (Fig 4). The decreased force development in all of the groups immediately after the exercise bout (ie, from Assessment Times 1 to 2) was consistent with acute muscle soreness.<sup>24,29,31,32</sup> Force development increased in all groups from Assessment Times 3 to 4 and then was followed by a decrease in force generation from Assessment Times 4 to 6. These results demonstrate a recovery from acute muscle soreness by 24 hours (Assessment Time 4) and the onset of the delayed soreness by 48 hours (Assessment Time 5).

The concentric and eccentric total work and peak torque produced by the wrist extensors decreased significantly for all groups after the eccentric muscle activity. The most notable was the eccentric total work, which fell to less than 54% of the baseline values. The recovery of the concentric and eccentric muscle function appeared to parallel one another with all groups returning to a level of 79% to 90% of baseline by Assessment Time 6. This long recovery time (72 hours) suggests that the repair of the contractile elements, sarcoplasmic reticulum, and/or connective tissue is a slow process.<sup>12</sup>

The angle of peak concentric torque development was extremely variable between treatment groups and across time.

The primary emphasis of this study was on eccentric muscle activity. The pilot phase, the exercise protocol, and all assessments involved eccentric activity. There were only three maximal concentric contractions per assessment period. This was not an adequate number of repetitions to produce a learning effect. Therefore, specificity of training may have played a role in the variability of the performance of the concentric muscle activity. The angle of peak eccentric torque development was not quite as variable. Eccentric peak torque decreased at Assessment Time 2, but the angle of peak torque generation increased. This indicates that the peak torque was generated earlier in the ROM at Assessment Time 2 and could be attributed to a learning effect. Each subject had completed over 225 eccentric muscle contractions at that point and could then "catch" the isokinetic machine earlier in the eccentric phase. By Assessment Time 3, the peak eccentric torque was occurring later in the ROM and could be related to fatigue. In the attempt to generate a maximal contraction, the muscles will increase the number of fibers recruited to maintain or increase force development. The increased fiber recruitment is time-consuming and could have delayed peak torque generation.

## NSAID

The inflammatory process begins within several hours after a tissue-damaging event.<sup>31</sup> The signs and symptoms of DOMS do not begin until 24 to 48 hours postexercise, however. Waiting to treat the anticipated inflammatory process until the time the signs and symptoms appear has been shown to be ineffective.<sup>20,21,30,32,33,37,39,46</sup> Early intervention with a prophylactic NSAID has been successful in

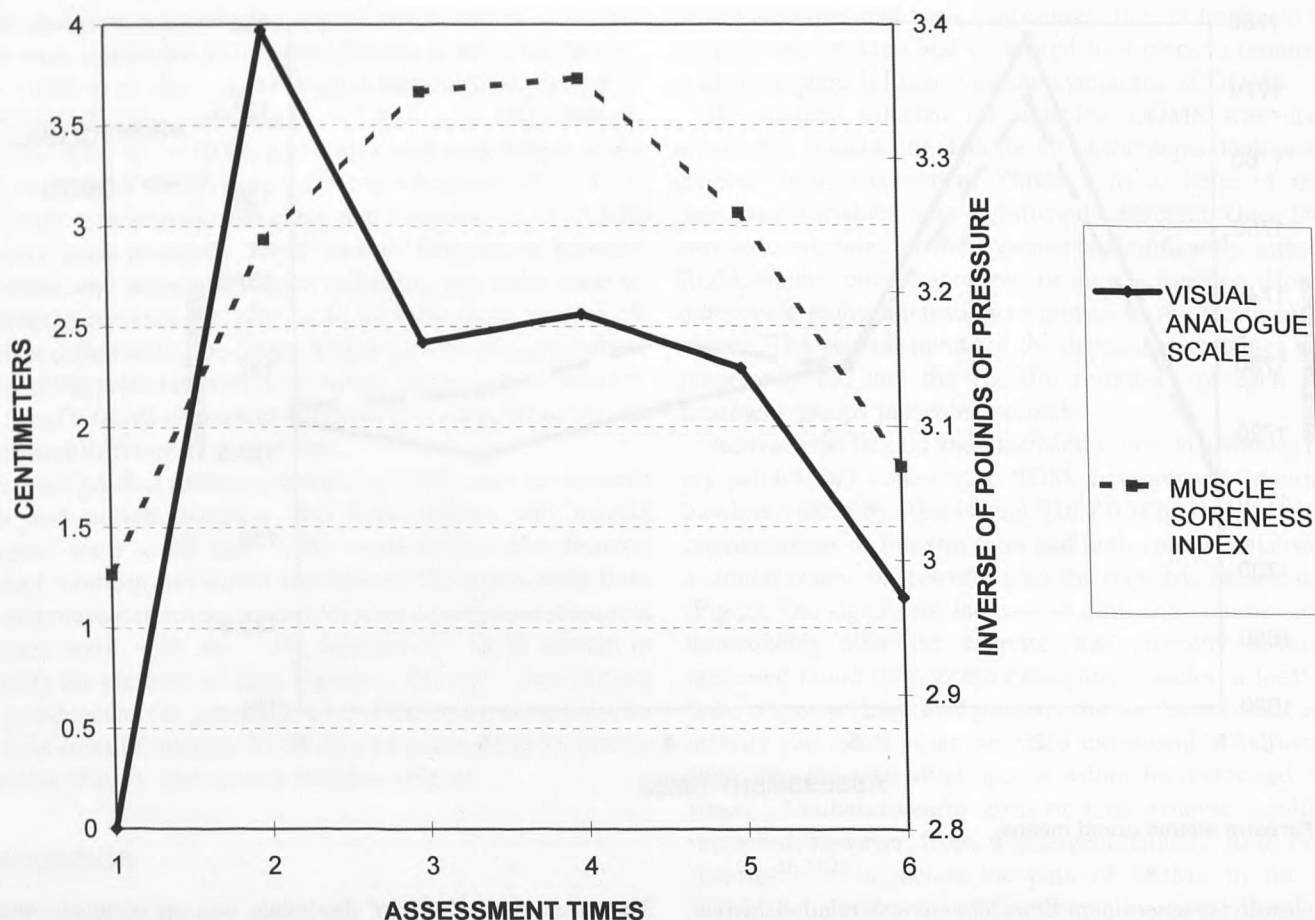


Fig 3. Muscle soreness grand means.

reducing the symptoms of DOMS.<sup>31</sup> Studies with varying dosages of ibuprofen<sup>20,30</sup> revealed contradictory results. Hasson et al<sup>31</sup> administered 400 mg of ibuprofen 3 times per day, whereas this investigator examined the effect of a load dose of 1,800 mg and daily doses of 1,200 mg of oxaprozin. Perhaps the inflammatory process is a necessary component of the healing process, and interference in this process impairs the recovery of muscle function. NSAIDs administered in greater dosage may in fact impede the production of myofibrillar protein.<sup>32</sup>

### Upper Extremity Ergometer

Submaximal concentric muscle activity does not cause tissue damage and produces much lower intramuscular pressures than eccentric activity.<sup>25</sup> The popular belief that muscle soreness can be alleviated by "working it out" has been implemented for many years.<sup>29</sup> Hasson et al<sup>29</sup> studied the effects of high velocity concentric exercise on DOMS and found a significant reduction in muscle soreness and an improvement in muscle performance. However, neither volumetric nor circumferential limb measurements were performed to demonstrate the relationship between edema and DOMS. In this study, changes in forearm girth and limb volume did not coincide with muscle soreness. The velocity selected for treatment was similar to that of Hasson et al,<sup>29</sup> but there were several parameters in the present study that

differed. In the present study, 10 minutes of upper extremity ergometry was performed for a total of 600 submaximal contractions, with the upper extremities immediately after the eccentric muscle activity. Hasson et al<sup>29</sup> used 120 maximal contractions with the lower extremities, 24 hours after the eccentric bout. Any or all of these parameters could have influenced the results of the two studies.

### Ice Massage

In all groups active wrist flexion increased from Assessment Times 2 to 3; however, ROM decreased in the ice group. Lehmann and DeLateur<sup>40</sup> attributed an increase in collagen stiffness to the application of cold. However, after Assessment Time 5, the ROM measurements progressed toward pre-exercise levels, and the ice group was the only treatment group to return to baseline by Assessment Time 6.

The path in which the muscle soreness index data returned to baseline was similar from Assessment Times 2 to 3 for all groups except the ice treatment group. The muscle soreness index for the ice group decreased immediately following treatment. This was attributed to the numbing effect of the 20-minute ice massage. The application of a cold modality depresses the excitability of the free nerve endings and peripheral nerves, which increases the pain threshold and decreases pain.<sup>28</sup> The muscle soreness index data for the ice massage group notably increased from Assessment Times 3 to



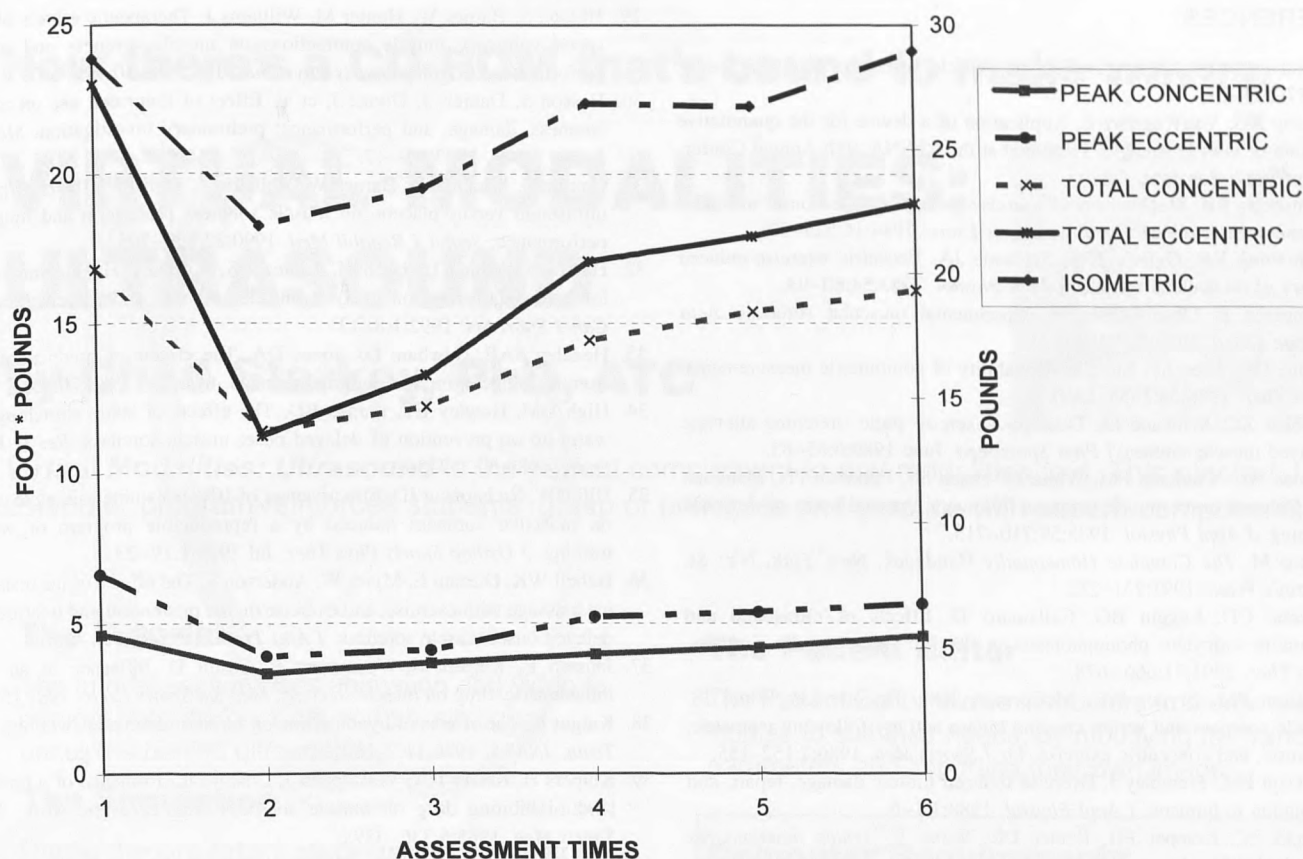


Fig 4. Wrist extension muscle function grand means.

4 and may be due to a compensatory response of the earlier numbing effect. This indicates that the ice massage provided relief from acute muscle soreness<sup>38,41,42</sup> but was not effective in abating DOMS. These results correspond with previous results.<sup>54</sup>

The ice group generated less isometric force after treatment, while other groups increased force generation. These findings are in agreement with Fox<sup>23</sup> who revealed a transient decrease in strength with cold application.

### Static Stretching

Researchers have investigated the effects of warm-up, pre-exercise,<sup>34</sup> and postexercise<sup>1,7,18</sup> stretching on DOMS. The results were as varied as the stretching techniques. In this study, the greatest decrease in active wrist flexion occurred in Assessment Time 4 for all groups except the group treated with static stretching. The prolonged stretch to the forearm extensor muscles was apparently effective in maintaining active wrist flexion for at least 72 hours. This was the only parameter that was notably different in the response to the treatment of prolonged, static stretching.

### *Arnica montana*

The use of *Arnica montana* L as a medicinal plant dates back to the 16th century.<sup>9,13,52-54</sup> The components of the *A. montana* compound are believed to be analgesic, antibiotic, and anti-inflammatory in nature.<sup>9,22</sup> Tveiten et al<sup>52</sup> administered five

pellets of *A. montana* twice daily to marathon runners. They found a significant reduction in stiffness ratings on a visual analogue pain scale for the group treated prophylactically with *A. montana* but reported no change in muscle function. Armstrong et al<sup>4</sup> used animals to demonstrate that the tissue damage induced by eccentric exercise may not follow the normal inflammatory sequence. If the eccentrically induced inflammatory process is also altered in humans, the lack of improvement in ROM and muscle function with both the NSAID and *A. montana* treatments could be explained. Conversely, the preparations of *A. montana* in this study may not have been effective, because they were too diluted. Older studies with higher concentrations of this medication and European research still recommend its use for DOMS.<sup>51</sup> No recent double-blind studies of the effects of higher concentrations of *A. montana* on DOMS appears in the literature reviewed.

Numerous other modalities are yet to be explored. Nonetheless, the results of this study did not reveal a treatment method that was significantly better than that of a placebo for the symptoms of DOMS.

### ACKNOWLEDGMENTS

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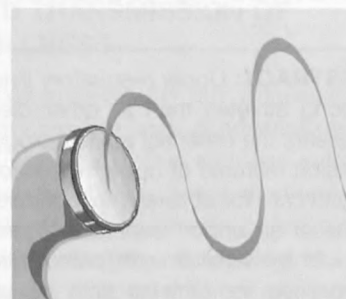
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# Sport, Exercise, and the Common Cold

Thomas G. Weidner, PhD, ATC; Thomas L. Sevier, MD

**ABSTRACT:** Upper respiratory illness may cause more disability among athletes than all other diseases combined. This paper presents the essential epidemiology, risks of infection, and transmission features of upper respiratory illness. Those who provide health care for athletes must understand the subsequent implications of an upper respiratory illness on sport performance and should be familiar with participation and clinical management guidelines for athletes with an upper respiratory illness. The literature suggests that regular, rigorous exercise increases both the incidence and severity of upper respiratory illness, yet the

immune system appears to have a distinct level at which moderate exercise promotes optimum health. Although research indicates that upper respiratory illness infections are surprisingly reluctant transmitters, upper respiratory illness transmission may escalate during winter sports seasons. The impact of upper respiratory illness on selected pulmonary, cardiac, and skeletal muscle functions may lead to illness complications in athletes, and sport performance during illness may also decline. Athletes should monitor symptoms, adjust training schedules, and rest during an upper respiratory illness.

Some researchers<sup>53</sup> contend that upper respiratory illness causes more acute disability among athletes than all other diseases combined. The average adult has between one and six episodes of a common cold each year,<sup>5</sup> but athletes who engage in heavy training and competition may suffer from more frequent colds.<sup>42</sup> Disease patterns among summer and winter Olympic athletes are remarkably consistent, with respiratory infections heading the list, followed by gastrointestinal disorders, and skin infections.<sup>30</sup> In the 1992 Winter Olympics, some of the world's greatest athletes were unable to compete or did not perform strongly because of an upper respiratory illness,<sup>42</sup> and several athletes were reportedly unable to compete in the 1988 Summer Olympic Games due to infectious illness.<sup>23</sup> It is important to understand, then, the essential epidemiology, risks of infection, and transmission features of upper respiratory illness. It behooves those who provide health care for athletes to realize the subsequent implications of upper respiratory illness on sport and exercise participation and performance. Health care providers must be familiar with participation and clinical management guidelines for athletes with an upper respiratory illness.

## EPIDEMIOLOGY OF UPPER RESPIRATORY ILLNESS

There is support in the literature that regular, vigorous exercise (eg, sport participation) increases both the incidence and severity of upper respiratory illness. To date, 10 studies have made an attempt to examine the relationship between the epidemiology of upper respiratory illness and physical activity.<sup>58</sup> However, all 10 studies required subjects to self-report upper respiratory illness symptoms, and reported scores were subsequently used to diagnose whether or not an upper respiratory illness was present. This type of reporting needs to be interpreted cautiously because subjective rather than valid objective measurements are collected.

Better designed studies, done primarily with runners, have revealed an increased upper respiratory illness incidence rate as a result of physical activity. Heath et al<sup>31</sup> studied illness patterns longitudinally in a cohort of 530 male and female runners. An upper respiratory illness was indicated by a runny nose, cough, and/or sore throat. The results suggested that running mileage greater than 485 miles in a year was a significant risk factor for upper respiratory illness in this group. Peters and Bateman<sup>48</sup> studied the effect of the acute stress of running on infectious illness, showing that ultramarathon runners (35 miles) were at more than twice the risk of developing a upper respiratory illness within 2 weeks after competition. Additionally, symptoms were found to be most common in runners with the fastest race times.

Linde<sup>38</sup> investigated a 12-month upper respiratory illness incidence in a group of 44 elite runners and 44 nonathletes. Subjects were matched for age, gender, and occupational status. On average, the runners had 2.5 upper respiratory illnesses per year versus 1.7 upper respiratory illnesses in the control group. The average lengths of the illness periods were 7.9 and 6.4 days, respectively.

Results of a study conducted by Nieman et al<sup>45</sup> revealed that the risk of an infectious episode is five times greater for runners 1 week after a marathon race than for runners who trained but did not compete in the race. Another study completed by Nieman et al<sup>44</sup> investigated the incidence of upper respiratory illness in a group of recreational runners during January and February. At the time of the study, runners were training for either 5 km, 10 km, or half-marathon road races to be held in March. Results showed that 25% of those runners training more than 25 km/wk with an average of 42 km/wk reported at least one upper respiratory illness incident. On the other hand, 34.3% of the runners training less than 25 km/wk with an average of 12 km/wk did not report any incidence of upper respiratory illness. Nieman concluded that training more than 25 km/wk with the average mileage nearing 42 km/wk can increase the incidence for an upper respiratory illness.

## RISKS OF UPPER RESPIRATORY INFECTION

In research reviews completed by Shephard et al<sup>54</sup> and Keast et al,<sup>36</sup> a plethora of literature is reported on the human and

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animal immune responses to exercise and stress. Included are countless studies that examine the relationship of exercise to antibody-mediated cell immunity, cell-mediated immunity, factors that modify immune mechanisms, phagocytic cells, numbers of circulating lymphocytes, lymphocytic function, catecholamines, glucocorticoids, and prostaglandins. Although very few definitive conclusions are drawn, this research indicated that the results of epidemiological studies on exercising individuals reported above can be supported. Nieman et al<sup>45</sup> stated that intense exertion, whether short-term and maximal or long-term and submaximal, may be associated with some potentially negative immune system changes; yet other research, also reported by Nieman et al,<sup>44</sup> suggested that moderate submaximal exercise bouts and long-term training may enhance immunosurveillance, potentially decreasing the risk for infection. Nieman<sup>42</sup> maintained that the relationship between exercise and upper respiratory illness can be depicted as a J curve with the most sedentary at greatest risk of upper respiratory illnesses along with the vigorously active; those engaged in moderate levels of activity manifest the apparently better host defense. Berk<sup>6</sup> suggested that the immune response is damaged by the stress of acute, exhaustive exercise. Lewicki et al<sup>37</sup> commented that nonspecific immunity is suppressed by intensive exercise and may render athletes more susceptible to infections. Fehr et al<sup>21</sup> and others<sup>26,37,49</sup> contended that immune suppression may also occur as a result of daily training over a long period of time (ie, overtraining). The defense mechanisms do not respond in the usual way (by elimination of the antigens); thus, a partial breakdown may occur periodically, leading to an acute infection.

Berk<sup>6</sup> surmised that people who exceed their optimum exercise level may be fostering infection. Though triathlons may not be too much for some, even moderate exercise may be detrimental for sedentary people. Hormones (eg, adrenaline, cortisol) and neuropeptides (eg, endorphins, encephalins) released from the stress of excessive physical activity, or from psychological or emotional stress, seem to have an adverse affect on the immune system.<sup>1,12,20,25,36,47,57</sup> Certainly, athletes who superimpose the psychological and emotional stress of competition upon a compromised immune system brought on by overexertion may be more susceptible to infection. Regardless of conditioning, those who exceed their physical limits are at risk to become sick, although the optimum level of exercise for the immune system is not known. More research is needed to improve our understanding of the workload threshold below or above which exercise becomes detrimental rather than protective. Tomasi<sup>56</sup> also contended that there appears to be a distinct level of moderate exercise for the immune system of each individual.

One other risk factor for an upper respiratory illness, the acute phase response, has been discussed by Heath et al.<sup>32</sup> The acute phase response following endurance exercise involves complement system, neutrophils, macrophages, various cytokines, and acute phase proteins. The acute phase response can last for several days, promoting clearance of damaged tissue and setting the stage for repair and growth. The authors suggested that the activity of the immune system in the muscle tissue repair and inflammation process means that resistance to

respiratory infection is, perhaps, compromised. Further research is warranted.

## COMMUNICABILITY AND TRANSMISSION OF UPPER RESPIRATORY ILLNESS

Specific research on the communicability and transmission of an upper respiratory illness has not been conducted on an athlete population. To date, research in this area has yielded contradictory results. The amount of virus being shed and the length of exposure time to the virus seem to be the center of this controversy. Although many families of viruses and their serotypes may cause the common cold, most upper respiratory illnesses are caused by rhinoviruses,<sup>11</sup> accounting for about 40% of all infections in adult populations.<sup>9</sup> There are more than 100 serotypes of the rhinovirus that may cause the common cold (see Table).<sup>51</sup> Rhinoviral infections occur throughout the year with well-defined periods of prevalence in the fall and spring, but the infections also can be found during the winter months.<sup>9</sup> Another group of viruses responsible for common colds among adults are the coronaviruses,<sup>33</sup> with the greatest incidence reported in persons between the ages of 15 and 19 years.<sup>9</sup> The greatest frequency of coronavirus infection is in the late fall, winter, and early spring, and these viruses are considered to be the major cause of winter colds.<sup>9</sup> Of particular significance to athletes in rigorous training are the enteroviruses, usually occurring during summer and autumn months. Although these viruses do not commonly cause acute adult respiratory tract illness,<sup>41</sup> the chief importance of enterovirus infection for the athlete lies in the association of some Enteric Cytopathogenic Human Orphan (ECHO) virus and Coxsackie virus strains with myocarditis and aseptic meningitis.<sup>53</sup> Exercise may increase the risk of developing enterovirus cardiomyopathy.<sup>8,56</sup>

The majority of viruses enter the body via the respiratory tract, then enter individual cells by penetrating the cell membrane and displacing host control mechanisms. The cell may produce many viruses that are then released by either cell lysis or by budding from the cell. This method of reproduction

Common Respiratory Viruses and Their Clinical Features

Virus Groups	No. of Serotypes	Clinical Features
Rhinovirus	>110	Common cold
Coxsackie A	23	Upper respiratory tract infection
Coxsackie B	6	Infection, especially common cold
Echovirus	31	Common cold
Adenovirus	33	Upper and lower respiratory tract infection
Coronavirus	7	Common cold
Respiratory syncytial virus	1	Upper respiratory tract infection: bronchiolitis, pneumonia
Influenza (ABC) <sub>3</sub>	3	Influenza: upper respiratory tract infection
Parainfluenza	1	Upper respiratory tract infection
Herpesvirus: Epstein-Barr virus	1	Infectious mononucleosis

Reprinted from Roberts.<sup>51</sup>

renders the virus resistant to all the common antibiotics. The host responds to the viral infection by mobilizing antibody and cellular defenses. It is only if these defenses are overwhelmed that severe illness occurs.<sup>51</sup>

Although specific research on the communicability and transmission of upper respiratory illness has not been conducted on an athlete population, logical inferences from results of related work can be made about this group. Research indicates that rhinoviral infections are surprisingly reluctant transmitters and seem to be spread chiefly by aerosol contact, rather than by fomites or personal contact. It follows then that upper respiratory illness transmission among infected athletes to other team members would be spurious. Upper respiratory infections are spread from person to person by respiratory secretions containing a virus. The virus may gain entry to a susceptible host's respiratory tract via small or large particle aerosols, by direct contact, or by indirect contact involving contaminated environmental objects. Very low transmission rates (0% to 9%) have been reported for exposure periods extending from 45 to 72 hours, whether exposure was by aerosol alone or by all routes.<sup>34</sup> In a week-long experiment with childless married couples,<sup>13</sup> a transmission rate of 38% occurred between rhinovirus-infected donors and recipient spouses. Successful transmission was associated with donors who spent many hours with their spouses (122 hours), had virus on their hands and anterior nares, were at least moderately symptomatic, and had large amounts of virus in their nasal secretions.

Transmission rates of upper respiratory illness have also been investigated using a system called the Miniature Field Trial.<sup>34</sup> Natural rhinovirus transmission, theoretically by all possible routes, was achieved at predictable rates over time periods of up to 1 week. This system used experimentally induced adult donors, selected from a pool of infected individuals for their moderate to severe colds, and recipients. Interaction between donors and recipients took place in a single large room. In a series of miniature field trial experiments, the rate of transmission correlated closely with the number of hours the recipients interacted with the donors. About 200 hours of exposure to an individual with a moderately severe cold was needed for an antibody-free adult to have a 50% chance of infection. Other miniature field trial experiments examined aerosol and direct or indirect contact transmission of rhinovirus colds. Laboratory-infected men and susceptible men played cards together for 12 hours. In three experiments, the infection rate of restrained recipients (who could not touch their faces and who could only have been infected by aerosols) and that of unrestrained recipients (who could have been infected by aerosol, by direct contact, or by indirect fomite contact) was not significantly different. In a fourth experiment, transmission of fomites via playing cards heavily used for 12 hours by eight donors, represented the only possible route of spread. No transmissions occurred among the 12 recipients.<sup>15</sup>

Other research on upper respiratory illness transmission may imply that athletes could spread the virus through athletic equipment and implements. There is some inferential evidence that transmission by indirect contact routes is possible, but the importance of this evidence in the natural spread of colds is

questionable.<sup>27,34</sup> The environment of an individual with a cold does become contaminated with rhinovirus. Virus readily gets onto the hands if the individual has a moderate to severe cold.<sup>13</sup> However, very little virus appears to be transferred from the hands. Virus was recovered from only 6 of 40 objects,<sup>50</sup> and 7 of 114 objects<sup>29</sup> recently handled by infected persons. All objects yielded very little virus. These researchers concluded that the spread of colds is unlikely to occur via objects contaminated by the hands of the infected person. Although transmission routes for an upper respiratory illness may not be completely clear, the potential for an infected individual to spread a cold appears important. Large amounts of virus are found to be shed by an infected individual for at least 8 days.<sup>15</sup> Virus may continue to be produced for 2 to 3 weeks.<sup>18</sup> Intensive studies with children in natural settings also indicate secondary attack rates (a week later or longer) of about 50%.<sup>15</sup> Subsequently, adults who live in households with children tend to suffer more colds per year, and adult women tend to suffer more colds than adult men.<sup>28</sup> For now, athletes should be advised to limit or avoid exposure to infected teammates or individuals. Studies designed to investigate specific transmission rates among different sporting activities (eg, wrestling and basketball) may assist in the development of intervention strategies.

## **SPORT/EXERCISE PARTICIPATION AND UPPER RESPIRATORY ILLNESS**

Several investigators have examined the impact of upper respiratory illness on selected pulmonary, cardiac, and skeletal muscle functions. Because previous studies have rarely determined etiology of upper respiratory illnesses, caution should be taken when interpreting their results. The implications for continued sport and exercise participation relative to illness complications and susceptibility need to be considered. Protracted courses of upper respiratory illness and performance levels during illness also warrant discussion.

Three studies of the effects of upper respiratory illness on the pulmonary function of subjects at rest were completed in the 1970s, but investigation of the effects of upper respiratory illness on pulmonary function during exercise is needed. All three studies suggested that peripheral airway abnormalities are associated with upper respiratory illness. One study concluded that large airways were involved during upper respiratory illness.<sup>46</sup> This research demonstrated significant impairment of peak expiratory flow rate, forced vital capacity, forced expiratory volume in 1 second, and maximal midexpiratory flow rate, measured at 50% of vital capacity. Changes in the maximal expiratory flow rate measured at 75% of vital capacity were not significant. The other two investigations identified no large airway dysfunction. One of these found that the subjects developed increased frequency dependence of compliance,<sup>7</sup> and the other found a reduction in steady-state carbon monoxide diffusing capacity.<sup>10</sup>

Respiratory muscle strength was studied in 12 subjects who developed naturally acquired upper respiratory illness.<sup>40</sup> Maximum static respiratory and expiratory mouth pressures fell significantly during these infections. The greatest falls were



documented between the third and seventh days of clinical illness. However, the lowest pressures occurred several days after the peak of clinical symptoms, when malaise had greatly improved. Full recovery occurred by day 14. The authors concluded that weakness of the inspiratory muscles may contribute to breathlessness during exertion. In contrast, weakness of the expiratory muscles might affect the cough mechanism and clearing of pulmonary secretions. The authors speculated that those who suffer either from lower respiratory tract infections or from exercise-induced asthma should also refrain from athletic activity during upper respiratory illness or episodes of exercise-induced asthma.

Reduced functional capacity of skeletal and cardiac muscle has been demonstrated during upper respiratory illness. In a controlled test, Astrom et al.<sup>3</sup> examined muscle tissue obtained from patients recovering from recent viral or mycoplasma illnesses. They found significantly reduced muscle enzyme activity (glyceraldehyde phosphate, lactate dehydrogenase, cytochrome oxidase, and citrate synthetase) in infected patients. Moreover, electron microscopy showed abnormalities in muscle ultrastructure. These changes had almost completely resolved when muscle biopsy was repeated 3 months after illness. Roberts<sup>51</sup> suggested that a decrease in muscle glycogen use occurred during upper respiratory illness, while Ardawi<sup>2</sup> reported that a decrease in muscle glutamine release occurred with upper respiratory illness during prolonged physical training. Other researchers<sup>60</sup> have also reported that myositis ossificans may be the result of hematoma infection following a respiratory tract infection.

The effects of myalgia and fever on muscle and circulatory function have also been examined.<sup>24</sup> During, but not after, a fever, subjects exhibited decreased isometric and dynamic strength and endurance. Impairment could not be explained by altered activities of relevant muscle enzymes or altered muscle ultrastructure. However, severity of myalgia, as rated by each subject, correlated significantly with reduced muscle function. Cardiac stroke volume was lower during and after a fever. During a fever, an increased heart rate maintained cardiac output at preinfection values, whereas cardiac output fell in early recovery. This decrease in cardiac output correlated significantly with the severity of the fever. The actual influence of a fever and myalgia from an upper respiratory illness on the above parameters has not been determined.

A variety of illness complications may be associated with upper respiratory illness, including protracted courses of infection and sudden death. Roberts<sup>51</sup> discussed an increasingly recognized postviral fatigue syndrome (epidemic myalgic encephalomyelitis). It usually occurs after a Coxsackie virus infection,<sup>4</sup> although it has also been diagnosed after influenza and varicella virus infections. The patient complains of persistent malaise, fatigue, lassitude, and aching muscles. Symptoms may last for months or years, and there is no treatment.

The predilection of the Coxsackie virus to produce myocarditis or pericarditis may increase the risk of acute arrhythmias leading to sudden death.<sup>51,55</sup> In a study of 78 sudden deaths during or immediately after exercise, Jokl and McClellan<sup>35</sup> found a history of recent upper respiratory tract infection in five subjects; cardiovascular problems accounted for most of

the remainder. Roberts<sup>51</sup> commented that there are numerous anecdotal reports of death in young healthy people who undertake vigorous exercise during viral illness. He also reported that numerous case studies have identified viral infections as the cause of sudden death.

The impact of upper respiratory illness on sport performance has not been clearly identified. In related work by Friman et al.,<sup>24</sup> a decrease in muscle performance correlated to the subjects' own ratings of the intensity of some disease-related symptoms such as myalgia, but not to a fever reaction. Regarding performance, then, the authors concluded that a person's perception or experience of a febrile illness seems to influence his ability and/or willingness to perform exercise. Roberts<sup>52</sup> presented four case reports of athletes who experienced a loss of form (decreased stamina, inability to manage normal training schedule) during subclinical episodes of upper respiratory illness. Two of these highly trained athletes had no prodromal symptoms, and two had minor symptoms of the upper respiratory tract. All had laboratory evidence of recent viral infections. Roberts<sup>52</sup> concluded that inquiry about recent minor illness should be standard practice in athletes with unexplained loss of form. Infections that are subclinical in the normal population may greatly affect maximum performance in athletes.

One study<sup>59</sup> has been completed concerning the reporting behaviors and activity levels of intercollegiate athletes with upper respiratory illness. This study attempted to discern which upper respiratory illness symptoms are the most problematic for an athlete. Distinctions among symptoms were assessed by examining which symptoms athletes reported the earliest to their medical supervisors (eg, athletic trainers, team physician) or coaches. Likewise, those cold symptoms, which prevented an athlete from participating in a practice or a game and/or affected perceptions of physical performance, were also examined. This study is the first to use a comprehensive and validated symptom checklist in sports medicine research. In addition, the study was further strengthened by specifying that an upper respiratory illness was only present in any athlete with three or more symptoms from this checklist. Similar studies employing the use of a self-report cold symptom survey have used the presence of only one symptom of a list of three as the determination of a cold. Symptoms of cough, fever, laryngitis, aching joints/muscles, and nasal discharge were significantly correlated with reporting behaviors, activity levels, and/or perceived physical performance ( $p < .05$ ).

The impact of upper respiratory illness on sport performance has not been clearly identified. Certainly alterations in cardiac, respiratory, and skeletal muscle functions discussed above may individually or collectively alter performance, but further research is needed.

## **PARTICIPATION AND CLINICAL MANAGEMENT GUIDELINES**

There has been no research regarding the disposition of an athlete with an upper respiratory illness. If the athlete has symptoms of a common cold with no constitutional upset, Roberts<sup>51</sup> recommended safely resuming training a few days

after the resolution of symptoms. However, if the athlete experiences symptoms or signs of extreme tiredness, myalgia, or swollen lymph glands, then he/she should not resume full training for at least a month. For very competitive athletes who cannot afford to miss any training days, even when ill, Eichner<sup>19</sup> recommended that athletes perform a "neck check." If symptoms are located "above the neck," such as a stuffy or runny nose, sneezing, or scratchy throat with no constitutional symptoms, then the athlete should be allowed to proceed cautiously through his/her scheduled workout at half the speed. After a few minutes, if the congestion clears and the athlete feels better, then intensity can be gradually increased. If the athlete feels worse, rest is recommended. The athlete with "below the neck" symptoms, such as a fever, aching muscles, hacking or a productive cough, vomiting, or diarrhea, should not train. Fitzgerald<sup>22</sup> comments that exercising during the incubation period of an infection may worsen the illness. Certainly, athletes who feel that they may be getting ill should reduce their training schedule for 1 or 2 days. If exercise is capable of compromising the immune response in healthy subjects, it seems logical to assume that exercise would certainly do so during an illness. If this is the case, both symptom severity and duration may be increased. In addition, training techniques should take into consideration the need for the body to restore host resistance by including lower intensity training interposed between higher intensity training bouts.<sup>32</sup> Again, further research in this area is needed.

According to comments found in selected medical magazines and newsletters, heart rate and oxygen consumption changes that accompany a fever during some upper respiratory illnesses may provide reason to decrease training. Heart rates increase by 2.44 beats/min with every 1.5°C rise in temperature in afebrile subjects.<sup>39</sup> As discussed earlier, cardiac output correlated significantly with the severity of the fever.<sup>24</sup> A fever also increases the demand for oxygen.<sup>16</sup> For every increase of 1°C over 37°C, there is a 13% increase in oxygen consumption. In addition, overtraining, fatigue, or illness may increase resting heart rates. For instance, a difference of 10 to 20 beats per minute upon rising in the morning may signal the onset of illness or lack of adequate rest between workouts.<sup>48</sup>

Nieman<sup>42</sup> advocated several precautions that can help athletes reduce their risk of an upper respiratory illness. The athlete is urged to eat a well-balanced diet, keep other life stresses to a minimum, avoid overtraining and chronic fatigue, shun sick people before and after important events, obtain adequate sleep, and space vigorous workouts and competitive events as far apart as possible. If the athlete is competing during the winter months, a flu shot is highly recommended.

Conditions that may increase the transmission of an upper respiratory illness among athletes warrant the attention of those in the sports medicine field. Particularly during winter weather, athletes are exposed to the cold virus in crowded dormitories, classrooms, and gymnasiums, perhaps accounting for the higher incidence of colds during cooler months.<sup>9</sup> Because there is some evidence that strenuous exercise may increase the incidence of upper respiratory illness infections,<sup>17,32,38,44,49</sup> athletes should be advised to maintain a good health profile (eg, rest, nutrition, stress management), especially during

winter months. In clearing the nasal passages, facial tissues should be used and care should be taken by team members to clear their respiratory passages gently in order to prevent wide dissemination of infected mucous.<sup>14</sup> Casey et al<sup>9</sup> recommended careful hand washing, avoidance of direct skin-to-skin contact, or contact with contaminated tissues, sporting equipment, and appliances. Towels and water bottles should not be shared. Paper handkerchiefs and cups should be carefully used and disposed of in closed plastic container bags. Commonly used washing facilities should be cleaned with disinfectants or tincture of iodine before and after each use.

Treatment for viral upper respiratory illnesses is supportive for the most part, consisting of rest, fluids, analgesics, and over-the-counter cold remedies. Acetaminophen is recommended for fever, headache, and muscle pain along with lozenges, saltwater gargles, or viscous lidocaine for sore throat. If training is to be attempted, caution must be used with cold medications containing antihistamines because their anticholinergic side effects may lead to impaired thermoregulation. Also, some decongestants still contain substances banned by several governing athletic bodies (eg, ephedrine). Athletes must be careful to avoid potential disqualification by testing positive for an illegal substance from a seemingly innocent over-the-counter medication.

## CONCLUSION

The essential epidemiological and immunological features of upper respiratory illness seem to indicate that sport and exercise participation may increase the incidence of upper respiratory illness, depending on the individual's immune system reaction. The risk of upper respiratory illness transmission among a cohort of athletes is potentially high, although the risk is not completely clear. Athletes' performance levels may decline during an upper respiratory illness; however, more research is needed in this area. Through early intervention and education programs, illness complications and protracted courses of upper respiratory illness may be prevented.

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# The Importance of State Regulation to the Promulgation of the Athletic Training Profession

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**ABSTRACT:** States regulate professions to protect the public from harm by unqualified practitioners. Without regulation of athletic trainers (ATs), there is no legal way to assure quality health care to athletes because there is no legal definition as to what an AT can and cannot do. Problems exist, however; 1) ATs nationwide may not be adequately familiar with state regulations; 2) without regulation, legal support is given to high schools to use less qualified persons to care for student-athletes; 3) more education is needed to familiarize the public and the health care industry with the functions and qualifications of a certified AT; and 4) without uniformity of regulation, athletes may continue to suffer as untrained and/or unqualified persons continue to be per-

ceived as members of the profession and as certified and noncertified ATs continue to practice without legal sanction, perhaps beyond their area of expertise. This article encompasses both a literature review and an opinion survey (of ATs) with regard to state regulation of the athletic training profession. The intent of this article is to help ATs understand the implications of state regulation on our profession. A survey was mailed to 500 ATs across the country soliciting opinions on state regulation and its implication of the profession of athletic training. The intent of the survey results are not to verify the literature review nor to infer information regarding other ATs, but merely to be a gathering tool to solicit information from fellow ATs.

At an Athletic Trainers of Massachusetts meeting I attended a couple of years ago, the topic of licensure came up. At the time, Massachusetts was (and still is) trying to amend the licensure law in statute. A colleague of mine was frustrated with the amount of time and money our state athletic training organization was spending on resolving the issue. He did not see how licensure in any form would change what he did on a daily basis. Licensure did, he felt, limit his scope of practice and for that reason was undesirable. This incident prompted me to look further into the issue of regulation in order to help my fellow colleagues understand that we are public servants and, as such, we should help to ensure that those seeking the care of an athletic trainer (AT) are receiving care from an educated professional and not from an untrained layperson calling himself/herself an AT.

According to the National Athletic Trainers' Association (NATA) Career Guide, the certified athletic trainer (ATC) is a highly qualified allied health professional, educated and experienced in the management of health care problems associated with sports participation. The NATA offers the credential of "certification" to those persons who satisfy the requirements of course study, internship, and successful completion of the National Athletic Trainers' Association Board of Certification (NATABOC) exam. This certification process is valuable for ensuring that those credentialed as ATCs are competent professionals, but it cannot assure that all people who call themselves ATs are certified, nor can it guarantee that all those earning the credential are practicing within their defined scope of practice. State licensure laws provide and impose disciplinary sanctions, civil or criminal, against those who do not meet or adhere to the procedures, qualifications, and/or standards established by the

particular statute. In this way, state licensure helps to ensure that only qualified professionals are caring for athletic injuries.

In a letter, Laura Jetton, Director of Governmental Regulations at NATA, indicated that licensure is the strictest form of state regulation and is thus the most desirable standard for the practitioner to meet as well as the most effective means of protecting the public. Licensure is necessary in order to protect the general public, insure public safety, maintain minimum standards in the practice of athletic training, and promote the highest degree of professional conduct on the part of the athletic trainer.

Survey research was conducted to supplement a review of related literature and comparative analysis of state statutes in support of the argument that state regulation of athletic trainers will promote better care to the nation's injured athletes. Included are the results of a survey sent to 500 randomly selected ATCs across the nation. The intention behind soliciting opinions of ATCs was not to provide a statistical conclusion or to infer opinions of other ATs, but rather to display a random selection of ATCs' opinions of state regulation of their profession. In light of the intention of the survey as well as the return rate of 188 (38%), the results are given but are not scientifically analyzed. Five hundred surveys were mailed to a random list of ATCs throughout the 50 states and the District of Columbia. The list was generated through random selection, using the current NATA directory. A cover letter explaining the study as well as a description of the laws regulating athletic trainers was included with each survey. Each packet included a self-addressed stamped envelope for easy return.

## PROFESSIONAL RECOGNITION

Historically, the athletic trainer has been regarded as that member of the team who holds expertise in taping skills and provides first aid and simple health care when appropriate (eg,

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a boxing trainer). This may be one reason why today many ATCs desire a name change for their profession that would reflect their academic pursuits and credentialed health care expertise.<sup>10,24,34,45</sup> Perhaps the general public, as well as members of academic and health care professions, have held on to the idea of what "trainers" used to be and do not recognize the qualifications of today's ATC. In light of these perceptions, it is not surprising that the survey indicated that only 66 (35%) of the respondents felt they were recognized by the general public as allied health professionals. It is encouraging, however, that respondents generally felt their co-workers, students, and athletes did in fact recognize them as allied health care professionals.

It may be surprising to the general public that, of the 188 survey respondents, 137 (73%) held master's degrees, 9 (5%) held doctorates, and 24 (13%) were licensed physical therapists. These results support the fact that some athletic trainers are obtaining advanced degrees and that their skills should not be perceived as merely an adjunct to a coaching or physical education career. Until further strides are taken by state athletic training organizations and the NATA to educate the public about the athletic training profession, there will continue to be a lack of recognition of ATCs as legitimate allied health professionals.

## INAPPROPRIATE CARE

Lack of recognition may contribute to the small numbers of ATCs in high school settings. Richard Ray's survey<sup>35</sup> of Michigan superintendents offers merit to the idea that many high schools are providing inappropriate care to student-athletes through the use of nonregulated ATs or by providing no care at all. In many instances, superintendents did not even realize that they were remiss in the care they guaranteed to their students—70 superintendents reported that they employed an ATC when in fact only 20 actually had an ATC on staff.<sup>35</sup> Because Michigan has no regulation in place for athletic trainers, it is conceivable that 50 of 70 superintendents were employing incompetent persons to care for student-athletes. Though recent literature is laden with examples of inappropriate care provided by noncertified ATs at many of the nation's high schools, there is no conclusive evidence comparing the number of injuries/complications in states with state regulation versus those without state regulation.<sup>3,4,12,37,40</sup>

Several respondents offered anecdotal information indicating that they knew of instances where noncertified trainers were providing inappropriate care in high schools, including the mishandling of both a cervical spine injury and a wrist fracture. It was the contention of the respondents that inappropriate care resulted in the compounding of each injury.

A comparison analysis of state statutes indicates that of the states that have regulation, only seven have practice protection.<sup>1,2,5-7,9,11,13-18,20-22,25-33,36,38-39,41-45</sup> Practice protection states that only those persons regulated by the state may practice as athletic trainers. This contrasts title protection which merely offers that only those regulated by the state may call themselves athletic trainers. As long as a person does not refer to himself/herself as an AT, the law does not specifically

govern him/her. In other words, in 43 states it is conceivable that student-athletes, primarily at the high school level, are being treated by less than qualified professionals.

Currently, approximately 19% of the high schools nationwide employ an ATC.<sup>19</sup> Although superintendents would prefer an ATC on site, fiscal constraints are most often cited as the reason for lack of personnel.<sup>19</sup> Budget constraints are compromising the health and well-being of the nation's high school student-athletes. The fact that, in 1988, high school football alone produced greater than 500,000 injuries should alert superintendents and legislators of the dangerous effect of unsubstantial care of student-athletes.<sup>34</sup>

## UNIFORMITY OF STATE REGULATION

Uniformity of state regulation at the licensure or state certification level, especially in the area of practice protection, would better secure quality care to athletes by insuring that, regardless of the state they competed in, they would receive athletic injury care from a qualified professional. There is wide variation in state statutes across the board, especially between the different forms of regulation. For example, although Ohio and Arizona both technically have regulation, Ohio's licensure law can hardly be compared to Arizona's exemption to the Physical Therapy Act.<sup>31,32</sup> Access to settings and persons vary notably among the statutes. An ATC in Ohio may practice to the full extent of his/her abilities in a variety of settings; however, in Massachusetts the same person would be relegated to a physical therapist aide in a clinic or restricted to a high school or college setting. The qualifications section of the statutes that pertain to protection, in many instances, accomplish very little except to restrict the title of Athletic Trainer to those who are regulated in the state. Title protection does not prevent someone from acting as an AT, performing all duties as such, as long as they do not call themselves an ATC. With the exemptions that some bills include, practice protection allows for those most often accountable for poor care to student-athletes (ie, "teacher-trainers") to legally act as ATs. Perhaps the most disturbing of these is in the Georgia Licensure Statute which states that:

No person shall hold himself out as an athletic trainer or perform, for compensation, any of the activities of an athletic trainer as defined in this chapter, provided, however, that nothing in this chapter shall be construed to prevent any person from serving as a student-trainer, assistant-trainer, teacher-trainer, or any similar position if such service is not primarily for compensation and is carried out under the supervision of a coach, physician or licensed athletic trainer (emphasis added).<sup>9</sup>

Under this statute, a teacher may be legally protected if he/she feels competent to evaluate and treat an anterior cruciate ligament tear as long as a coach supervises him/her. Differences in qualifications/requirements for regulation permit some states to allow uncertified ATs to work as allied health professionals while in other states that field is restricted to credentialed professionals.

## PUBLIC EDUCATION

Along with strict state regulations governing the practice of athletic training, education of the public could help control

abuse of the athletic training profession by unqualified persons. If more people understood and recognized the qualifications of ATCs, they might insist that only credentialed professionals care for athletic injuries. Thirty percent of the AT survey respondents felt that public relations and education are as important as strict regulation in controlling the abuse of the athletic training profession. Many of the additional comments/insights given at the end of the survey mentioned the importance of educating the public and other members of allied health professions in attaining recognition and appreciation of the athletic training profession. Perhaps if more ATCs took the initiative to offer workshops on athletic training to high schools and/or public organizations, more people would understand the importance of quality health care for athletes and would demand that care for their sons and daughters. The NATA provides a video for such workshops.

Education must also be provided to ATCs so they may better understand the various forms of state regulation and the implications to the profession. The cover letter to the athletic trainers' survey addresses a complaint of state organization leaders surrounding the general complacency of ATCs regarding the issue of regulation. Perhaps this is due to the lack of knowledge on the part of the ATC regarding regulation and the implications regulation has on the profession. A 38% return rate, however, to a survey that offered no incentive for return seems to indicate that there exists an interest in the topic by many. Public relations and education must be initiated by ATCs on a grass roots level. State organizations could do more about emphasizing the importance of ATCs by writing articles in their local newspapers and providing workshops in their areas. ATCs could do more to promote their profession and to learn about the implications of its regulations.

### **LACK OF AWARENESS REGARDING REGULATION AMONG ATCS**

ATCs are not always aware of the implications of regulation (if any) in their particular state. An author-predicted problem with the survey was the lack of awareness among ATCs of which regulation was in place in their particular state and what exactly that type of regulation meant. In order to properly categorize the respondents, return addresses were color-coded. Before opening the survey, the proper state regulation was recorded. Question 3 of the survey inquired which form of regulation their state required. There, indeed, were differences in the athletic trainers' perceptions of current state statutes as compared to those statutes actually in place. A notable number of respondents were mistaken with respect to the state law that governed their practice. Sixty-eight (36%) of the sample submitted that they were governed by licensure when in fact only 45 (24%) actually had statutory licensure. Similarly, 4 (2%) of the respondents said they had exemption when actually 24 (13%) worked in a state with an exemption law, 23 (12%) said they had certification with 19 (10%) from a certification state, and 19 (10%) reported a registration law when 11 (6%) came from a state governed by registration. These findings show that some athletic trainers are not adequately familiar with the issue of state regulation. These misconceptions may

account for the complacency of some ATCs surrounding regulation of the profession. If one is unclear about the specifics of a topic, one may find it difficult to speak out and/or support that topic. Conceivably, state athletic training organizations have failed to communicate to their members the extent, or lack, of protection afforded them in their individual states. It is also possible that some ATCs have been remiss in their education regarding state statutes and the implications to their profession. Regardless of the reason, it is clear that this group of ATCs must become more aware of the regulations governing their profession. Perhaps state organizations could write and distribute more newsletters regarding laws affecting athletic trainers in their state.

### **STATE REGULATION PROMOTES QUALITY OF CARE**

State licensure not only ensures that only those credentialed may refer to themselves as ATs, it also provides guidance as to where and how that AT may practice by placing limitations on approved settings, clarifying proper medical supervision, and restricting client population. ATCs should not be caring for stroke patients in a hospital but should be allowed to care for athletes in a sports medicine clinic. This allows great freedom for the ATC who wants to practice in a nontraditional setting, but also allows for the legal sanction of the science teacher who wants to become the health care provider for the interscholastic sports program when he/she does not possess the necessary qualifications to do so. Licensure is sometimes thought of by ATCs as too restrictive in that it may limit the scope of practice and setting. Massachusetts, for example, restricts clinical access by restricting ATCs to traditional high school, college, professional, or other bona fide amateur organization settings. Nevertheless, Massachusetts does offer practice protection restricting the field of athletic training to licensed professionals.<sup>18</sup>

ATCs surveyed argue that they want licensure to restrict the profession to those who have become credentialed, but they also want the freedom to care for athletes and athletic injuries in a variety of settings. Also expressed in the AT survey was the fear that strict licensure could prevent ATs from performing the tasks they had been educated and trained to perform. A well-written licensure law, as opposed to Massachusetts statute limiting clinical access, enables ATCs to practice within the limits of the profession while ensuring that those not qualified are prohibited by law from performing the duties of an ATC. The Ohio licensure statute is one of the few that provides for clinical access while also restricting the profession to licensed ATs.<sup>31</sup>

The survey lends support to the idea that many ATCs want licensure; the sample was very supportive of obtaining licensure laws in their states if given the choice. The majority of respondents, if given the choice, would change the type of regulation governing their profession. In all, 137 of 188 or 73% either wanted to retain their licensure statutes or to implement a licensure law in their state. There were several who wanted to amend the licensure bill now in statute, primarily because the bill limited access. A well-written bill would ensure access.



Licensure guarantees, under punishment of law, that only qualified and regulated professionals will care for athletic injuries, thereby protecting the public from harm and athletic trainers from losing jobs to unqualified personnel who are paid a lesser salary. Although there may be misconceptions in terms of the specific language and/or implications of licensure statutes, the concept of licensure was supported by nearly 75% of ATCs in the sample. According to the sample, the professional recognition and protection afforded by licensure outweighs the fear of restrictions licensure may put on the profession. Many statements in favor of no regulation inferred that the respondents were unclear how state regulation affected the profession. Perhaps further education of the respondents about state regulation would lead to a greater number of them desiring at least some form of regulation.

## **STALLED ATTEMPTS FOR REGULATION**

Tom Jones, of the Virginia Athletic Trainers' Association, reported that pressures from Physical Therapy (PT) organizations, as well as fiscal restraints from legislators have stalled the attempts of many states to secure licensure. Many of the laws now in statute began as licensure bills, but were relegated to certification, registration, or exemption bills in order to guarantee some form of regulation on the books. Currently, an amendment to the Massachusetts Act, which will provide clinical access for ATCs, sits in committee for the sixth straight year, while in Vermont an 11-year battle continues over proposed legislation. Physical therapists (PTs) fear that an AT licensure law will infringe on the PT profession, while legislators fear that implementing a licensure law will create new administrative costs. Arguments from PTs opposed to state regulation are that ATCs, especially in the clinical setting, are practicing beyond their scope of expertise; this may in fact be occurring in some instances.<sup>8</sup> Often, state laws do not clearly delineate what an AT can and cannot do regardless of the setting. For example, Arizona law states merely that ATs are exempted from the PT licensure law and that the law does not prohibit an athletic trainer certified by a national athletic trainers' association approved by the board from providing care and treatment to participating athletes of an educational institution, or a professional or bona fide amateur sports organization at the institution or the organization's athletic training facility, or at the site of athletic practice or competition.<sup>2</sup>

A strict law would limit the scope of practice to the areas that the ATC is qualified and trained to practice in. Ethically, if not legally, ATCs must limit their practice to those persons delineated in the respective state regulation. If indeed some are working beyond their expertise, they should be held legally accountable.

The arguments concerning pressures by the American Physical Therapy Association (APTA) and state legislators with respect to licensure laws are supported by the survey sample. Of 93 persons who were familiar with the history of their states' attempts at regulation, 34 mentioned that conflicts with and pressure from the APTA were factors in the state's bid for regulation. Several mentioned that their states were able to

overcome the pressure, while most conceded that the pressure led the state athletic training organization to settle for a less than ideal statute or for no legislation at all. ATCs need to educate the APTA as to the intent of licensure (ie, to allow ATCs to do the job they are educated and trained to do and not to allow them to practice areas of care restricted to Physical Therapists).

A few respondents also mentioned arguments from the state legislature that licensure was too expensive and that perhaps the profession does not need to be regulated. Legislators must be educated as to the importance of guaranteeing that only qualified health professionals are caring for athletic injuries. Support of the APTA and legislators for state regulation may lead to the implementation of licensure for athletic trainers in every state.

Athletic trainers should be regulated in every state, and regulation should be comparable among states in order to insure that quality care is given by qualified health professionals and to end abuse of the profession by both incompetent persons practicing athletic training and by ATCs practicing in areas of health care restricted to other health care professionals. ATs need to understand the implications of state regulation to the promulgation of the AT profession. As ATs, we are public servants and, as such, it is our responsibility to help ensure that the public will not be harmed by unqualified athletic injury caretakers. Without regulation, it is conceivable that the AT profession may be eroded.

## **AREAS OF CONCERN**

The problem remains that empirical evidence is lacking to support state regulation's will guarantee of proper care. Research must be conducted regarding numbers and severity/complications of injuries and perhaps legal implications of certified versus noncertified ATs exacerbating or mistreating injuries in states with regulation versus states without regulation.

Possible future areas of concern include the NATA's role in standardizing programs, especially internship route programs, to insure that candidates for the NATABOC exam have received a comprehensive quality education adequately preparing the candidates for the profession of athletic training. The NATA has begun to make strides in this area with a movement toward the Committee of Accreditation of Allied Health Education Programs (CAAHEP). Further research in this area may provide some insight to the capability of athletic trainers being certified by the NATA.

An additional area of concern considers ATs' needs to understand, realize, prepare for, and abide by the scope of practice of the athletic training profession as it is defined in statute. Although ATCs offer a definite skill in caring for athletic injuries, they must realize that ATs are not PTs. Perhaps if more is done to educate ATs and PTs regarding the expertise and scope of each practice, the two groups can work together in a more symbiotic relationship than often exists today. The first steps toward this goal may be a further examination of knowledge and perceptions of physical thera-

pists with respect to the profession of athletic training and of athletic trainers with respect to physical therapists.

A final concern is the role of state athletic trainers' organizations and of the NATA in the promotion and support of uniformity of state regulation. States with suitable licensure statutes could provide insight and ideas in terms of working with the legislatures, negotiating with opposing groups, and forming the language and scope deemed appropriate for the bill. The NATA currently offers assistance to those pursuing legislative regulation through the Governmental Affairs Committee and the Governmental Relations Department.

In Virginia, the Board of Health Professions argues that practical competency of ATCs is assured by NATA certification and thus state regulation is superfluous.<sup>23</sup> The NATA and strong state organizations could object to this type of contention and argue that, while NATA certification is a viable assurance of competency, state regulation with practice protection would help to ensure that only competent professionals treat athletes and athletic injuries. Without state regulation, this assurance is tenuous, especially in the high school setting.

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# Positive Drug Screen for Benzodiazepine Due to a Chinese Herbal Product

Patricia L. Eachus, MD, FAAFP

**ABSTRACT:** A female athlete tested positive for benzodiazepine on a random drug screen. She denied taking any illicit or prescription drugs. The positive screen was found to be caused by undeclared addition of diazepam to a Chinese herbal product, "Miracle Herb." Some foreign vitamins, health care products, or herbal tea may contain banned or dangerous additives unknown to the consumer. These additives may

include ingredients such as benzodiazepine, mefenamic acid, or corticosteroids. Possible physical harm may result when using products containing these undeclared additives. Team physicians and athletic trainers should educate athletes about the purchase and use of vitamins, herbal teas, and substances that are perceived to be performance-enhancing products, especially those manufactured outside the United States.

At times athletes take vitamins or other ergogenic products that they hope will enhance their athletic performance.<sup>4</sup> The athlete, as well as health care professionals, may be unaware that certain nonprescription drugs, vitamins, herbal teas, and other health products manufactured outside the United States may contain small amounts of undeclared prescription drugs such as diazepam, mefenamic acid, corticosteroids, or other products that could prove harmful to the uninformed user.<sup>4</sup> If these products are ingested by an athlete, a positive drug test could result. The purpose of this study is to inform athletes, athletic trainers, and team physicians of various products containing undeclared, banned, and potentially dangerous additives.<sup>5</sup>

## CASE REPORT

A 20-year-old female athlete tested positive for benzodiazepine on a random drug screen. The student denied the use of any prescription medication or any illicit drug use. It was initially speculated that some compound was causing a "false-positive" test for benzodiazepine. Benzodiazepines are manufactured products; there are no known naturally occurring benzodiazepines that would result in a false-positive test.

After further confirmation of the presence of diazepam in the urine specimen, the athlete was questioned about any other drugs she might have obtained from physicians while visiting at home. She revealed that she was taking a Chinese herbal product obtained from her hometown chiropractor. The athlete supplied several samples of the product to be analyzed. The pills looked like black balls. Roche Biomedical Laboratories analyzed the herbal product "Miracle Herb" by gas chromatography/mass spectrometry. The analysis indicated that the samples provided contained small amounts of the prescription drug diazepam. The Ohio chiropractor had obtained the "Miracle Herb" from a supplier located in Hutchinson, Kansas.

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## DISCUSSION

When informed of the presence of diazepam in this vitamin, the chiropractor said that he was unaware of its addition.

In 1995, Gertner et al<sup>5</sup> reported on five patients who developed medical complications while taking "Chinese black balls." The only ingredients listed on the bottle were the herbs, but all black balls contained diazepam and mefenamic acid in various concentrations. Patient complications from ingesting these black balls included nonsteroidal anti-inflammatory drug-induced gastritis, massive gastrointestinal bleeding, hypotension, and benzodiazepine toxicity. Fedoruk and Lee<sup>3</sup> reported a case of a pre-employment urine drug screen that proved positive for diazepam. The diazepam was from a vitamin manufactured in El Salvador.

Abt et al<sup>1</sup> reported a case of acute renal failure due to the mefenamic acid (not quantitated) and diazepam (0.43 mg per pill). DuPont and Bogema<sup>2</sup> detected the presence of diazepam in a nonprescription health product obtained from a California address. The pill was "NAN-LIEN CHUIFUNG TOUNKU-WAN." The Food and Drug Administration traced the manufacture of these pills to Hong Kong.<sup>4</sup> "Analysis of the tablets has demonstrated the presence of a corticosteroid (probably prednisone) and a benzodiazepine tranquilizer like diazepam (Valium) . . . some of the tested samples have shown lead in the product, which can result in toxicity."<sup>4</sup> Benzodiazepines and corticosteroids are banned by the United States Olympic Committee.<sup>4</sup>

## CONCLUSION

Some athletes look for ways to enhance their performance and may seek advice and ergogenic aids from friends, family, and health care providers. Many athletes are unaware that some foreign manufactured products may contain various undeclared substances, including benzodiazepine and mefenamic acid. Even the supplier may be unaware of the presence of illicit drugs in a seemingly harmless health product. Such was the case in this situation.

Team physicians, athletic trainers, and athletes need to be aware that certain foreign-made health products may contain benzodiazepine, mefenamic acid, or corticosteroids that would

result in possible physical harm to the patient, including drug dependence, benzodiazepine toxicity, drug interactions, acute renal failure, gastrointestinal bleeding, and/or nonsteroidal anti-inflammatory drug-induced gastritis. The regular use of benzodiazepines, even in therapeutic doses, may result in dependence, although the incidence is low.<sup>6</sup>

We need to inform our athletes and other health care providers that certain foreign products should be avoided because they may contain small amounts of prescription drugs not listed on the label. Vitamins and herbal products are frequently not thought of as "drugs," so they are not included when the athlete lists recent medications used. When obtaining a drug history, specific questions should be asked about vitamins, herbal products, and other over-the-counter preparations that the athlete may be taking.

By presenting this case, it is hoped that awareness will be increased that the use of these products could result in serious

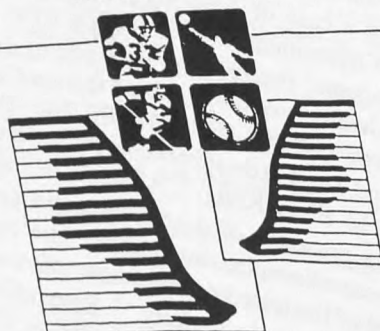
medical complications as well as a positive drug test that may affect an athlete's future participation in organized sports.

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# Pneumothorax—A Medical Emergency

Ronald D. Cvengros, MS, LAT; James A. Lazor, DO

**ABSTRACT:** A traumatic pneumothorax (collapsed lung) can be a life-threatening injury if it is not recognized and treated immediately. An 18-year-old high school athlete wearing rib protection sustained a pneumothorax while playing varsity football. On-site evaluation raised suspicions that the injury could be more than a rib contusion. Further examination by the team physician suggested a possible rib fracture and pneumo-

thorax. The athlete was transported by ambulance to the hospital for x-rays and confirmation of the physician's diagnosis. The athlete was hospitalized for 2 weeks and upon release was allowed to return to school with restricted activity. This article alerts the athletic trainer to an infrequent but serious injury and discusses the signs, symptoms, and basic care instructions for a suspected pneumothorax.

**P**neumothorax refers to the presence of air between the visceral and the parietal pleura of the pleural cavity.<sup>1,2,4,5</sup> This injury is commonly known as a collapsed lung. Although the etiology of a pneumothorax can vary, the two most common types are traumatic and spontaneous.<sup>3</sup> A traumatic pneumothorax is caused by a penetrating wound to the chest such as a stab wound, or a fractured rib which violates the visceral pleura (a thin sheet of collagen and elastic tissue that encases each lung).<sup>4,7-9</sup> A spontaneous pneumothorax is the term used to designate a sudden, unexpected pneumothorax which may occur with or without underlying disease.<sup>9</sup> Pulmonary diseases that may cause a spontaneous pneumothorax include asthma, cystic fibrosis, emphysema, and pneumonia.<sup>4,5,7,8</sup> This paper focuses on a traumatic closed pneumothorax. Our objective is to alert the reader to this infrequent injury that can be potentially life-threatening to an athlete if it is not recognized and treated immediately.

## CASE REPORT

An 18-year-old male wide receiver was injured during a varsity high school football game. The injury was sustained when the athlete caught a pass and was hit by the defender on the right side of the chest wall. At the time of the injury, the athlete was wearing a recommended rib vest for protection (Rawlings GB Rib Vest; Rawlings Sporting Goods Co, St Louis, MO). After catching the pass, he was able to "bounce off" the initial hit to his right thorax and run for an additional 5 yards before being tackled. Once tackled, the athlete removed himself from the game without assistance, explaining he felt like "the wind had been knocked from him."

In the initial examination, the athlete indicated that he had no pain but a general soreness in the right side of his chest and was having "a hard time breathing." Ice was provided to the injury site and he was told that he would be observed and re-examined before being allowed to play. After several minutes, he started to complain of increasing pain, difficulty in breathing, a feeling of lightheadedness, and not being able to sit up straight without pain. At this time, he was examined by

the team physician who removed the athlete from the sideline into the locker room. The locker room examination by the team physician included a history and physical examination of the injury site. This examination included auscultation, percussion, and observation of the athlete's breathing. The diagnosis by the team physician was of a possible fractured rib and punctured right lung. The athlete was immediately transported by ambulance to the hospital where the diagnosis was confirmed with a chest x-ray and examination by the emergency room physician. The traumatic closed pneumothorax was caused by a fractured right 5th rib which lacerated the visceral pleura.<sup>4</sup>

The athlete was admitted to the hospital and underwent a thoracostomy and insertion of a chest tube. A thoracostomy is a surgical procedure in which an incision of the chest wall is made, with maintenance of the opening for drainage.<sup>6</sup> The chest tube was used to inflate the lung and for drainage of the pleural cavity. The athlete was hospitalized for 12 days and placed on antibiotics for an additional 2 weeks. Since this was the last football game of the season, the athlete did not return to play but made a full recovery.

## DISCUSSION

If not recognized and treated immediately, a large pneumothorax could be fatal.<sup>4</sup> If left untreated, a pneumothorax results in a collapse of the lung tissue which may cause a mediastinal shift.<sup>5,7</sup> This mediastinal shift causes the collapsed lung to be pressed against the uninjured lung and heart resulting in a reduction of their functioning capacity and possible failure. A pneumothorax could also result in a tracheobronchial fracture or an esophageal rupture, which could have potentially fatal complications.<sup>4</sup> It should also be noted that, in many cases of chest trauma, a pneumothorax results even though there are no broken ribs. Finally, an untreated pneumothorax could cause severe dyspnea, shock, life-threatening respiratory failure, and/or circulatory collapse.<sup>1</sup>

A suspected traumatic pneumothorax can lead to the rapid deterioration in an athlete's breathing and alter other vital body signs. Signs and symptoms are given in Table 1. It is important that the athletic trainer be familiar with these signs and symptoms, and not dismiss any injury complaint without a thorough examination. If a pneumothorax is suspected, the athletic trainer should follow specific care guidelines (Table 2).

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**Table 1. Signs and Symptoms of a Pneumothorax**

Sudden sharp chest pain  
Dyspnea  
Shortness of breath  
Occasionally, a dry, hacking cough on onset  
Pain, which may be referred to the corresponding shoulder, across the chest, or over the abdomen  
Lightheadedness  
Tightness in chest  
Decreased or absent breath sounds over the collapsed lung  
Cessation of normal chest movements on the affected side  
Fall in blood pressure  
Tachycardia

**Table 2. Care for a Suspected Pneumothorax**

Keep the athlete quiet and calm.  
Place the athlete in a sitting position.  
Have the athlete try to control coughing and gasping.  
Do not give fluids to the athlete.  
Immediately transport the athlete to a medical facility for x-rays.

Besides the obvious medical considerations this injury presents, it also demonstrates the importance of communication between the athlete, athletic trainer, and team physician. The athletic trainer-student athlete relationship is unique and evolves over time by building on open communication and trust. This communication and trust is important in an injury evaluation and cannot be established by part-time medical coverage or coverage that varies or changes from year to year. When evaluating an injury, identify the obvious complaints but listen and suspect all other possibilities. For what at first might seem like a routine injury could in fact be a medical emergency. Know your athletes; listen to how they describe their injuries; be suspicious; err on the side of caution; and observe them for any other possible injury considerations.

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# Adaptation of a Foot Plate for Use in an Isokinetic and Isotonic Leg Press

Herbert K. Amato, DA, ATC; Lonnie A. Smith, ATC

**ABSTRACT:** The use of isokinetic equipment and the leg press exercise have been major components of rehabilitation for the past several years when redeveloping muscular strength. Recently, closed kinetic chain exercises have been shown to be more beneficial and have less adverse affects on the knee when rehabilitating a patient's lower extremity. The purpose of this

article is to introduce the leg press foot plate to the rehabilitative community. This foot plate is a versatile piece of equipment that has been adapted for use with various isokinetic, isometric, and isotonic devices in order to do leg press exercises. The device allows for closed kinetic chain strengthening and testing from equipment typically used only for open kinetic chain activities.

**A**thletic trainers must consider many factors when designing an ideal knee rehabilitation protocol. An effective rehabilitation program should restore the knee's normal strength, range of motion, and function. Theoretically, these goals should be accomplished as rapidly as possible without causing harm to the patient. Over the past few years, the sports medicine community has witnessed more aggressive rehabilitation protocols following anterior cruciate ligament (ACL) reconstruction.<sup>7,19</sup> Unfortunately, aggressive rehabilitation protocols may place undue stress on the affected knee if shear and compressive forces are not considered.

Isokinetics are commonly employed when rehabilitating the extremities. Isokinetic devices offer a means of strengthening and identifying discrepancies between limbs. However, commonly prescribed isokinetic exercises and testing techniques of the knee (flexion and extension) are performed in an open kinetic chain position. Stress placed on the ACL increases dramatically within the last 35° of knee extension<sup>3,4,9,12,13,16,21</sup> and increases as the amount of force generated by the quadriceps increases in an open kinetic chain.<sup>2</sup> The major flaw of using open kinetic chain isokinetic devices is that the lower extremity cannot be exercised or tested in a functional position.<sup>14,19</sup> The exception to this statement would be any athlete who performs kicking type movements as part of his/her sport.

Various researchers have shown that open kinetic chain exercises impose deleterious shear forces and decrease the compressive forces on the knee.<sup>1,2,4,9,15-17,19</sup> These forces place added stress on the ACL at various knee joint angles. Butler et al<sup>4</sup> have reported that the ACL is the main stabilizing structure against anterior/posterior shear forces across the tibiofemoral joint and absorbs up to 86% of this force. Hirokawa et al,<sup>11</sup> reported that, during open kinetic chain exercise, anterior displacement of the tibia (7 mm) occurred between 0° and 80° of extension, and concluded that the quadriceps created rotation of the tibia throughout the entire range of motion. In comparison to open kinetic chain exercises, the forces applied to the knee in closed

kinetic chain exercises differ in a more functional and predictable manner.<sup>6,19</sup>

Closed kinetic chain exercises of the lower extremity are those in which the foot comes into contact with either the ground, a pedal, or a foot plate. These exercises are commonly performed in a weight-bearing position, where stabilization of the distal segment of the leg occurs.<sup>18</sup> The ankle, knee, and hip together comprise the lower extremity kinetic chain. Tibiofemoral joint compression forces in the weight-bearing position add stability to the knee joint<sup>18,19</sup> because the articulating surfaces fit closely together. Also, the majority of the joint structures are under maximum tension. Graham et al<sup>9</sup> reported that anterior shear forces reach only 0.20 times the body weight during walking; however, these forces can reach 0.43 times the body weight during a maximum isometric exercise involving an open kinetic chain activity. Closed kinetic chain exercise enhances coactivation of the hamstrings and quadriceps to aid in the dynamic stability of the knee complex.<sup>20</sup> Numerous authors have found that the strength of the hamstring muscles are critical in allowing coactivation to occur in order to prevent anterior translation of the tibia.<sup>3,10,12,20</sup> Furthermore, closed kinetic chain exercises facilitate normal proprioceptive feedback by placing functional stress on the extremity.<sup>14,19</sup>

## WHY AND HOW THE FOOT PLATE WAS DEVELOPED

The leg press foot plate was developed: 1) to objectively measure isometric, isotonic, and isokinetic leg press strength, and 2) to reduce the shear forces placed on the knee during these types of exercises or tests. The original adaptation involved the Cybex plantar/dorsiflexion foot plate (Cybex, Division of Lumex, Ronkonkoma, NY; Fig 1).<sup>5</sup> Modification of the plantar/dorsiflexion plate was first published by Engle<sup>8</sup> in 1983. These changes involved removing two lateral adjustment arms, welding a half-inch circular tube to the underside of the channel, and adding support to the foot plate (Fig 2). In conjunction with Winchester Physical Therapy and Sports Medicine, Inc (Winchester, VA), significant modifications in the original design of the foot plate were made. In the original design, the foot was loosely fitted on the foot plate. To keep the foot from moving around and slipping off the foot plate, the heel cup and mechanism that holds

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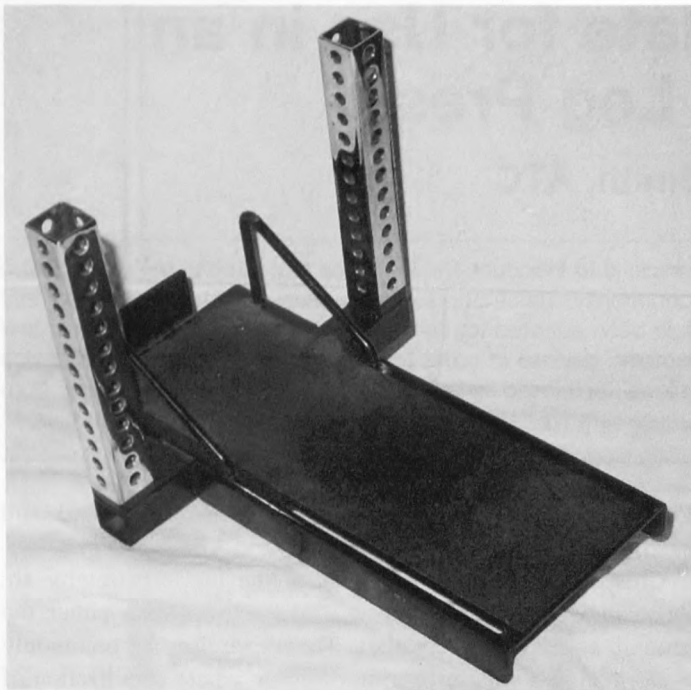


Fig 1. Cybex plantar/dorsiflexion foot plate (side view).

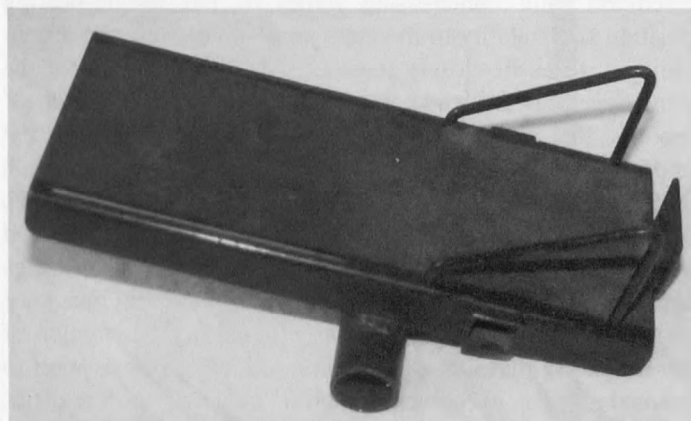


Fig 2. Original modification of leg press foot plate (side view).

the foot to the foot plate were redesigned (Fig 3). The heel cup was modified by rounding a piece of bent steel in the shape of a half circle (Fig 4). This change prevented the heel from moving from side to side. The second modification involved removing the side bars from the original foot plate and cutting out an angled opening from the channel for the VELCRO® strips to run through (Fig 4). These changes allow for greater foot stability and comfort while performing the leg press. A patent is pending by the Winchester Physical Therapy and Sports Medicine, Inc for this new design.

## DESCRIPTION OF THE TECHNIQUE

### Professional Exercise Table (Model 345) and Orthotron

The foot plate is versatile and can be used with numerous devices in addition to the Cybex. For instance, with the foot plate, subjects can perform a full range-of-motion isotonic



Fig 3. Redesigned leg press foot plate (side view).

leg press on the Professional Exercise Table (Model 345; Bailey, Lodi, OH; Fig 5 or isokinetic or isometric leg presses on any Orthotron (Cybex, Division of Lumex, Ronkonkoma, NY) with the leg press plate attached (Fig 6). To position the patient for both the Orthotron and the Professional Exercise Table, the patient lies supine on the floor or an exercise mat while resting on the elbows, as shown in Figures 5 and 6. This position allows movement in the sagittal plane along the lower arc of motion about the axis of the machine. Resting on the elbows will cause slight flexion of the trunk, increasing the anterior pelvic tilt position, which increases the tension of the hamstrings and creates a greater co-contraction in counteracting the anterior tibial forces due to the quadriceps.<sup>18</sup>

By placing the weight on the outside arm of the Professional Exercise Table, position the patient so that the involved limb is fastened to the bar next to the weight bar (Fig 5). To prevent the weight bar from interfering with the movement of the involved limb, position the patient so that the opposite leg is nearest to the center of the Professional Exercise Table chair. On the Orthotron, place the patient with the lateral aspect of the involved side closest to the dynamometer, as shown in Fig 6. Use the lower wooden support on the Orthotron table to limit the degrees of extension. On the Professional Exercise Table, there is no physical method of limiting knee extension.

Place the Orthotron or Professional Exercise Table against a wall to prevent any backward movement. Control the amount of extension and flexion of the lower extremity by adjusting the height of the foot plate on the moving arm of the Orthotron or Professional Exercise Table and by manipulating the distance of the patient from the axis of the movement. Allow the hip to approach full extension (to ensure appropriate hamstring recruitment), taking advantage of the closed kinetic chain.<sup>18</sup> The subject should be wearing shoes at all times while performing this exercise.

### Cybex II

The starting position when using the Cybex II (Lumex, Ronkonkoma, NY) is full hip flexion. This technique is similar to that of the hip extension/flexion technique described in the *Isolated Joint Testing & Exercise Handbook*.<sup>5</sup> Rotate the



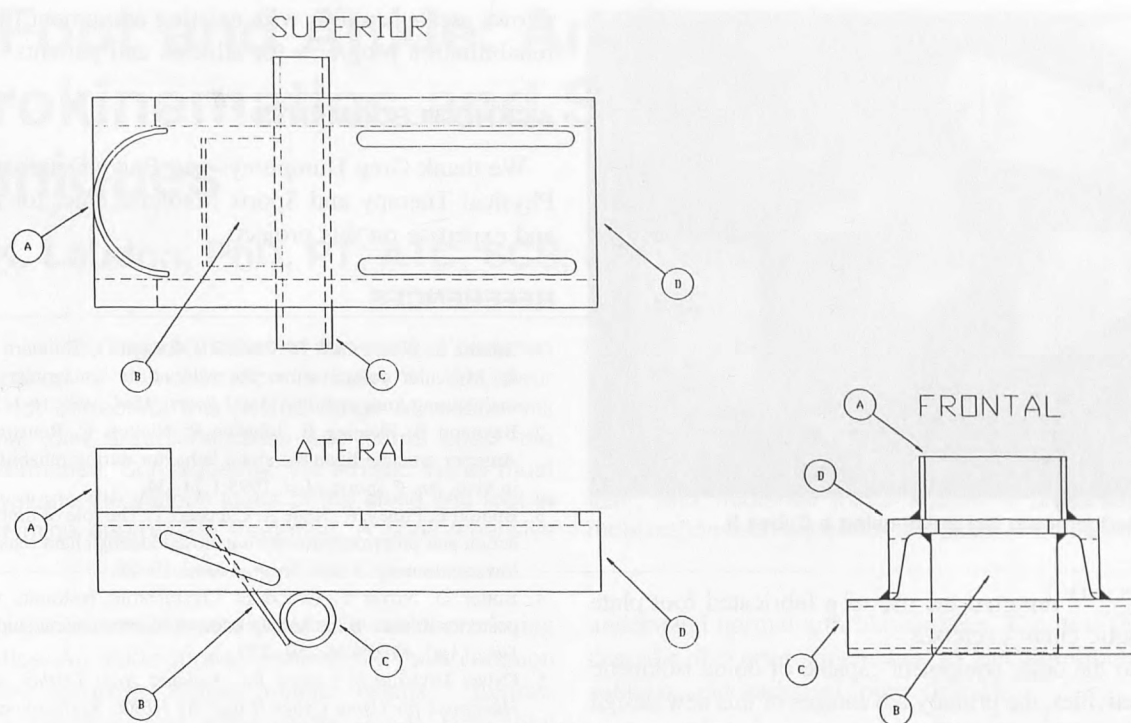


Fig 4. Blueprint of the leg press foot plate. A, 5" × 2" × 1/8" bent steel; B, 3.5" × 3" × 0.125" plate; C, 7" × 1.025" inner diameter tube or pipe; and D, 12" × 5" × 1.75" channel.

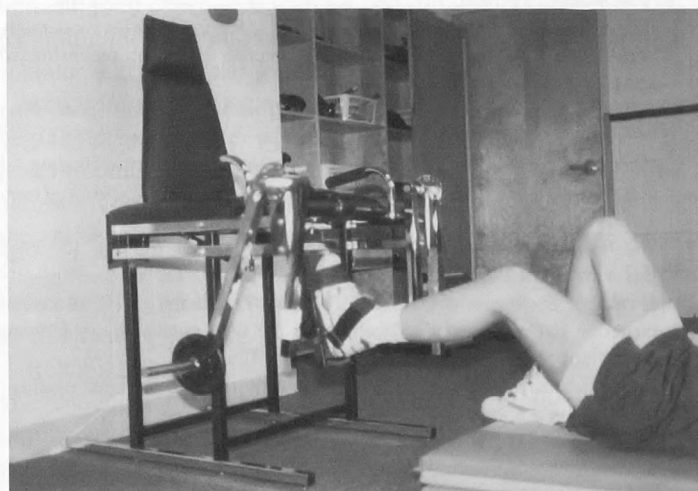


Fig 5. Isotonic leg press using the Professional Exercise Table, Model 345.



Fig 6. Isokinetic/Isometric leg press using an Orthotron.

dynamometer to face the right or the left, depending on the side to be tested (Fig 7). Fix the upper body extremity testing table (UBXT) backrest at 20° to increase the anterior pelvic tilt.<sup>18</sup> The 20° position was added to the shaft to prevent the patient from sliding. Place the UBXT seat in the middle position and adjust the foot rest height for patient comfort. Stabilize the trunk and the pelvis with VELCRO straps once the patient has been positioned. Using the UBXT results in a nonlinear movement of the limb. This position causes the lower extremity to move about an arc around the axis of the machine—just the opposite of the Orthotron and Professional Exercise Table.

Position the foot plate so that the hip approaches full extension. Align the hip straight with the foot, because movement for this exercise occurs in the sagittal plane. The patient's foot should be dorsiflexed with the hip/knee approaching full

extension on the involved side for the leg press exercise (Fig 7). (Set the range-limiting device on the dynamometer to restrict the undesired amount of knee extension.) Having the patient place the ankle into dorsiflexion prevents the lower extremity from achieving terminal extension. Once the patient has reached the appropriate position, lock the UBXT to prevent any movement of the table. To perform the isometric leg press correctly, the knee needs to be positioned in the desired amount of knee flexion while keeping the hip aligned with the foot.

#### ADVANTAGES AND DISADVANTAGES

A review of the literature yielded little information in comparing the leg press foot plate to similar pieces of equipment. Kin-Com (Chattanooga Group, Inc, Hixson, TN) has commercially developed a device to do an isokinetic leg press.<sup>6</sup>

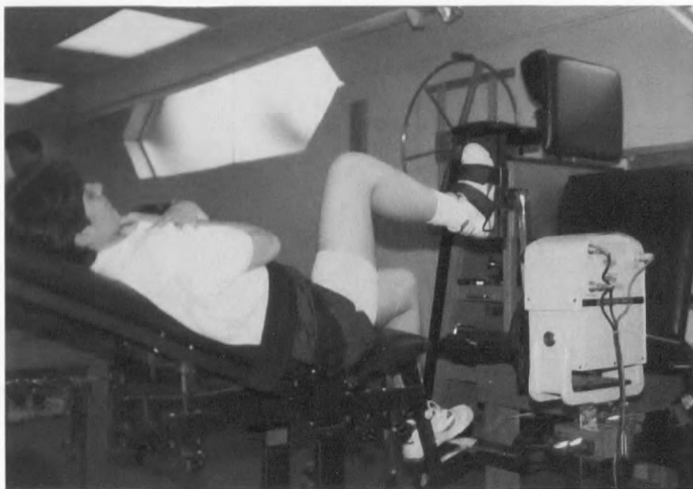


Fig 7. Isokinetic/Isometric leg press using a Cybex II.

Three articles<sup>8,14,15</sup> reported the use of a fabricated foot plate for closed kinetic chain exercises.

In relation to the other equipment capable of doing isokinetic closed chain activities, the primary advantages of this new design are its versatility, cost, and stability of the foot on the foot plate. The leg press foot plate can be used on a Professional Exercise Table (Fig 5), an N-K 330 BRQ Exercise Table (N-K Products, Soquel CA), as well as the Orthotron (Fig 6) and Cybex (Fig 7) isokinetic devices. We believe the redesigned heel plate and modified location of the VELCRO strips make the foot more stable during the pull phase of the leg press during isokinetic exercises. The pull phase of an isokinetic exercise is the reciprocal movement of the leg press. The prime movers in bringing the lower extremity back into the starting position of the leg press are hip flexors, hamstrings, and dorsiflexors.

In performing an isokinetic leg press using the foot plate, a disadvantage is the inability to limit specific ranges of motions. An example of this limitation would be if a rehabilitation protocol restricts full knee extension. The range-limited device limits extension to some extent; however, as the ankle moves into plantar flexion during the exercise, the angle at the knee moves closer to 0° of extension. This potential problem is due to the inability to keep the foot in dorsiflexion. Positioning the athlete so the foot is in extreme dorsiflexion and instructing the athlete not to lock out the knee decreases the problem.

The second concern with using the foot plate on an isokinetic device for closed kinetic chain exercises is the amount of force that can be generated. Working the muscles of the hip alone during isokinetic testing in a healthy individual may exceed a peak torque of 400 ft-lb.<sup>5</sup> The Cybex II is designed to withstand occasional peak torques up to 360 ft-lb; however, the safe limit for repeated forces is 240 ft-lb.<sup>5</sup> At slow speeds of contraction, the isokinetic leg press could easily exceed these recommended limits.

There are many factors for the athletic trainer and sports therapist to consider when dealing with the rehabilitation of an athlete with a lower extremity injury. The development of the foot plate has allowed several pieces of equipment typically used only for open kinetic chain exercises to be modified for closed kinetic chain strengthening and testing. This versatility

allows greater options with existing equipment for developing rehabilitation programs for athletes and patients.

## ACKNOWLEDGMENTS

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# The Foot and Ankle: An Overview of Arthrokinematics and Selected Joint Techniques

Janice K. Loudon, PhD, PT, ATC, SCS; Stephanie L. Bell, MS, PT

**ABSTRACT:** Limited range of motion of the ankle is common following a period of immobilization or injury to the lower extremity. If not corrected, this limited range of motion will disturb normal joint arthrokinematics and could affect the athlete's performance. Consequently, the athletic trainer must thoroughly evaluate the various joints of the ankle and foot in order to determine appropriate treatment. A comprehensive

evaluation should include assessment of passive accessory motions at the foot and ankle. If accessory movements are restricted at any joint, mobilization techniques can be used to restore normal ankle/foot joint arthrokinematics. This article describes the biomechanics of the tibiofibular, talocrural, subtalar, and midtarsal joints and is a presentation of basic mobilization techniques for the ankle and related joints.

Ankle injuries are commonly seen in athletic training facilities. An ankle sprain is one of the most common injuries occurring during athletic events.<sup>16</sup> Injuries range from a simple lateral ankle sprain (grade I) to total disruption of the joint (grade III), requiring a period of immobilization. Immobilization can result in adhesion formation and joint capsule shortening and can involve several joints, including the proximal and distal tibiofibular joints, and/or the subtalar and midtarsal joints.<sup>1,5</sup>

According to Akeson et al,<sup>1</sup> fibrofatty connective tissue begins to proliferate within a joint as early as 2 weeks postimmobilization of an adult rat knee. From 30 to 60 days, adhesions develop between the fibrofatty connective tissue and the underlying cartilage surface. As a result of these tissue changes, joint arthrokinematics might be altered. Ankle stiffness can also result from immobilization of other joints, such as the knee or hip.

Rehabilitation of the injured ankle should focus on progressive range of motion and strengthening. Complete range of motion at any given joint requires appropriate soft tissue length and full accessory motions. Therefore, to improve range of motion, soft tissue stretching and restoration of normal joint arthrokinematics should be incorporated. If normal arthrokinematics of the foot and ankle are not restored, abnormal stress is placed on the ankle and surrounding joints, possibly resulting in reinjury. The purpose of this article is to review the arthrokinematics of the ankle and foot complex (proximal tibiofibular joint to midtarsal joint) and the principles of joint mobilization specific to these joints.

## NORMAL ARTHROKINEMATICS

To appreciate the selection and application of joint mobilization techniques for the foot and ankle, it is important to first

understand normal arthrokinematics. The next few paragraphs describe the arthrokinematics of the tibiofibular, talocrural, subtalar, and midtarsal joints (Fig 1).

### Tibiofibular Joint

The tibiofibular joint consists of the junction between the tibia and fibula. Proximally, this joint is classified as a plane synovial joint in which gliding occurs between the articulating surfaces. The proximal joint is primarily affected by movement of the knee, but can also be affected by traumatic inversion forces directed at the ankle.<sup>9,12,13</sup>

The distal tibiofibular joint is the articulation between a concave tibial facet and a convex fibular facet.<sup>13</sup> Movement at the foot will have a direct effect on the distal tibiofibular joint. During foot dorsiflexion, the fibula must glide superiorly and rotate laterally.<sup>13</sup> This movement occurs to accommodate the wider anterior portion of the talus as it moves into the mortise.<sup>8</sup> Actual separation of the distal tibiofibular joint with dorsiflexion varies from 1 mm to 4 mm of spread.<sup>3,8</sup> During plantar flexion, the accessory movement is reversed with the fibula gliding inferiorly and internally rotating toward the tibia.

### Talocrural Joint

The talocrural joint is a uniaxial modified hinge synovial joint designed for stability. It is comprised of the proximal articular surface of the talus (trochlea) and the distal articular surfaces of the tibia and fibula. Motion at the talocrural joint is primarily dorsiflexion and plantar flexion. Because the trochlea of the talus is wider anteriorly than posteriorly and the radius of curvature is longer laterally, a helical movement occurs during plantar flexion-dorsiflexion rather than a pure swing. During dorsiflexion the talus glides in a posteromedial direction on the tibia, while in plantar flexion the talus glides in an anterolateral direction. Consequently, weight-bearing dorsiflexion of the ankle is accompanied by internal rotation of the limb, and weight-bearing plantar flexion is accompanied by

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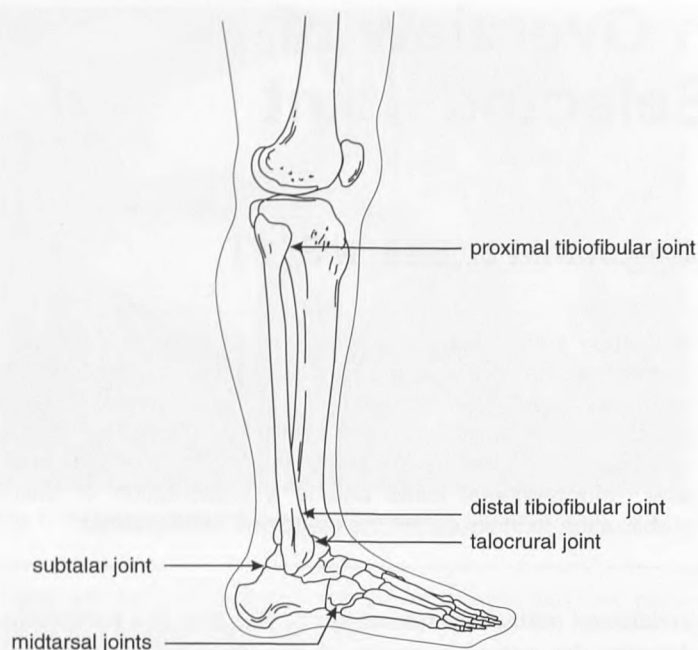


Fig 1. Joints of the lower leg.

external rotation of the limb. Accessory component movements for plantar flexion and dorsiflexion are listed in Table 1.

### Subtalar Joint

The subtalar joint consists of a bicondylar articulation between the talus and calcaneus.<sup>2</sup> The arthrokinematics of the subtalar joint can be very complicated due to its triplanar movement. Subtalar joint motion in weight bearing and non-weight bearing are described differently.<sup>1,4</sup> The nonweight-bearing subtalar joint motion is described strictly by calcaneal movement. Pronation consists of calcaneal eversion, calcaneal dorsiflexion, and calcaneal abduction (medial tilt), whereas supination involves calcaneal inversion, calcaneal plantar flexion, and calcaneal adduction (lateral tilt).

Pronation occurs early in the gait cycle; the foot begins to pronate at heel strike and continues until midstance. Weight-bearing pronation consists of calcaneal eversion, talar adduction (medial glide), talar plantar flexion (posterior glide), and tibiofibular internal rotation. Supination occurs during midstance through preswing. Weight-bearing supination involves calcaneal inversion, talar abduction (lateral glide), and talar dorsiflexion (anterior glide) with tibiofibular external rotation.

The importance of subtalar joint pronation becomes apparent during gait as the foot becomes a mobile adapter during the loading response to accommodate to the ground.<sup>4</sup> During the later stages of gait, the foot supinates to become a rigid lever in preparation for push-off.<sup>4</sup>

### Midtarsal Joint

Themidtarsal joint is composed of the talonavicular and calcaneocuboid joints.<sup>12</sup> When the subtalar joint is supinated, themidtarsal joint becomes locked. It unlocks when the subtalar joint is pronated. Supination requires inferior and medial glide of the navicular on the talar head, while a superior and lateral glide of the navicular accompanies eversion.<sup>6</sup> Table 2 presents the accessory joint components of supination and pronation.

In addition to basic range-of-motion measurement, strength assessment, and joint stress testing, the athletic trainer's evaluation of the ankle-foot complex should include assessment of joint play movements. Each joint should be assessed for normal accessory movements. Any disturbance along the lower extremity chain causing alteration of normal arthrokinematics will result in compensation at any or all other lower extremity joints.<sup>15</sup>

### JOINT MOBILIZATION FOR THE ANKLE

Passive accessory movements are performed by an athletic trainer to assess joint arthrokinematics, and, when indicated, joint mobilization is used to increase joint mobility within the anatomical limit of a joint's range of motion.<sup>2,9,10,14</sup> Two distinct grading systems are commonly used for joint mobilization techniques.<sup>7,9,13</sup> One technique, described by Maitland,<sup>11</sup> uses a five-grade system incorporating various degrees of oscillations within various degrees of tissue resistance. A second system developed by Kaltenborn<sup>7</sup> uses a three-grade system of sustained translatory techniques (Fig 2). Treatment direction is generally indicated by the convex-concave rule.<sup>7,9</sup> The convex-concave rule states that, when a convex surface moves on a concave surface, the mobilization force is applied opposite to the angular movement of the bone. If the moving surface is concave, the mobilization force occurs in the same direction as bone movement.

For the purpose of stretching a tight joint capsule following ankle immobilization, sustained stretch techniques can be used as a beginning technique.<sup>9</sup> This technique uses the gliding component of joint motion to restore joint play and improve joint mobility. A sustained glide force of 6 to 10 seconds is applied parallel to the joint surfaces with a force large enough to place a stretch on the joint capsule. After the sustained 6 to 10 seconds, the force is partially released, then reapplied at 3- to 4-second intervals.<sup>8,9</sup> The number of sustained stretches per session will depend on the effectiveness of the technique in regaining joint play.

Reassessment before and after each treatment will indicate the need for further joint mobilization. One general contrain-

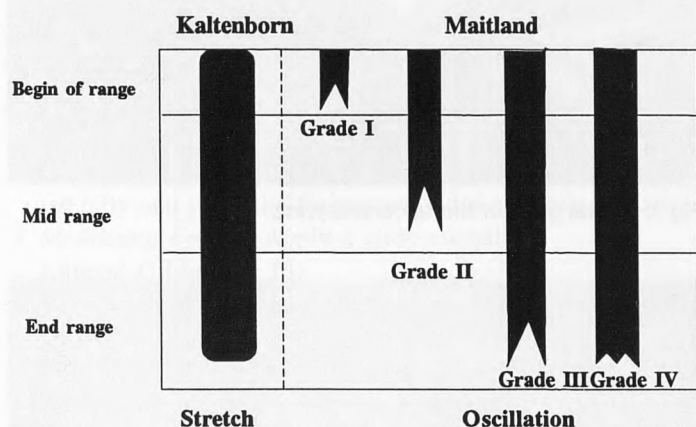
Table 1. Component Movements for Dorsiflexion and Plantar Flexion

	Dorsiflexion	Plantar Flexion
Proximal tibiofibular joint	Fibula glides superiorly	Fibula glides inferiorly
Distal tibiofibular joint	Superior glide of tibia and fibula	Inferior glide of tibia and fibula
Talocrural joint	Talus posteromedial glide on tibia	Talus anterolateral glide on tibia



**Table 2. Component Movements for Supination and Pronation**

	Supination	Pronation
Subtalar joint (nonweight bearing)	Calcaneal inversion, plantar flexion, and adduction	Calcaneal eversion, dorsiflexion, and abduction
Subtalar joint (weight bearing)	Calcaneal inversion, talar abduction, and dorsiflexion	Calcaneal eversion, talar adduction, and plantar flexion
Midtarsal joint	Inferior and medial glide of the navicular on the talus	Superior and lateral glide of the navicular on the talus



**Fig 2. Joint mobilization techniques.**

dication to joint mobilization is hypermobility. When dealing with an unstable joint, one would not apply these techniques in the hypermobile planes. Other contraindications include: acute stage of inflammatory reaction, infection, advanced osteoarthritis, and vascular disease.<sup>14</sup>

An example of an indication for ankle/foot mobilization would be following a healed bimalleolar fracture for which the athlete was immobilized for 6 weeks. Once the cast was removed, gentle mobilization of the proximal and distal fibula and subtalar joint can begin if stiffness exists in these joints. Gentle oscillatory distraction can be used to aid in swelling reduction, pain reduction, and lymphatic drainage. More specific capsular stretching should be initiated to improve limited range of motion once pain and swelling are no longer a primary issue.

The following section is designed as a review of accessory movement for motions about the ankle and foot. For a more complete description of joint mobilization techniques, refer to the reference list. It is the responsibility of the reader to pursue supervised instruction before directly applying these techniques to the athlete.

## JOINT MOBILIZATION TECHNIQUES

### Tibiofibular Joint

#### Proximal Tibiofibular Joint (Anterior/Posterior Glide; Fig 3)

- **Indication**—To increase joint play at the tibiofibular joint. The fibular head must move anteriorly on knee flexion and posteriorly on knee extension.
- **Patient**—Supine with the knee flexed to 90° with foot flat.



**Fig 3. Anterior/posterior glide of the proximal tibiofibular joint.**

- **Operator**—Stabilize the knee with the medial hand. Grasp the head and neck of the proximal fibula with the lateral hand, the thumb contacting anteriorly, and the index and long finger pads contacting posteriorly. (Be cautious of the peroneal nerve.)
- **Mobilizing Force**—The lateral hand may glide the proximal fibula posteriorly or anteriorly.

#### Distal Tibiofibular Joint (Posterior Glide; Fig 4)

- **Indication**—To assist in increasing the joint mortise spread during dorsiflexion.
- **Patient**—Supine with knee in extension.
- **Operator**—Place the fingers of the medial hand under the tibia and the thumb over the tibia to stabilize it. Place the lateral hand using the thenar eminence over the lateral malleolus, with fingers underneath.
- **Mobilizing Force**—Glide the lateral malleolus posteriorly directing force through the left thenar eminence.

### Talocrural Joint

#### Distraction (Fig 5)

- **Indication**—To increase joint play at the ankle mortise. Oscillations may also be used for pain control.
- **Patient**—Supine with lower extremity extended and ankle in a resting position.
- **Operator**—Stand or sit at the end of the table and wrap the fingers of both hands over the dorsum of the patient's foot. Place your thumbs on the plantar surface of the foot.



Fig 4. Posterior glide of the distal tibiofibular joint.



Fig 7. Dorsal glide of the talocrural joint.



Fig 5. Distraction of the talocrural joint.

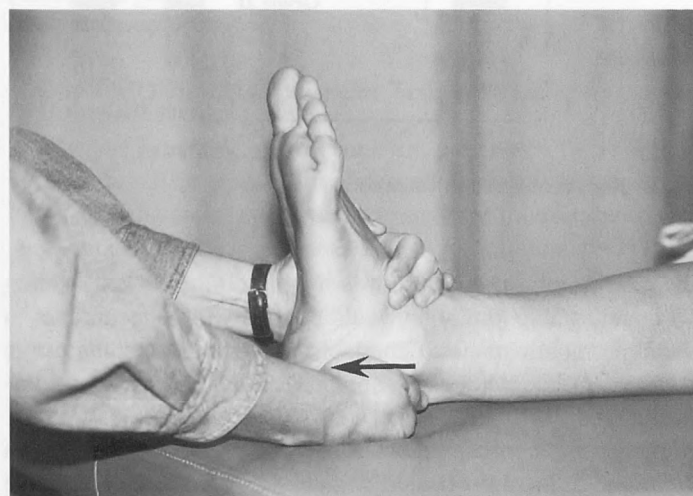


Fig 8. Distraction of the subtalar joint.



Fig 6. Ventral glide of the talocrural joint.

- *Mobilizing Force*—Distract the joint with both hands by leaning back, being careful to keep the athlete's foot in the mobilizing plane.

#### **Ventral Glide (Fig 6)**

- *Indication*—To increase plantar flexion.

- *Patient*—Prone with knee relaxed and foot over the edge of the plinth.
- *Operator*—Operator's cranial hand grasps the anterior/distal surface of the tibia and fibula. The caudal hand contacts the posterior talus/calcaneus with the web space.
- *Mobilizing Force*—Glide the calcaneus and talus downward in an anterior direction.

#### **Dorsal Glide (Fig 7)**

- *Indication*—To increase dorsiflexion.
- *Patient*—Supine and relaxed with heel over the edge of the plinth.
- *Operator*—Stabilize the distal tibia against the plinth with the cranial hand, wrapping the fingers around posteriorly. The web of the caudal hand grasps the neck of the talus with the fingers wrapped around the foot.
- *Mobilizing Force*—Glide the talus posteriorly on the tibia.

### **Subtalar Joint**

#### **Distraction (Fig 8)**

- *Indication*—General mobility; pain control.
- *Patient*—Supine with leg supported on the table.



- *Operator*—The distal hand grasps around the calcaneus from the posterior aspect of the foot. The other hand fixates the talus.
- *Mobilizing Force*—Pull the calcaneus distally with respect to the long axis of the leg. Medial and lateral glides of the calcaneus on the talus are used to improve eversion and inversion.

#### Medial Glide (Fig 9)

- *Indication*—To increase medial glide of the calcaneus on the talus.
- *Patient*—Sidelying with leg supported on the table and lateral side up.
- *Operator*—Align shoulder and arm parallel to the bottom of the foot. Stabilize the talus with your proximal hand. Place the base of the distal hand on the side of the calcaneus laterally and wrap the fingers around the plantar surface.
- *Mobilizing Force*—Apply a glide medially.

#### Lateral Glide (Fig 10)

- *Indication*—To increase lateral glide of the calcaneus on the talus.
- *Patient*—Sidelying with leg supported on the table and the medial side up.

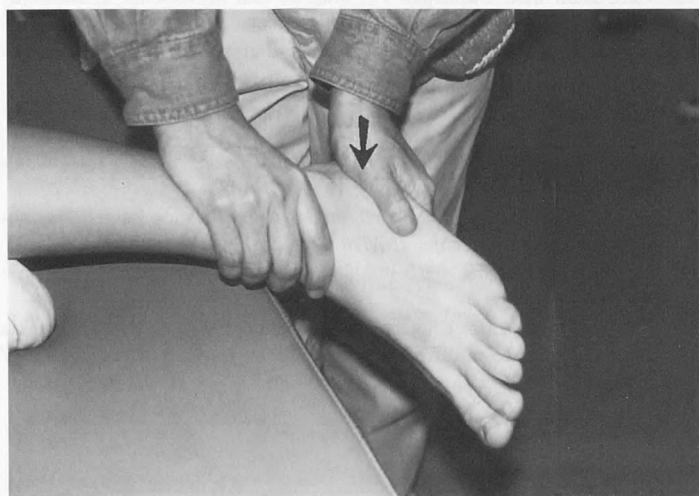


Fig 9. Medial glide of the subtalar joint.



Fig 10. Lateral glide of the subtalar joint.

- *Operator*—Align shoulder and arm parallel to the bottom of the foot. Stabilize the talus with your proximal hand. Place the base of the distal hand on the side of the calcaneus medially and wrap the fingers around the plantar surface.
- *Mobilizing Force*—Apply a glide laterally.

#### Midtarsal Joint

These glides can be used for the talonavicular joint, calcaneocuboid joint, naviculocuneiform joint, or the cuneiform-metatarsal joints.

#### Plantar Glide (Fig 11)

- *Indication*—To increase the medial arch of the foot.
- *Patient*—Supine with the knee relaxed.
- *Operator*—Fixate the more proximal bone with your finger by grasping dorsally at the level of the talar neck, the thumb wraps around laterally and the rest of the fingers wrap around medially. The other hand grasps the navicular, the thumb contacts dorsally and the hand and fingers wrap around the foot medially and plantarly.
- *Mobilizing Force*—Move the distal bones plantarly.



Fig 11. Plantar glide of themidtarsal joint.



Fig 12. Dorsal glide of themidtarsal joint.



Fig 13. Talar glide in a weight-bearing position.

#### Dorsal Glide (Fig 12)

- **Indication**—To decrease the medial arch of the foot.
- **Patient**—Prone with hip and knee flexed.
- **Operator**—Fixate the calcaneus with one hand. With your other hand, wrap your fingers around the lateral side of the foot.
- **Mobilizing Force**—Move the distal bones in a dorsal direction.

#### Weight-Bearing Talar Glide (Fig 13)

- **Indication**—To increase dorsiflexion.
- **Patient**—Standing with the knee slightly bent.
- **Operator**—Apply pressure to the anterior talus.

- **Mobilizing Force**—Pressure should be applied in a posterior glide direction as the patient flexes his knee and dorsiflexes his foot.

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# The "Tape Cast" Functional Taping for the Injured Athlete

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Ankle taping has been found to be an accepted method of protection for athletes for many years. Research has shown the effectiveness of various taping techniques in providing support and protection to the ankle through restriction of motion following application of the tape. However, it has also been found that restriction of motion gradually decreases as the duration of exercise increases.<sup>1,2</sup>

The "Tape Cast" technique described here is designed for the acute ankle sprain, or an ankle sprain that is in mid to late rehabilitation. The taping technique seems to allow the athlete to participate with greater support for a longer period of time. This technique is an extended variation of standard prophylaxis for an inversion ankle sprain. It has been common practice among trainers to use additional products such as moleskin or other heavy tapes to aid in the stabilization of the previously injured ankle. After trial of many different methods as to technique for the overlaying tape job, the authors have found the method presented here to be extremely effective as well as functional. While ankle taping techniques are most generally designed for medial and lateral support, the Tape Cast also adds posterior, anterior, and compression support for the joint.

## SUPPLIES

- One roll of 3-inch elastic adhesive tape
- One roll of white linen adhesive tape (tape used for this article was 1.5 inches)
- Prewrap
- Heel and lace pads
- Tape adherent
- Bandage scissors

## METHOD

1. Athlete should be seated comfortably with his/her leg extended and the foot in a 90° neutral position.
2. To prepare the ankle for taping, shave it and apply a good amount of adhesive spray. Allow spray to dry slightly. This is important for proper adhesion given the added stresses of the elastic adhesive tape. Heel and lace pads and prewrap are then applied. Using 1.5-inch tape, place three overlapping (about one-third-inch wide) anchor strips on lower leg beginning just above the musculotendinous junction of the gastrocnemius soleus muscle complex, and one anchor strip on the midfoot (Fig 1).

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Fig 1. Application of three overlapping anchor strips on the lower leg and one on the midfoot.

3. Ask the athlete to place his/her foot in moderate plantar flexion. Using 3-inch elastic adhesive tape, apply a posterior strap to the anchor on the lower leg by splitting the elastic tape and wrapping it around the leg (Fig 2). This strap should be applied on a slight angle, so that when stress is applied, the tape does not roll or migrate. Unroll the tape and cut it evenly with the end of the toes. This will provide sufficient length for the tape to be split again. Apply slight tension to the tape, and then secure it to the forefoot as on the lower leg (Fig 3). After applying this tape strap, ask the athlete to dorsiflex the foot back to neutral (Fig 4). The strap is applied this way to provide compression of the calcaneus into the talus. The theory here is that the compression should further stabilize the overall mortise of the joint.



Fig 2. Application of a posterior strap to anchor on lower leg.

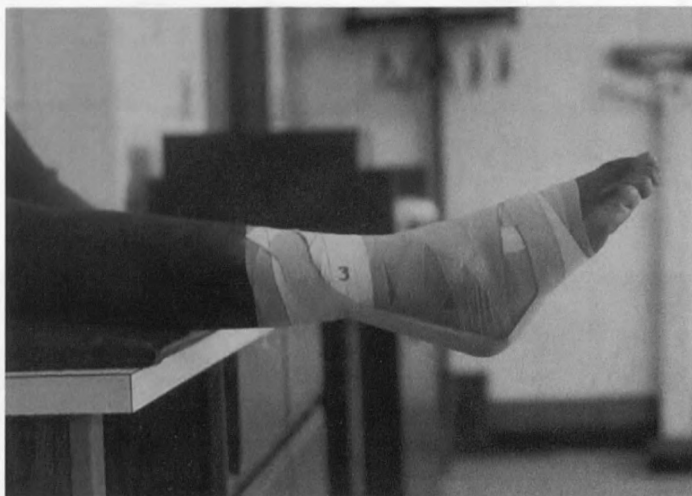


Fig 3. Tape secured to the forefoot after being split.



Fig 5. Application of anterior strap.



Fig 4. Foot dorsiflexed back to neutral.



Fig 6. Application of an elastic adhesive strap on the medial aspect.

- Check the areas where the elastic tape has been wrapped around the foot and leg and make sure it is not rolling or cutting off circulation. To prevent circulation problems, make sure that the ends of the elastic tape that are wrapped around the leg are not too tight and are on a slight angle.
4. Apply an anterior strap similar to the posterior strap, beginning at the foot. After splitting and wrapping the strap around the foot, unroll the tape and cut it evenly with the top of the tape line on the lower leg. Again, this will allow an adequate length to split the tape and wrap it around the lower leg. When applying this strap to the lower leg, you must pull the split ends toward the knee, assisting the athlete in making sure the foot is slightly dorsiflexed past  $90^\circ$  (Fig 5). This strap restricts plantar flexion during activity and protects the anterolateral ligaments of the ankle.
  5. Apply an elastic stirrup, from medial to lateral, so that it is centered over the malleoli (Fig 6). Split both ends of the stirrup so as to secure the tape around the leg like the previous two straps (Figs 6 and 7). This is a very important strap; its main function is to provide support to the lateral ligament complex. It should be pulled snug, but, again, make sure that the split ends of the tape are not wrapped around the leg too tightly.

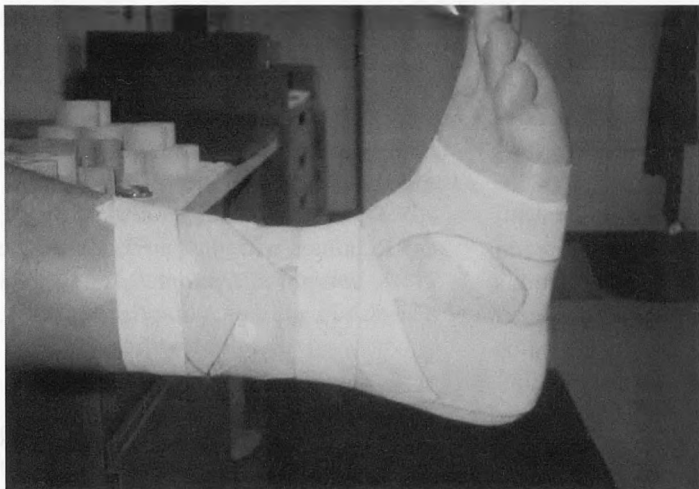


Fig 7. Elastic strap secured in place.

The remainder of the taping is done by applying a standard ankle taping over the elastic adhesive base. Our procedure is as follows:



6. With the foot in a neutral position, apply an anchor strip at the musculotendinous junction as well as one just above the malleoli (Fig 8). This bottom anchor functions as a "tie-off" for the elastic adhesive straps described previously.



**Fig 8. Bottom anchor strip applied at the musculotendinous junction and just above the malleoli.**

7. Apply three stirrups with anchors after each one. The anchors should be dispersed from the original three anchor strips and down the ankle as close to the malleoli as possible, to provide overall consistency of the tape's thickness (Fig 9).



**Fig 9. Application of three stirrups with anchors after each.**

8. Apply "C" strips in a series, starting from the stirrup anchors down to the insertion of the Achilles tendon with one on the forefoot (Fig 10).
9. Apply two medial and two lateral heel locks. Apply the heel locks so that the second heel lock on each side overlaps the first by approximately one third, proximally (toward the calf; Fig 11). These should not be continuous, because consistency in tape thickness is critical for preventing blisters, cuts, or "hot spots." The four heel locks should also be applied in an alternating fashion (eg, medially, laterally, medially, laterally). This also achieves continuity of tape thickness.
10. Apply two noncontinuous figure-of-eight tape layers in an overlapping fashion with the second starting distal to the



**Fig 10. Application of "C" strips.**



**Fig 11. Application of two medial and two lateral heel locks.**

first, making sure to start on the lateral aspect of the ankle (Fig 12).

11. Complete the tape job by applying "lace-up" closure strips to lock the support strips in place and to cover the tape ends.



**Fig 12. Application of two noncontinuous figure-of-eight layers.**

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**Zmierski T, Kegerreis S, Scarpaci J. Scapular muscle strengthening. *J Sport Rehabil.* 1995;4:244-252.**

The purposes of this study were: a) to determine the reliability of the Nicholas handheld dynamometer for measuring scapular adductor strength, and b) to determine if isokinetic strengthening of the scapular adductors while horizontally abducting the shoulder is more effective than strengthening the scapular adductors while extending the shoulder. An isometric test was used to determine scapular adductor strength before and after a 6-week training program. Intra-class correlation coefficients indicated high pretest and posttest reliability. The individuals who trained the scapular adductors while horizontally abducting the shoulder showed greater increases in mean force values (20.49 kg pretest to 31.74 kg posttest) than the group combining scapular adduction with shoulder extension (19.61 kg pretest and 25.5 kg posttest). ANOVA showed a significant interaction between group and time. It may be more effective to isokinetically strengthen the scapular adductors with shoulder horizontal abduction rather than shoulder extension as a combined movement.

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*Journal of Sport Rehabilitation*

**Worrell TW, Connelly S, Hilvert J. VMO: VL ratios and torque comparison at four angles of knee flexion. *J Sport Rehabil.* 1995;4:264-272.**

The purpose of this study was to determine the intrasession and intersession reliability of EMG vastus medialis oblique:vastus lateralis (VMO:VL) ratios at four knee positions (0°, 45°, 60°, and 90°) at 100% and 60% of maximal voluntary isometric contraction (MVIC). Once reliability was established, the second purpose was to determine VMO:VL ratios and torque at each knee position. Thirty-two sub-

jects participated in two sessions; 19 subjects were tested at 100% MVIC and 13 were tested at 60% MVIC. Results revealed the following intraclass correlations: 100% MVIC intrasession .40-.80, intersession .4-.70; 60% MVIC intrasession .60-.90, intersession .50-.80. A significant difference in torque occurred at all knee positions except 60° versus 90°. No significant difference existed in VMO:ML ratios at the four positions of knee flexion. Pain and measurement error significantly increased during 100% MVIC testing. It was concluded that no selective VMO recruitment occurred as revealed by the VMO:VL ratios in asymptomatic subjects. Future study is needed that reports EMG reliability data during exercises that theorize selective VMO recruitment.

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*Journal of Sport Rehabilitation*

**Corso G. Impingement relief test: an adjunctive procedure to traditional assessment of shoulder impingement syndrome. *J Orthop Sports Phys Ther.* 1995;5:183-192.**

Shoulder impingement syndrome, a common disorder directly related to the unique anatomy, mobility, and biomechanics of the shoulder girdle complex, is a condition that results from repetitive microtrauma to the structures within the subacromial space, primarily the supraspinatus, the long head of the biceps, and the subacromial bursa. Several factors contribute to shoulder impingement syndrome, including rotator cuff weakness, capsular tightness, poor scapulohumeral rhythm, and muscle imbalance of the scapular upward rotation force couple. This article briefly reviews the biomechanics of the shoulder girdle complex and the pathology of shoulder impingement syndrome. The author introduces an adjunctive assessment procedure that assists the clinician in isolating the primary tissue and the structures

involved with shoulder impingement syndrome. Conservative treatment management can then be directed to the involved contractile and/or noncontractile tissue involved with shoulder impingement syndrome.

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*Journal of Orthopedic and Sports Physical Therapy.*

**Astrom M, Arvidson T. Alignment and joint motion in the normal foot. *J Orthop Sports Phys Ther.* 1995;22:216-222.**

Biomechanical evaluation of the foot is based on the assumption that a vertical stance position of the calf and the calcaneus in subtalar neutral (the "ideal foot") provides optimal function with a minimal risk of injury. The purpose of this study was to discuss the content of the "ideal foot" with reference to a set of normative goniometric data. One hundred and twenty-one healthy subjects (59 men and 62 women; avg age = 35 yr; range = 20 to 50 yr) participated in a standardized clinical assessment of ankle and subtalar joint motion, subtalar neutral, forefoot alignment, calcaneal stance, and the tibia to vertical angle. All subtalar measurements were referred to the neutral position. A majority had a subtalar neutral in slight valgus (overall avg = 2°), a forefoot in moderate varus (overall avg = 6°, and a calcaneal stance in valgus (overall avg = 7°). The mean tibia to vertical angle was 6° in varus. Women had a greater range of ankle and subtalar joint motion than men but age had little influence. None of the subjects conformed to the "ideal foot," which appears to be rare and should be abandoned in favor of a reference based on clinical observation rather than on theoretical considerations.

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*Journal of Orthopedic and Sports Physical Therapy.*



**Greenberger HB, Paterno MV. Relationship of knee extensor strength and hopping test performance in the assessment of lower extremity function. *J Orthop Sports Phys Ther.* 1995;22: 202-206.**

Traditionally, open kinetic chain rehabilitation and evaluation have been used as the primary tool to assess a patient's strength and readiness to progress to a higher functional level. More recently, closed kinetic chain activities have been developed and well documented as an alternate means to prepare and evaluate a patient's ability to return to a higher functional level. However, a dearth in recent literature comparing the correlation between an open kinetic chain isokinetic strength and performance on a functional performance test exists. Therefore, the purpose of this study was to examine the relationship between a knee extensor strength and functional performance test, specifically the one-legged hop for distance. Twenty subjects (avg = 20.7 yr), with no prior history of lower extremity injury, participated in

the study consisting of isokinetic evaluation of the quadriceps muscle using a Kinetic Communicator and a one-legged hop for distance. Isokinetic testing was performed at 240°/s. All tests were performed on the dominant and nondominant limbs. Pearson product moment correlation coefficients for peak torque and distance hopped were .78 for the dominant leg and .65 for the nondominant leg ( $p < .05$ ). These results support the belief that isokinetic strength does not correlate strongly with functional tasks.

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*Journal of Orthopedic and Sports  
Physical Therapy.*

**Mattingly GE, Mackarey PJ. Optimal methods for shoulder tendon palpation: a cadaver study. *Phys Ther.* 1996; 76:166-174.**

*Background and Purpose*—Physical therapists often must either palpate tendons of the shoulder or, as part of treatment, apply forces to those tendons.

Many methods have been suggested for minimizing the amount of soft tissue that overlies these tendons, but no data have been presented to justify the use of any approach. The purpose of this study was to evaluate methods described in the literature by use of cadaver models. *Subjects*—Twenty-four shoulders from 12 cadavers of individuals aged 55 to 92 years were dissected. *Methods*—Shoulders were placed in the positions described in the literature, and the positions in which the tendons were maximally exposed (ie, had the least overlying tissue) were noted. *Results*—Positions were found in which tendons were maximally exposed. *Conclusion and Discussion*—Positions described in the literature for optimizing the exposure of shoulder tendons are not always optimal, and palpation and treatment may be improved by using positions determined by research such as those suggested in this report.

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# New Products

## PowerFlex Taping System

Andover Coated Products, Inc introduces the PowerFlex Taping System: an advancement that's stronger, more comfortable, and will not slip (even from sweat) as compared to the old way of taping. While existing tape methods offer protection from tape only, the PowerFlex System provides three-way strength from fabric wrap, elastic yarn, and athletic tape. The high elasticity of PowerFlex results in more compression and better protection, yet remains completely stable and comfortable, even after hours of training or competition.

The PowerFlex fabric wrap is applied directly to the athlete's skin; no thin foam or spray adhesive is required. Three-way protection is achieved in two easy steps: an initial PowerFlex wrapping procedure followed by an outer layer of athletic tape. To make application easier, PowerFlex tears clean by hand and is self-sticking. It is breathable to trap moisture and absorb sweat. With PowerFlex, taped areas remain comfortable, without tape slippage. PowerFlex is also lightweight and soft to the skin

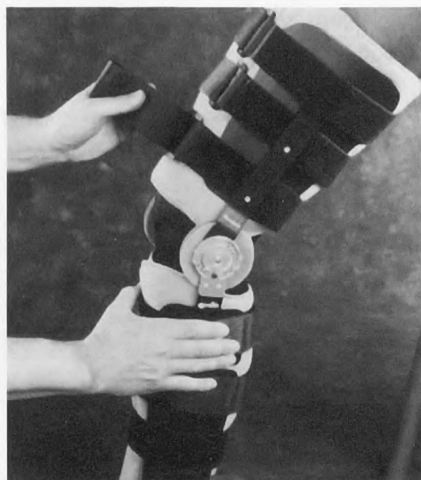


By using the PowerFlex System, the amount of white tape used by athletic trainers is cut by an average of 33%. Standard sized rolls are: 2", 2-3/4", 3", and 4"—all by 6 yards and in white. Other colors are available by special order.

For more information, call 800-432-6686.

## Pacesetter™ II Post-Op Knee Brace

Carapace introduces the Pacesetter™ II Post-Op Knee Brace. Its aircraft aluminum hinge arms are lightweight and strong and it is precontoured for a better fit. Plastic paddles securely fasten to the hinge arms to provide excellent soft tissue containment for superior stability. Simple "pin" stop hinges with 7.5° increments are easy to use and extremely strong offering precise flexion and extension control.

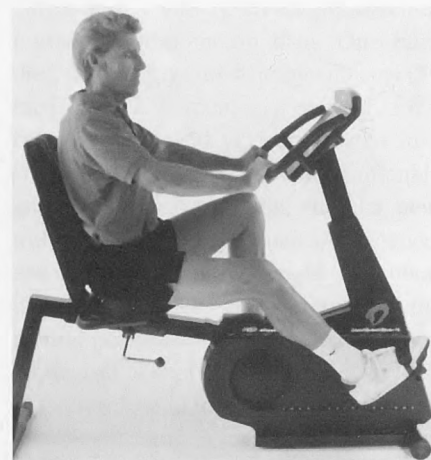


Six circumferential straps mounted to the hinge arms for a more secure fit provide for increased stability and patient comfort. Centered foam pads with popliteal cut-out are anatomically "friendly," easy to fit, and offer increased comfort. The popliteal cut-out prevents material from "bunching up" behind the knee during flexion. The brace fits either the right or left leg, allowing for less inventory. Its low profile design fits easily under clothes. The Pacesetter II Post-Op Knee Brace is economical, offering solid functional construction and high quality components at an affordable price and comes in sizes standard (fits inseams over 31") or short (fits inseams up to 31").

For more information, call: 800-223-5463.

## New Recumbent Cycle From Diamondback Fitness

Diamondback introduces the new 1000R Recumbent Exercise Cycle. The 1000R features the latest in electronic console technology, heart rate control programming, and advanced biomechanical design. It features a nonfriction electronically-controlled braking system with 16 levels of resistance and is one of the quietest trainers in the industry. Its contoured and tapered seat and lumbar supported back pads help position the upper body for better support, while allowing for hamstring interference and proper leg extension. Its oversized console offers an easy-read, 3-color dot matrix readout that programs the wireless Polar Heart Rate Training System for fat burning, stamina/endurance, or to target specialized training, which allows resistance levels to adjust for training in



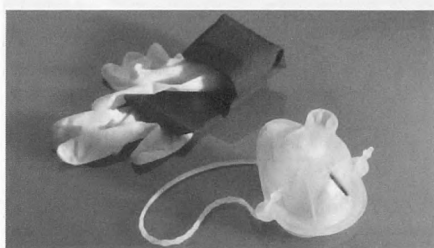
the user's target heart rate zone. The electronics package also offers manual and custom hill profile options as well as four preprogrammed hill courses. For those who are just beginning their exercise training, there is a heart rate-based fitness test to determine the user's current fitness level and recommended training zones.

For more information, call: 800-223-5463.



## New **IRM™** Instant Response Mask™

The **IRM™** *Instant Response Mask™* CPR mask by CDX Corporation automatically deploys fully assembled and ready for instant use upon opening its face shield size belt pouch. The **IRM** has a new improved one-way valve with a 3 M™ Filtrete™ filter to protect the rescuer, an improved O<sub>2</sub> port, and a new mouthpiece that enables the rescuer to use a resuscitation bag. The one-size-fits-all **IRM** has a new seal area, making it easier to obtain a seal (even in extreme temperatures) on adults, children, infant



patients, and mannequins. The **IRM** easily folds up to fit back into the pouch after training sessions. This unique CPR mask has the portability of a face shield and the functionality of a mask.

For more information, call 800-245-9949.

## **PMD Sports Introduces MxKnee**

**MxKnee**, made from DuPont's Coolmaxcm or Thermostatcm, is a soft, knitted knee support that provides compression and stabilization of the knee without impairing motion and activity. Features include a viscoelastic insert surrounding the patella, providing stabilization and gentle massaging action, and lateral stays providing knee joint support and protection.

The Coolmax fiber has the ability to wick moisture away from skin and provide breathability, keeping the skin cool and dry, while the Thermostat fiber wicks moisture away keeping the skin warm and dry. The **MxKnee** is easy to get on or off, keeps the skin dry and free from chaffing and rashes, provides support comparable to neoprene, and provides uniform fit and compression.

For more information, call 800-245-3278.

## **PMD Sports Introduces MxInterface**

**MxInterface** is used as an interface to a functional knee brace, providing compression, general support, and protection to the skin. **MxInterface** is manufactured from DuPont's Coolmaxcm, keeping the skin under the interface cool, dry, and free from skin irritations. It is designed for comfort and ease of use. It has a low bulk design, providing compression for edema control.

Available in five fashion colors, including black, white, royal blue, navy, and red, the product can match team colors or braces and is washable, reusable, and an extremely economic alternative to neoprene.

For more information, call: 800-245-3278.

## **ClimbMaster™**

Heart Rate, Inc introduces the new **ClimbMaster™**. What makes the **ClimbMaster** unique is that the climbing motion emphasizes the arms. With four times more arm motion than leg motion, everyone can find a movement that is comfortable and easy. Because the leg motion is limited to that of typical stepping machines, everyone in the gym can now enjoy total body climbing for cardiovascular benefits.



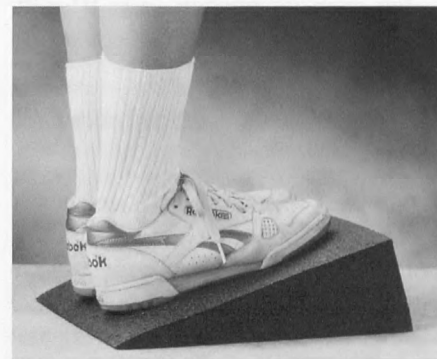
**ClimbMaster's** vertically flashing lights keep sync with users as they climb, and its user friendly display is vertically

adjustable so everyone can easily monitor their progress. Instructional and motivational messages appear on the display showing users how to start their exercise as well as give them exercise tips and words of encouragement throughout their workout. The display also shows calorie burn rate, total calories burned, climbing speed, stroke length and total distance climbed. It is designed to be user-friendly as well as a complete aerobic workout.

For more information, call: 800-237-2271.

## **OPTP Slant™ From OPTP Conservative Care Specialists**

Stretching the gastroc/soleus complex is extremely important for the prevention and treatment of many common lower leg and foot problems. Stretching with the **OPTP Slant™** can help reduce lower extremity overuse syndromes, and prevent postsurgical contracture and excessive scar formation. The **Slant™** also



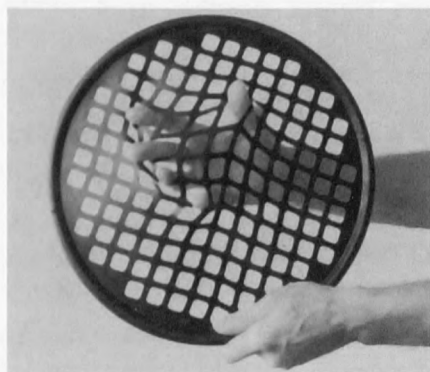
assists with general stretching and weight bearing and can help promote a normal, stable gait. Constructed of special weight-bearing form, it can be used for home or clinic.

For more information, call: 800-367-7393.

## **The Power-Web® Exerciser**

Turner Enterprises Inc introduces the **Power-Web®** Ultimate Hand Exerciser (available in 6 color-coded resistance levels, as the most versatile and effective device ever invented for strengthening and conditioning the finger, thumb, wrist, and forearm. Until now, several devices were required to accomplish

overall hand and forearm strengthening. With its unique patented design, the PowerWeb Exerciser allows the duplication of virtually all joint actions. Portable and easy to use, it is ideal for clinic and home.



Priced under \$35, it measures 14" in diameter and weighs less than 1 lb. Each hand exerciser comes with a 14-page fully illustrated instruction manual, with an optional carrying case.

For more information, call: 216-630-5090.

### Quality Tables at Affordable Prices

Saunders Examination/Treatment Tables are constructed of welded high carbon tubular steel with a Naugahyde®-covered foam top. high-low models use state-of-the-art, virtually soundless, fluid-drive mechanics with manual or electric hydraulic actuation. Prices start at \$700 (+S&H). Portable Treatment Tables provide a solid working surface with an easy-to-maintain vinyl upholstered top over thick urethane padding. Each folding table comes complete with comfort-grip handles, eight protective brass cover plates on all corners and two bottom bumpers. Prices are \$335.95 or \$380.95 (+S&H) depending upon table height.

Saunders S'ports Table brings quality and versatility to the training room. Adjustable height and gatch back are just two of the features that make this table unique. They are constructed of welded high carbon tubular steel with a Naugahyde-covered foam top and are available with a hand crank backrest or a flat top.

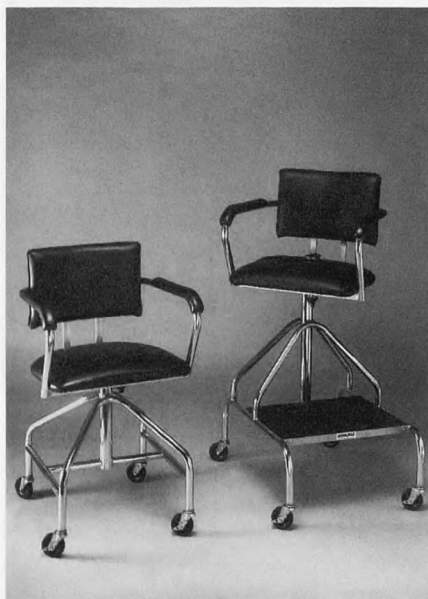
Prices are \$995 and \$895, respectively (+S&H).

For more information, call: 800-654-8357.

### Whirlpool Chairs

Bailey introduces the Models 7700/7702 Whirlpool Chairs. The chairs are designed to permit a close fit to the end of stationary or mobile whirlpool baths. The chairs' heights are adjustable to fit over the rim of the whirlpool, where they can be locked in place.

Features of Model 7700: four 3" swivel casters, two with locks; safety belt; height adjusts from 33: to 46½"; 14" × 19" nonslip rubber foot platform; chrome plated steel frame; padded black vinyl (standard) upholstered seat and back.



Features of the Model 7702: same features as 7700; height adjusts from 29½" to 43½".

For more information, call: 800-321-8372.

### CrossLine™, The Ultimate Cross-Training Experience

Introducing CrossLine, the result-oriented cross-training program from Universal. CrossLine is an exciting, time-efficient, easy-to-follow exercise program that combines aerobic and

strength training into one structured, total body workout.

By working out on CrossLine, users can improve their cardiorespiratory fitness and build muscle strength and endurance. They can also lower resting pulse rate, reduce blood pressure, become more flexible, and substantially reduce body fat.



The standard CrossLine Circuit consists of 10 Power Circuit™ weight training machines arranged in agonist/antagonist order interspersed with 10 CrossLine step platforms. Users move through CrossLine, alternating between the weight training and aerobic stations in a structured sequence and for a predetermined amount of time.

Learn more about the Universal CrossLine Circuit by calling 800-843-3906.

### Cramer Introduces New Products

Cramer has expanded its sports medicine line with the addition of the Active Ankle T2. The new T2 features a single quick-fastening strap that adjusts for high and low top shoes while providing high comfort without the bulk.

The Neoprene Hip/Groin Spica is another new addition to the sports medicine line. This wrap's unique design has one solid end for wrapping the injured area, providing warmth and compression. The other end is ventilated to release unwanted heat.

Their books and software line has grown with the addition of the *Manual of Taping and Wrapping* and the *Athletic Taping and Wrapping* video. This video is presented by a certified athletic trainer and covers everything from supplies to skin preparation to over 50 beginning and advanced taping and wrapping techniques.

For more information, call: 913-884-7511.



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# 1996 Request for Proposals NEW - Education Grants!

The NATA Research & Education Foundation is pleased to announce that \$100,000 is available in 1996 for Research and Education Grants. The deadlines for grant applications are March 1 and September 1 of each year. Priority consideration will be given to proposals which include an NATA-certified athletic trainer as an integral member of the research or project team.

## RESEARCH GRANTS - \$75,000 AVAILABLE

\$50,000 is available to fund proposals which address important issues in four categories: basic science, clinical studies, sports injury epidemiology, and observational studies.

\$25,000 is available to fund studies which investigate the validity and efficacy of therapeutic techniques, modalities, clinical procedures, and equipment used by allied health care practitioners.

## EDUCATION GRANTS - \$25,000 AVAILABLE

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. These grants range from \$1,000 to \$15,000.

**Education Program Grants** include seed money for seminars, lectures, or any other educational program focusing on health care of the physically active or athletic training education. Program topics of particular interest to the Foundation are closed-head injury, management of spinal conditions, on-the-field injury management procedures, and dysfunctional eating patterns. These grants range from \$1,000 to \$5,000.

To receive a copy of the Educational Grant Application or the Research Grant Application, please write to NATA Research & Education Foundation, 2952 Stemmons Freeway, Dallas, TX 75247, e-mail the request to [BrianaE@aol.com](mailto:BrianaE@aol.com), or call 800-TRY-NATA ext 142.

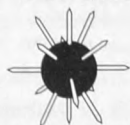
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# A

# Authors' Guide

(Revised April 1995)

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

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5. Manuscripts are edited to improve the effectiveness of communication between the author and the readers, and to aid the author in presenting a work that is compatible with the style policies found in the *AMA Manual of Style*, 8th ed. (Williams & Wilkins) 1989. The author agrees to accept any minor corrections of the manuscript made by the editors. Galley proofs are sent to the author for proofreading when the article is typeset for publication and it is important that they are returned within 48 hours. Important changes are permitted, but authors will be charged for excessive alterations.
6. Published manuscripts and accompanying work cannot be returned. Unused manuscripts will be returned when submitted with a stamped, self-addressed envelope.

## STYLE POLICIES

7. The active voice is preferred. Use the third person for describing what happened. "I" or "we" (if more than one author) for describing what you did, and "you" or the imperative for instruction.
8. Each page must be typewritten on one side of 8.5 × 11 inch plain paper, double spaced, with one-inch margins. **Do not right justify pages.**
9. Manuscripts should contain the following, organized in the order listed below, with each section beginning on a separate page:
  - a. Title page
  - b. Acknowledgements
  - c. Abstract and Key Words (first numbered page)
  - d. Text (body of manuscript)
  - e. References
  - f. Tables—each on a separate page
  - g. Legends to illustrations
  - h. Illustrations

10. Begin numbering the pages of your manuscript with the abstract page as #1; then, consecutively number all successive pages.
11. Titles should be brief within descriptive limits (a 16-word maximum is recommended). The name of the disability treated should be included in the title if it is the relevant factor; if the technique or type of treatment used is the principle reason for the report, it should be in the title. Often both should appear.
12. The title page should also include the names, titles, and affiliations of each author, and the name, address, phone number, and fax number of the author to whom correspondence is to be directed.
13. A comprehensive abstract of 75 to 200 words must accompany all manuscripts except **Tips From the Field**. Number this page one, type the complete title (but not the author's name(s)) on the top, skip two lines, and begin the abstract. It should be a single paragraph and succinctly summarize the major intent of the manuscript, the major points of the body, and the author's summary and/or conclusions. It is unacceptable to state in the abstract words to the effect that "the significance of the information is discussed in the article." Also, do not confuse the abstract with the introduction.
14. List three to six key words or phrases that can be used in a subject index to refer to your paper. These should be on the same page as, and following your abstract. For **Tips From the Field**, the key words should follow immediately after the title on the first numbered page.
15. Begin the text of the manuscript with an introductory paragraph or two in which the purpose or hypothesis of the article is clearly developed and stated. Tell why the study needed to be done or the article written and culminate with a statement of the problem (or controversy). Highlights of the most prominent works of others as related to your subject are often appropriate for the introduction, but a detailed review of the literature should be reserved for the discussion section. In the one to two paragraph review of the literature, identify and develop the magnitude and significance of the controversy, pointing out differences between others' results, conclusions, and/or opinions. The introduction is not the place for great detail; state the facts in *brief* specific statements and reference them. The detail belongs in the discussion. Also, an overview of the manuscript is part of the abstract, not the introduction.
16. The body or main part of the manuscript varies according to the type of article (examples follow); however, the body should include a discussion section in which the importance of the material presented is discussed and related to other pertinent literature. Liberal use of headings and subheadings, charts, graphs, and figures is recommended.
  - a. The body of an **Experimental Report** consists of a methodology section, a presentation of the results, and a discussion of the results. The methodology section should contain sufficient detail concerning the methods, procedures, and apparatus employed so that others can reproduce the results. The results should be summarized using descriptive and inferential statistics, and a few well-planned and carefully constructed illustrations.
  - b. The body of a **Review of the Literature** article should be organized into subsections in which related thoughts of others are presented, summarized, and referenced. Each subsection should have a heading and brief summary, possibly one sentence. Sections must be arranged so that they progressively focus on the problem or question posed in the introduction.
  - c. The body of a **Case Study** should include the following components: personal data (age, sex, race, marital status, and occupation when relevant—but not name), chief complaint, history of present complaint (including symptoms), results of physical examination (example: "Physical findings relevant to the rehabilitation program were..."), medical history (surgery, laboratory results, exam, etc.), diagnosis, treatment and clinical course (rehabilitation until and

after return to competition), criteria for re-turn to competition, and deviation from the expected (what makes this case unique). NOTE: It is mandatory that the *Journal of Athletic Training* receive, with the manuscript, a release form signed by the individual being discussed in the case study. Case studies cannot be reviewed if the release is not included.

- d. The body of a **Technique Article** should include both the *how* and *why* of the technique, a step-by-step explanation of how to perform the technique, supplemented by photographs or illustrations; and why the technique should be used. The discussion of *why* should review similar techniques, point out how the new technique differs, and explain the advantages and disadvantages of the technique in comparison to the other techniques.
  - e. A **Tip From the Field** is similar to a technique article but much shorter. The tip should be presented and its significance briefly discussed and related to other similar techniques.
17. The manuscript should not have a separate summary section—the abstract serves as a summary. It is appropriate, however, to tie the article together with a summary paragraph or list of conclusions at the end of the discussion section.
  18. Citations in the text of the manuscript take the form of a superscripted number, which indicates the number assigned to the citation. It is placed directly after the reference or the name of the author being cited. References should be used liberally. It is unethical to present others' ideas as your own. Also, use references so that readers who desire further information on the topic can benefit from your scholarship.
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    - a. Knight K. Tips for scientific/medical writers. *Athl Train*. JNATA. 1990;25:47–50.
    - b. Day RA. *How to Write and Publish a Scientific Paper*. 3rd ed. Phoenix, AZ: Oryx Press; 1988;54–55.
    - c. Albohm M. Common injuries in women's volleyball. In: Scriber K, Burke EJ, eds. *Relevant Topics in Athletic Training*. Ithaca, NY: Movement Publications; 1978:79–81.
    - d. Behnke R. Licensure for athletic trainers: problems and solutions. Presented at the 29th Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association; June 15, 1978; Las Vegas, NV.
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# CEU Quiz

**NOTE: New cost for CEU quiz. The Board of Directors voted in December 1995 to increase the cost of the CEU quiz to \$20.00**

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

**Please note the new procedure for participating in this program.** Read the material in this issue carefully, photocopy this page, and record your test answers on this page. It is no longer necessary to photocopy the test. Fill in

your name, address and other information and mail with \$20 for processing to the address below. **FOR CREDIT, the form must be postmarked by August 30, 1996.**

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

end of the year or when asked. Participation is confidential.

## Answers to March '96 CEU Quiz Volume 31, Number 1

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

☐ Please check here if this is your first CEU Quiz or if your address has changed since your last quiz.

☐ NATA Membership Number or  
☐ NATABOC Certification Number  
(please check one) \_\_\_\_\_

Social Security Number \_\_\_\_\_

Name \_\_\_\_\_

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Please indicate below the setting in which you work:

☐ High School   ☐ Junior College   ☐ College  
☐ University   ☐ Sports Medicine Center  
☐ Other (please specify) \_\_\_\_\_

## INSTRUCTIONS

- Carefully read the articles in this issue.
- Photocopy this page.
- Record your answers below by darkening the appropriate letter of your answer.
- Mail with \$20 fee (check or money order only payable to **Indiana State University**) postmarked by August 30, 1996 to:

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

## CEU Quiz Evaluation

- Questions challenging enough? ... ☐ Yes ☐ No
  - Presented clearly? ... ☐ Yes ☐ No
  - Material covered well? ... ☐ Yes ☐ No
  - Will information be useful to you in your work? ... ☐ Yes ☐ No
- Please add any suggestions on how to improve the CEU Quiz on the back of this form when you are finished.

**RECORD ANSWERS HERE - Darken the appropriate letter. Example: 1 a ● c d e**

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



## MARK ANSWERS ON PREVIOUS PAGE.

1. When evaluating a brachial plexus injury, clinicians should pay particular attention to the athlete's previous history, because strength deficits may not appear for 72 hours and EMG analysis is not effective until 2 weeks after a grade I brachial plexopathy.
  - a. True
  - b. False
2. Athletes should be made aware that using certain herbal products can cause:
  - a. gastritis.
  - b. gastrointestinal bleeding.
  - c. hypotension.
  - d. a false-positive drug screening.
  - e. All of the above
3. While obtaining a drug history, athletic trainers should question athletes about which of the following?
  - a. prescription drugs
  - b. amount of caffeine products consumed
  - c. herbal products
  - d. over-the-counter prescriptions being taken
  - e. All except b.
4. Adhesions develop in a joint in:
  - a. 5 to 10 days.
  - b. 10 to 20 days.
  - c. 30 to 60 days.
  - d. 60 to 90 days.
  - e. None of the above.
5. Which of the following guidelines help athletes reduce the chance of upper respiratory illness?
  - a. Obtain adequate amounts of rest.
  - b. Avoid overtraining.
  - c. Space vigorous workouts and competitive events as far apart as possible.
  - d. Avoid other sick individuals.
  - e. All of the above
6. Licensure is necessary for which of the following reasons:
  - a. to insure public safety.
  - b. to protect the public.
  - c. to promote professional conduct.
  - d. All of the above.
  - e. a and b only.
7. The researchers found that after the ice immersion:
  - a. shuttle run times were significantly slower.
  - b. shuttle run times were significantly faster
  - c. shuttle run times were equal.
  - d. shuttle run was unable to be performed.
  - e. None of the above.
8. Which of the following is a major flaw in using open chain isokinetic devices for rehabilitation?
  - a. The lower extremity can't be exercised or tested in a functional position.
  - b. Compressive forces on the knee joint are increased.
  - c. There are decreases in the amount of shear forces placed on the anterior cruciate ligament during the last 15° of knee extension.
  - d. None of the above.
  - e. b and c.
9. Closed kinetic chain exercises are helpful in rehabilitation because:
  - a. placing functional stress on the knee facilitates normal proprioceptive feedback.
  - b. coactivation of the hamstrings and quadriceps to aid in the dynamic stability of the knee is enhanced.
  - c. the stabilization of the distal segment of the leg occurs while in the weight-bearing position.
  - d. the amount of shear force on the knee is reduced.
  - e. All of the above.
10. To perform joint mobilization on the proximal tibiofibular joint, the operator must:
  - a. stabilize the knee.
  - b. grasp the head and neck of the proximal fibula.
  - c. be cautious of the peroneal nerve.
  - d. All of the above.
  - e. a and b only.
11. In the article on functional outcome measures for knee dysfunction, which of the following is not mentioned as a performance test used for assessment?
  - a. timed hop
  - b. carioca test
  - c. triple hop for distance
  - d. figure eight running
  - e. shuttle run
12. A study comparing prophylactic knee braces suggested that prophylactic knee bracing:
  - a. enhances active and passive joint position sense.
  - b. inhibits active and passive joint position sense.
  - c. has no effect on active and passive joint position sense.
  - d. None of the above
13. The following statements are true about chronic brachial plexopathies.
  - a. Approximately one-half of these types of injuries go unreported.
  - b. College-level athletes probably sustain more injuries than those in lower levels of competition.
  - c. The chronic syndrome develops from repeated episodes.
  - d. All of the above.
  - e. a and c only.
14. During an upper respiratory illness, athletes have:
  - a. weakness of the inspiratory and expiratory muscles.
  - b. reduced muscle enzyme activity.
  - c. increased cardiac output.
  - d. normal muscle ultrastructure.
  - e. a and b.
15. Which of the following diseases can cause a spontaneous pneumothorax to occur?
  - a. asthma
  - b. cystic fibrosis
  - c. emphysema
  - d. all of the above
  - e. a and c only

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 BREATHE RIGHT/CNS, INC.....100  
 CRAMER PRODUCTS, INC. ....Cover 4  
 DONJOY .....112  
 F. A. DAVIS.....153  
 FOOT MANAGEMENT, INC. ....192  
 GATORADE .....111  
 JAYBIRD & MAIS, INC.....118  
 JOHNSON & JOHNSON.....102, 103

KENDALL ATHLETIC.....117  
 McDAVID KNEE GUARD, INC.....Cover 3  
 MEDICAL SPECIALTIES INC.....129  
 MULTIAXIAL, INC.....188  
 PMD SPORTS .....124  
 POLYMEDICA HEALTHCARE, INC. ....143  
 PRO ORTHOPEDIC DEVICES.....Cover 2  
 PROTEK-TOE PRODUCTS .....166  
 STAODYN, INC. ....168  
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 SWEDE-O, INC.....98, 130

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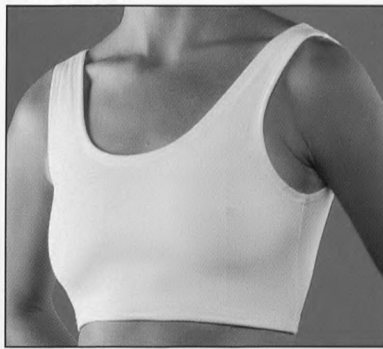
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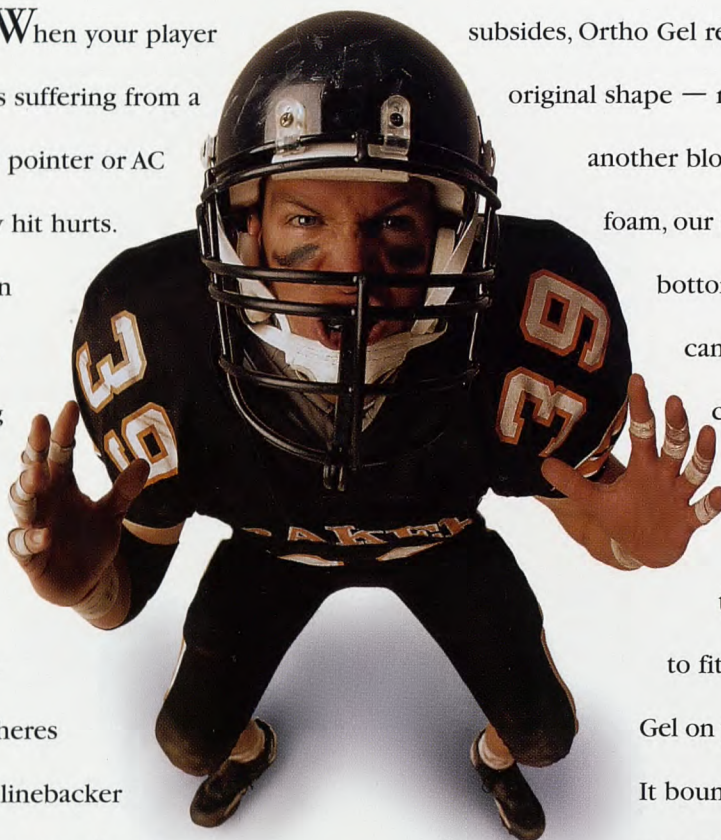
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