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Volume 33, Number 2, April-June 1998

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JOURNAL OF ATHLETIC TRAINING

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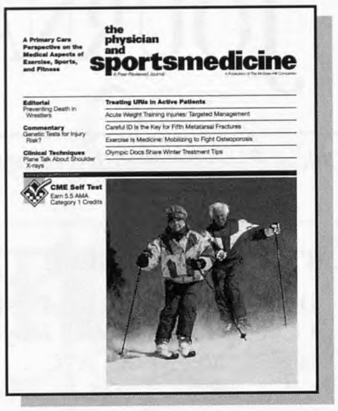

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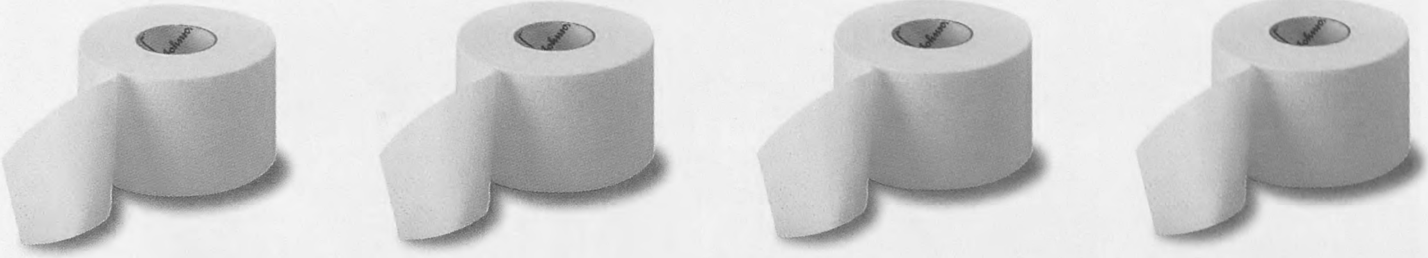

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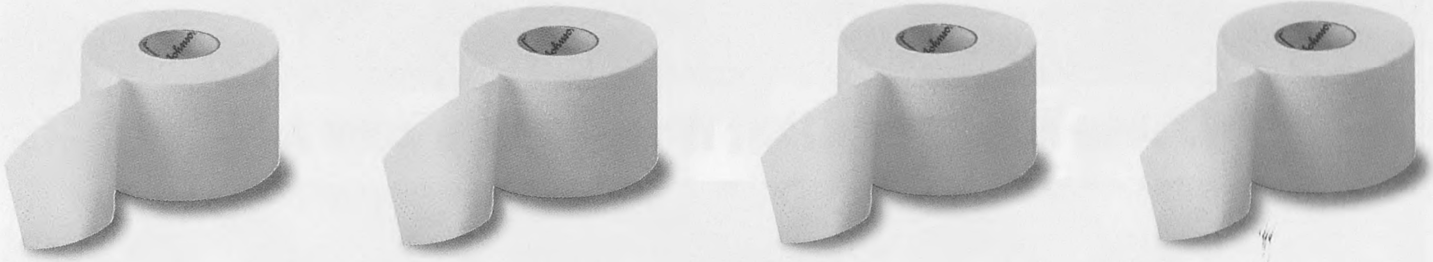

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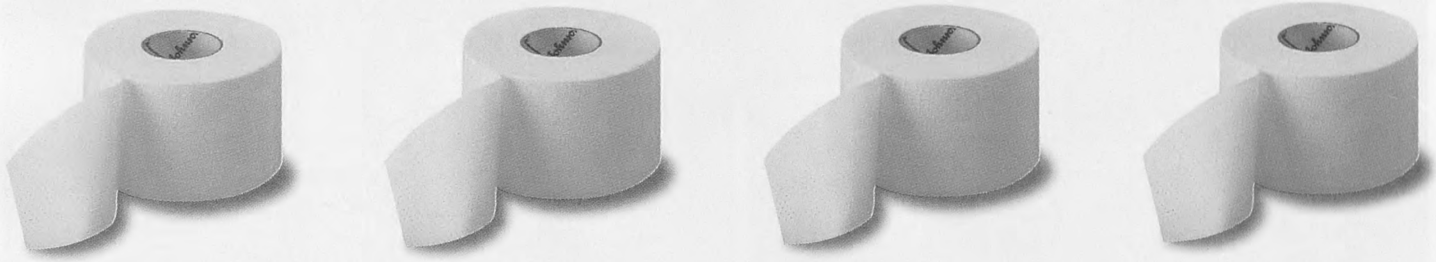

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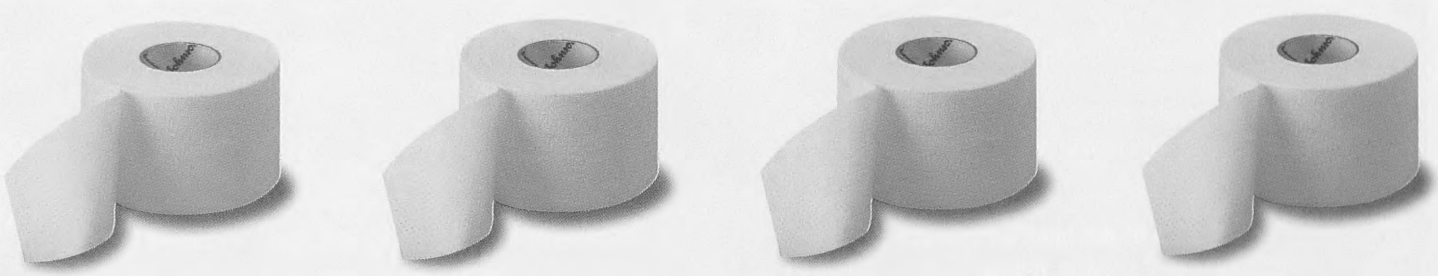

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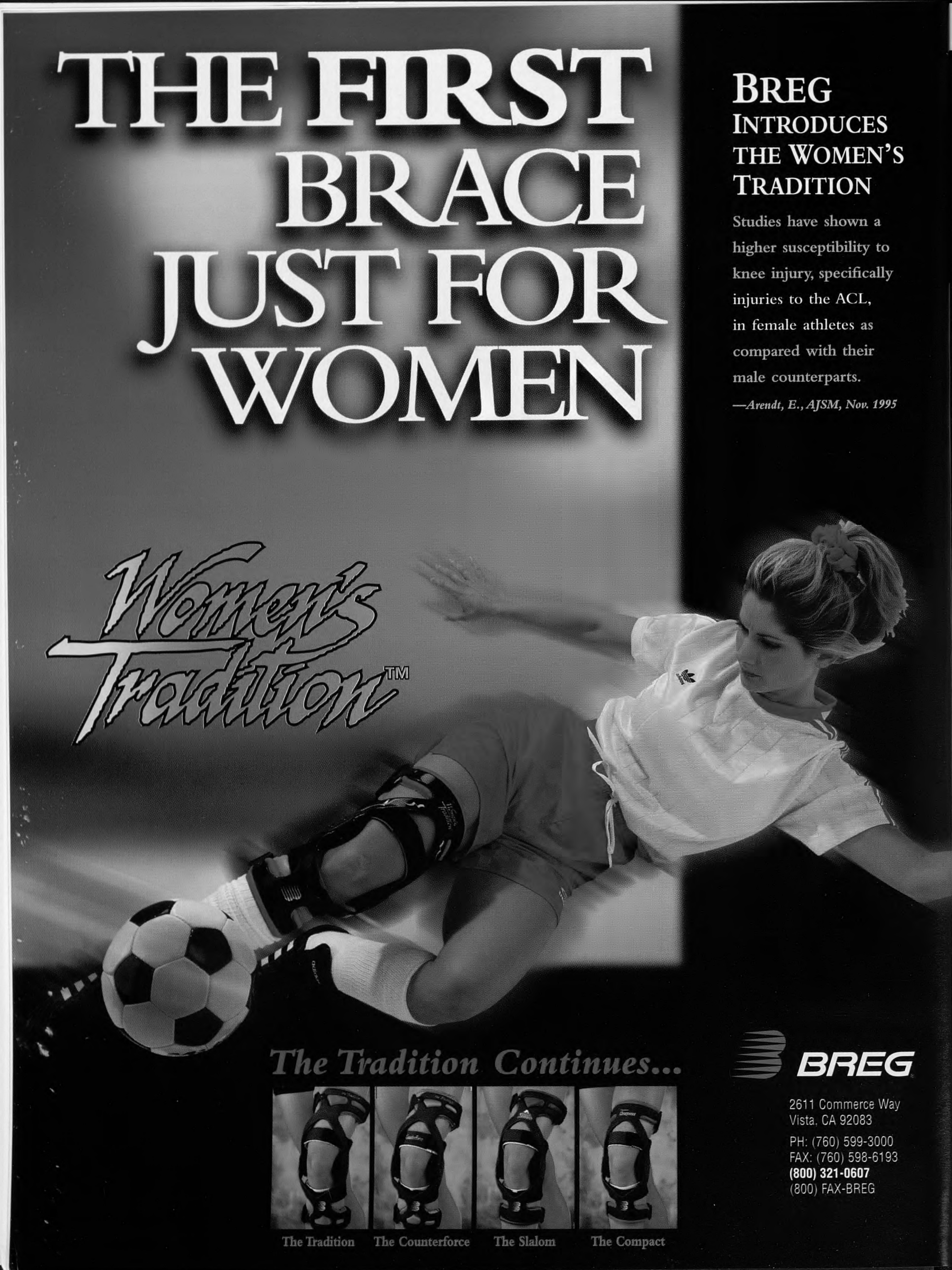
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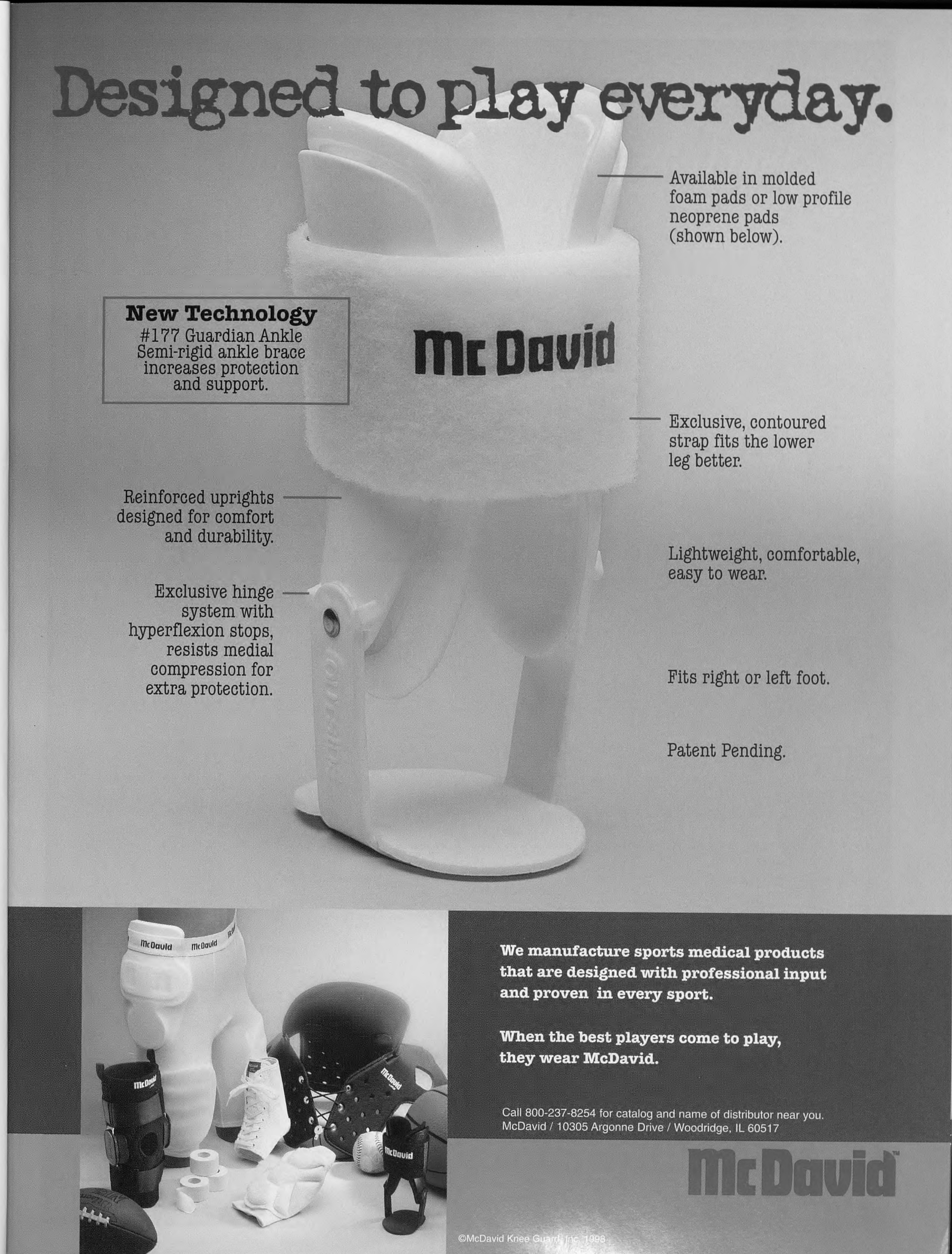
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1997 Outstanding Manuscript Awards

Congratulations to the winners and the runners-up of the 1997 Outstanding Manuscript Awards, as determined by the Editorial Board and the Associate Editors of the *Journal of Athletic Training*.

1997 *Journal of Athletic Training* Kenneth L. Knight Award for the Outstanding Research Manuscript

Winner: Dolan MG, Thornton RM, Fish DR, Mendel FC. Effects of cold water immersion on edema formation after blunt injury to the hind limbs of rats. 32:233–237.

First Runner-Up: Myrer JW, Measom G, Durrant E, Fellingham GW. Cold- and hot-pack contrast therapy: subcutaneous and intramuscular temperature change. 32:238–241.

Second Runner-Up: Butterfield DL, Draper DO, Ricard MD, Myrer JW, Durrant E, Schulthies SS. The effects of high-volt pulsed current electrical stimulation on delayed-onset muscle soreness. 32:15–20.

1997 *Journal of Athletic Training* Clint Thompson Award for the Outstanding Non-Research Manuscript

Winner: Clark JF. Creatine and phosphocreatine: a review of their use in exercise and sport. 32:45–51.

First Runner-Up: Hertel J. The role of nonsteroidal anti-inflammatory drugs in the treatment of acute soft tissue injuries. 32:350–358.

Second Runner-Up: Trupiano TP, Sampson ML, Weise MW. Fracture of the first cervical vertebra in a high school football player: a case report. 32:159–162.

■ 21st Annual NATA Student Writing Contest ■

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

1. The contest is open to all undergraduate members of the NATA.
2. Papers (eg, original research articles, literature reviews, case reports, clinical techniques articles, or communications articles) must be on topics germane to the profession of athletic training.
3. Entries must neither have been published by, nor be under consideration for publication by, any journal.
4. The winning entrant will receive a cash award and recognition as the winner of the Annual NATA Student Writing Contest. The winning paper will follow the normal process of submission and review for possible publication in the *Journal of Athletic Training*. One or more other entries may be given honorable mention.
5. Entries must conform to the *Journal's* Authors' Guide, which provides the most current information on format and style. For advice about writing, we suggest that authors consult Kenneth L. Knight and Christopher D. Ingersoll's "Structure of a Scholarly Manuscript: 66 Tips for What Goes Where" (*J Athl Train.* 1996;31:201–206) and "Optimizing Scholarly Communications: 30 Tips for Writing Clearly" (*J Athl Train.* 1996;31:209–213).
6. Entries must be received by March 1, 1999. The winner will be announced at the Annual Meeting and Clinical Symposia in June.
7. The Writing Contest Committee reserves the right to make no awards if, in its opinion, none of the entries is of sufficient quality to merit recognition.
8. An original and two copies of each entry must be received at the following address by March 1, 1999:

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

Editorial

Selecting Our Leaders

David H. Perrin, PhD, ATC
Editor-in-Chief

The Board of Directors of the National Athletic Trainers' Association comprises ten certified athletic trainers: one from each of our professional organization's ten districts. The selection of our Board of Directors is very important, as these members determine the future of our organization. The manner by which members are deemed eligible to seek the position of director is surprisingly inconsistent among the districts.

There are essentially three ways one becomes eligible for the position of district director: 1) nomination to run for election without requiring previous service in a state or district position; 2) nomination to run for election if the candidate has held a prior leadership role at the state or district level; and 3) automatic advancement from the position of district secretary or president. In Districts 1, 2, 6, 7, and 9, any member can be nominated for election as a director. Districts 4 and 8 require prior experience as an officer at the district or state level. In Districts 3 and 10, the district secretary advances to the position of director, as does the president in District 5.

The opportunity for any member of a district to run for the leadership position of district director would seem completely consistent with the democratic society in which we live and work. Prior experience as an officer at the state or district level is logical, although it would seem unlikely that a membership would elect an individual to the position of director without such experience.

The most unusual route for selection of a district director is to mandate prior service as a district secretary. As mentioned earlier, the role of a director is to represent the district membership in matters that determine the future of our profession. The district secretary serves as the custodian of all records and documents for the district and in some districts also assumes the role of treasurer. Both are essential roles, yet the responsibilities of a director and a secretary are very different. While a district secretary may indeed be well qualified to serve as a district director, there is no guarantee that competence in one role assures competence in the other. Moreover, a member might be interested in serving as a secretary without having to serve as a director, and vice versa. The linking of the director and secretary positions also creates the potential for 12 years of very time-consuming service to the association.

District 5 elects a president who ultimately becomes the district director. Service as a district president seems to offer a more logical and effective way of preparing for the role of district director than does service as a district secretary. However, this avenue still carries the potential for 12 years of continual service if one chooses to serve two terms as a district director. Is it reasonable to mandate a 12-year time commitment for a member to serve two terms as a district director?

The opportunity for a director to serve a second 3-year term exists in every district, but two very different mechanisms for reappointment exist. Districts 1, 2, 4, 6, 7, 8, and 9 require re-election to a second term, while Districts 3, 5, and 10 permit a second term by vote of confidence. Re-election requires an incumbent director to defend his or her platform and record of productivity against the proposed agenda of a challenger. The process of election is more consistent with the democratic society in which we live and work. By contrast, a vote-of-confidence procedure precludes another member from seeking the position of district director.

This editorial is not a reflection on the performance or qualifications of any of our current district directors, secretaries, or presidents, nor does it suggest that districts need be completely consistent in the way they select their leaders. Rather, I hope that the membership will re-examine the process by which we select our leaders and consider modifying the district bylaws so that every member has the opportunity to seek the position of district director.

I propose the establishment of three basic tenets for each district. First, any member should have the opportunity to run for election to district director. Second, the opportunity to run for the position of district director should be independent from the role of district secretary. Third, a district director seeking a second term should be required to run for re-election. Let us use the district meetings in Baltimore to discuss how we might select our future leaders, who will determine the course of our professional organization in the years to come.

Letters to the Editor

"The Peripheral View"

I have come to realize in recent years that many athletic trainers, unfortunately, grossly underestimate the ability and scope with which we can assist the athletes we supervise. It is not our goal to treat only athletes who are injured. One of our primary roles is to prevent problems from arising in the first place, and, in doing so, constantly work toward maximizing the performance of all athletes. Whether it be strength and conditioning, flexibility, nutrition, injury prevention techniques, or other related areas, we are competent to excel in any of these. And, if the issue is outside the scope of our training, then we can refer the athlete to an appropriate expert in the field. If we as a profession started to more actively involve ourselves in the preventive side of athletic health care, we would be enhancing the performance of the individuals and teams we supervise, we would limit the quantity of work we would have (less assessment and rehabilitation), we would dramatically cut costs, and we would become an even more integral component of the athletic support team.

In the athletic training classes I teach, I try to emphasize the "Power of Prevention" in every aspect of the curriculum. It is my hope that our flagship journal would encourage this natural expansion in breadth of our potential by occasionally publishing articles that focus completely on an athletic trainer's role in injury prevention and maximizing athletic performance.

Douglas J. Casa, PhD, ATC
Berry College
Mount Berry, GA

To the Editor:

In the October-December 1997 *JAT,* Craig Denegar wrote the editorial "Clinical Education in Athletic Training: Behind the Times and Threatening the Future." Dr. Denegar seems to feel that athletic training students are not adequately prepared to enter today's job market upon graduation. If reforms can help our profession, then we should institute them. However, if the reforms involve replacing too much of our education in the traditional setting with education in nontraditional settings, I think we will harm our profession. I think that athletic training students are better prepared to enter their profession than students in any other allied health care profession that I know of. I've always felt the practical experience and responsibilities student athletic trainers receive are the greatest strengths of our educational programs and are the main reason that we are well prepared to enter the work force upon graduation.

Dr. Denegar's call for education reform in athletic training to include more experience in the clinical setting could potentially be damaging to our profession. He stated in the editorial that "today many other physically active people also benefit from the expertise of a certified athletic trainer in sports medicine centers." We learn our "expertise" and special knowledge in the training room. This setting defines who we are, since it is a unique practice setting. If we learn our skills in the sports medicine clinic, we will learn to be physical therapy assistants. The more influence the clinical setting has on our educational programs and the more it reflects in the NATA role delineation studies, the more we will dilute the special knowledge and expertise we have as certified athletic trainers and eventually harm our ability to serve as certified athletic trainers in the traditional setting. Experience in other settings, such as rotations through orthopaedic or sports medicine clinics, is beneficial, but the majority of our education needs to be in the traditional setting if we are going to maintain our role as certified athletic trainers. Since the high school is a traditional setting, it makes a great place to have undergraduate students do some portion of their internship hours.

Finally, I disagree that instruction and patient education are more critical to successful outcomes in the clinical setting than they are in the traditional setting. In my high school, I am the only certified athletic trainer. With the high volume of athletes I see, instruction and patient education are critical. I cannot supervise each athlete all the time. Even though I often see them several times a week, it is vitally important to educate them on their injury and proper care and what they can do on their own. That is the only way I can keep up with the workload. Education in the traditional setting prepared me well to do that.

Tom Lyle, MS, ATC
Flagstaff High School
Flagstaff, AZ

To the Editor:

I read with great interest the editorial written by Dr. Craig Denegar appearing in the October-December 1997 *JAT*, "Clinical Education in Athletic Training: Behind the Times and Threatening the Future." I want to congratulate Dr. Denegar on an excellent expression of legitimate concern for our profession.

The clinical education of athletic training students has always been of primary importance to our preparation, and, in my opinion, it gives us the knowledge and skills that make us unique and effective health care providers. It is exactly those skills that now need to be effectively applied to physically active people of all ages in all practice settings. Individual differences do exist among the various populations that we, as athletic trainers, now serve. The actual skills required for effective health and injury care in various settings may not be dramatically different, but the application of those skills varies significantly among populations. We must recognize these differences and address them in our clinical preparation.

If we feature ourselves as the health care providers of choice for physically active people, then we have the responsibility to ensure that we can effectively demonstrate all that is implied by that designation, not only to our patients, but to employers, third-party payers, and our competitors. We must be given the skills to function comfortably and confidently in all of our practice settings, allowing us to develop employment positions that truly utilize and demonstrate our unique skills, rather than relegating us to subservient roles as aides or assistants. That confidence is built on knowledge and experience, and additional knowledge and experience are needed when considering the unique aspects of the various populations that comprise today's physically active.

The clinical setting in today's health care places great demands and expectations on providers to objectively prove and demonstrate their value. Patient satisfaction and patient outcomes are the determining factors in health care today for assessing quality care in clinical settings. Athletic trainers have historically been known for their effective outcomes. The clinical education experience for athletic training students must be reevaluated to ensure the continued effective demonstration of patient outcomes, and, more importantly, to validate and firmly establish the athletic trainer as the health care provider of choice for the physically active.

Marjorie J. Albohm, MS, ATC
Chairperson, NATA Reimbursement Advisory Group

To the Editor:

As I read Peggy Houglum's editorial, "Redefining our actions to better reflect our profession," in the January–March 1998 *Journal of Athletic Training*, my first thought was that I was glad someone was finally able to put into words what I have felt for years.

After working very hard, as we all do, to become certified, I began a career in the mid '80s in a high school doing the only job I ever wanted to do—athletic training. After 5 years of 60-hour weeks (sometimes more), which included additional teaching hours, and suffering from a severe case of burnout, I was faced with the decision of giving up a profession I dearly loved or sacrificing a desire for a family and a somewhat normal life. After being accused of "wanting it all," I did make the choice to give up active athletic training. Although I still keep up my CEUs, I am now in my ninth year strictly as a health and physical education teacher.

I give credit to those women and men currently in athletic training who can successfully juggle the demands and responsibilities of a family and still function as an athletic trainer. Meanwhile, I worry about the future of a profession in which there are so many skilled and dedicated people who feel forced to leave the career they love. This seems to especially apply to women.

I also agree with Ms. Houglum when she refers to the need for educators to teach athletic training students to be recognized as professionals. I think the students should be made aware early on in their study experience what the working world is still like—the hours, responsibilities, etc—and what it could be if they demand the respect they deserve.

Leigh Cicchino, ATC, ATR
Grice Middle School
Trenton, NJ

To the Editor:

I could not disagree with Ms. Houglum's editorial more. In fact, I was appalled to read that anyone who has actually worked as an ATC would suggest that we work in any situtation "more because we haven't learned to say no than because we are *really needed*." I average 50 hours/week, but do work as much as 70 hours/week. These hours are at the cost of my family, my health, and yes my precious "social" time. I do volunteer a portion of these hours and so may fall into "the way it's always been done." However, is it not possible that it's always been done because it is the right way to do things?

The essence of athletic training is long, hard hours. Athletic contests do not fall between 9 and 5, Monday through Friday. If we stand at an injury-free game for 2 hours and have used our time wisely, we should go home content that we did our job. Maybe we prevented injury that day or maybe the athletes were just fortunate. If an injury occurred, then we were available to provide initial care that could not have been provided the next day or when it was convenient to fit the athlete into the schedule. It is this care, which we are so highly trained for, and the willingness to "put in that extra effort" by being there when we are needed that make athletic training unique.

Each time we provide initial care is an opportunity to use and show others our level of knowledge and value. More importantly, each opportunity is a chance to make a difference in an athlete's life and sporting career. Being there when we are needed is our "true worth." If we volunteer time to events or programs that cannot afford medical coverage, are we not increasing our status in the community? Is this not especially true when the rest of the "medical arena" is not willing to do the same?

Comparing behaving like, and associating ourselves with, other medical professions endangers our unique characteristics. Certainly we deserve and should demand the respect of other professionals, but not at the cost of the respect from the athletes and patients we care for. A review of the current news literature would reveal the majority of medical patients do not feel that they "get what [they] pay for." The opposite "rings strong and true." Patients feel that they are overcharged and that medical professionals make too much money. How often have people received raises/promotions strictly on the merits of their profession? Personal merit, work habits, and work-related achievements are the cornerstones of any change in career status in any profession. I believe that athletic training is hindered by those of us who accept mediocre jobs and allow them to remain mediocre. Athletic trainers need to be aggressive in promoting themselves and increasing the value of themselves and their jobs to their individual employers.

It takes a special type of person to be a certified athletic trainer. We need to be cautious about instilling in our students selfish values, expectations for a deserved "quality of life," and the pursuit of the almighty dollar. What we really need to teach our students is the "strong subliminal message" I received from my mentors. Athletic training is caring, responsibility, and trying to make a positive difference in someone else's life. This is achieved through hard work and sacrifice. Those who received a different message are missing the true joy of our profession.

Andrew Nicholson, MS, ATC
Wooster Orthopaedic and Sports Medicine Center
Wooster, OH

Journal of Athletic Training 1998;33(2):118–121

Differences in Selected Predictors of Anterior Cruciate Ligament Tears Between Male and Female NCAA Division I Collegiate Basketball Players

Jamie L. Moul, EdD, ATC

Department of Health, Leisure, and Exercise Science, Appalachian State University, Boone, NC 28608

Objective: To examine sex differences in strength, Q-angle, and pronation as predictors of anterior cruciate ligament (ACL) injuries.

Design and Setting: Height, weight, sum-of-seven skinfolds, quadriceps and hamstrings strength, Q-angle, and pronation were measured in each subject.

Subjects: Male (n = 23) and female (n = 25) NCAA Division I basketball players, all from the same institution and participating in identical conditioning programs.

Measurements: Strength was measured at $180°\cdot s^{-1}$ using an isokinetic dynamometer. Q-angle was assessed with the leg fully extended and flexed to 30°. Pronation was determined with the navicular drop test.

Results: A 2×2 factorial analysis of variance indicated significant differences in the eccentric hamstrings-to-eccentric quadriceps strength ratio (female right = 46.11% ± 2.83%, left = 52.73% ± 3.74%; male right = 89.08% ± 6.34%, left = 93.16% ± 9.14% ($P < .001$)) and Q-angle measured in 30° of flexion (female right = 13.37° ± 0.99°, left 15.56° ± 1.34°; male right = 5.62° ± 0.75°, left = 6.00° ± 0.86° ($P = .05$)).

Conclusions: The results of this investigation indicate that, of the variables thought to contribute to ACL injuries, eccentric hamstrings strength relative to concentric quadriceps strength and Q-angle measured in 30° of flexion appear to be significantly different in males and females.

Key Words: sex, knee, strength, Q-angle, navicular drop test

The anterior cruciate ligament (ACL) tear is the most common severe ligament injury occurring to the knee.[1] Female athletes appear to be at greater risk for this injury than males.[2–4] In the recent NCAA injury statistics,[5] women's basketball players were six times more likely to incur an ACL tear than their male counterparts. Sex differences that may account for this include anatomic considerations, as well as different levels of strength.[3,6–10] Two anatomic considerations given credence include pronation[8,11] and Q-angle.[8,9]

Strength of the quadriceps and hamstrings has been investigated with respect to its effect on knee stability.[12–17] More et al[14] suggested that the hamstrings act as a protagonist to the ACL by reducing anterior tibial translation and internal tibial rotation during flexion, thus functioning synergistically with the ACL to provide anterior knee stability.

While several studies have investigated different anatomic markers,[3,8,11] few have explored specific strength parameters such as strength-to-body mass ratios and eccentric and concentric strength ratios. Nor have comparisons been drawn regarding anatomic and strength indicators in uninjured male and female basketball players. The purpose of this investigation was to examine sex differences in strength, Q-angle, and pronation as predictors of ACL injuries in healthy collegiate male and female basketball players. By identifying some specific differences, we can begin to work toward preventive measures that may minimize this devastating injury in the female population.

METHODS

Subjects

Forty-eight male (n = 23) and female (n = 25) subjects participated in this investigation. All subjects were NCAA Division I basketball players from the same institution participating in identical conditioning programs. The study was approved by the Institutional Review Board's Human Subjects Committee. Before testing, all subjects read and signed an informed consent form.

Height, weight, and sum-of-seven skinfolds data were collected for each subject. Additionally, each subject participated in three tests: a strength test to assess quadriceps and hamstrings strength, a measurement of Q-angle, and an evaluation of pronation.

Strength Assessment

All subjects performed three trials of maximal knee extension and flexion on a 125E KinCom (Chattecx Corporation, Chattanooga, TN) isokinetic dynamometer. Gravity correction was performed before each test. Tests were conducted on each of the subjects' contralateral limbs at $180°\cdot s^{-1}$. Data were processed with custom software (Chattecx Corporation). Knee extension and flexion were measured with the subjects in the seated position and the dynamometer axis of rotation aligned with the knee's frontal axis. The total range of motion at the joint for extension approximated 90° and that for flexion approximated 120°. Subjects were allowed unlimited submaximal warm-ups until they felt comfortable with the mechanics of the movement. Warm-ups ranged from three to five trials with each motion. Each subject was then asked to perform three maximal concentric and eccentric quadriceps and hamstrings contractions. The mean force outputs from each leg were used to calculate the following ratios: left and right hamstrings strength to body mass, left and right concentric hamstrings to concentric quadriceps, left and right concentric hamstrings to eccentric quadriceps, and left and right eccentric hamstrings to eccentric quadriceps.

Q-Angle Measurement

Q-angle measurements were obtained with the knee in 30° of flexion and in complete extension as described by Arnheim and Prentice.[1] A line was drawn from the anterior-superior iliac spine so that it bisected the patella; a second line was then drawn from the midpoint of the patella to the tibial tubercle. The axis of a goniometer was placed at the intersection of the two lines, with one arm of the goniometer aligned along the anterior-superior iliac spine line and the second arm along the tibial tubercle line. The angle was then read from the scale.

Navicular Drop Test

The navicular drop test described by Brody[18] was performed on each subject to measure pronation objectively. This test involves locating and marking the navicular tuberosity of the foot. With the athlete seated and the knees flexed to approximately 90°, the subtalar joint was positioned in neutral. An index card was placed at the medial aspect of the foot, and the level of the navicular tubercle was marked. The athlete then assumed a full weightbearing position, allowing the foot to relax. The navicular level was noted on the card. The difference between the two marks was measured in millimeters. Q-angle and navicular drop were both measured bilaterally.

Data Analysis

Data were analyzed using a repeated-measures analysis of variance. An a priori level of significance of 0.05 was adopted.

RESULTS

Descriptive data for the two groups (males and females) are summarized in Table 1. Strength testing data, Q-angle measurements, and navicular drop results are presented in Tables 2 and 3. Examination of the strength data revealed a significant difference between groups for the eccentric hamstrings-to-eccentric quadriceps ratio bilaterally ($F_{1,46} = 7.23$, $P = .01$). However, no significant differences were noted for hamstrings strength-to-body mass ratios or concentric hamstrings-to-concentric quadriceps or eccentric hamstrings-to-concentric quadriceps ratios.

Similarly, significant differences between groups were observed for Q-angle when measured with the knee in 30° of flexion ($F_{1,46} = 4.02$, $P = .05$). These differences were also noted bilaterally. There were no significant differences found for Q-angle measured with the knee in extension or for navicular drop.

DISCUSSION

These results suggest that eccentric hamstrings strength relative to eccentric quadriceps strength and Q-angle measured at 30° of flexion are significantly different for healthy male and female NCAA Division I collegiate basketball players.

Aune et al [12] have reported that hamstrings contraction helps to resist anterior tibial shear force at 30° of flexion in rats, thus reducing the load on the ACL. This finding is supported by Durselen et al,[16] who used nine cadaveric knees to investigate the influence of the quadriceps and hamstrings on ligament strain during loaded knee flexion. Their data suggested that activation of the quadriceps muscle had the most pronounced effect on ACL strain, especially in angles greater than 70° of knee flexion. An earlier investigation by More et al[14] indicated that hamstrings contraction decreases anterior tibial translation and internal tibial rotation and reduces tension on the ACL between 15° and 45° of knee flexion. The hamstrings, therefore, act as protagonists to the ACL in controlling tibial movement. Baratta et al[13] and Osternig et al[15] concurred that the hamstrings are activated independently from the quadriceps

Table 1. Subject Characteristics (Mean ± Standard Error of the Mean)

	Male		Female	
Variable	M	SEM	M	SEM
Age (y)	19.75	± 0.25	19.63	± 0.41
Height (cm)	187.21	± 4.64	176.10	± 1.91
Weight (kg)	88.01	± 5.93	70.80	± 2.93
Sum-of-seven skinfolds (mm)	81.88	± 15.01	102.69	± 6.72

Table 2. Strength Values (Mean ± Standard Error of the Mean)

Variable	Male M	Male SEM	Female M	Female SEM
Hamstrings: body mass (%)				
Concentric				
Right	28.58	± 1.53	33.11	± 3.20
Left	37.46	± 3.46	56.21	± 3.41
Eccentric				
Right	40.96	± 2.26	42.71	± 2.99
Left	52.54	± 5.98	68.69	± 7.68
Hamstrings: quadriceps (%)				
Concentric: concentric				
Right	76.95	± 7.00	57.09	± 3.50
Left	89.10	± 5.97	69.16	± 2.02
Eccentric: concentric				
Right	105.75	± 5.34	73.82	± 2.93
Left	108.16	± 7.14	75.65	± 3.78
Eccentric: eccentric				
Right	89.08	± 6.34	46.11	± 2.83*
Left	93.16	± 9.14	52.73	± 3.74*

* Denotes significance at $P \leq .05$.

Table 3. Navicular Drop and Q-Angle Values (Mean ± Standard Error of the Mean)

	Male M	Male SEM	Female M	Female SEM
Navicular drop (mm)				
Right	8.87	± 1.81	7.31	± 0.75
Left	8.50	± 1.05	7.37	± 0.98
Q-Angle (°)				
Extension				
Right	5.36	± 0.86	10.06	± 0.99
Left	5.50	± 0.96	10.31	± 1.42
30° Flexion				
Right	5.63	± 0.75	13.38	± 0.99*
Left	6.00	± 0.87	15.56	± 1.34*

* Denotes significance at $P \leq .05$.

and aid in stabilizing the knee. Baratta et al[13] used three groups of healthy individuals, ranging from sedentary to highly trained athletes, to quantify the coactivation patterns of the knee flexor and extensor muscles in an effort to identify the role of antagonist muscles in maintaining joint stability. Their data supported the findings of other researchers, in that the hamstrings aid in deterring anterior tibial translation at approximately 40° of extension. Additionally, Baratta et al[13] suggested that an individual with hypertrophied quadriceps without complementary hamstrings strength is predisposed to an ACL injury. Similarly, Osternig et al[15] investigated coactivation patterns and ACL dysfunction and reported that the hamstrings generated the greatest activity during maximal knee extension.

A landing/deceleration maneuver has been proposed as an activity that commonly causes ACL injuries.[19] Boden and Garrett[19] interviewed 40 athletes about the events surrounding their injuries and found that 1) 62% were noncontact injuries; 2) the average angle of knee flexion at the time of injury was 20°; and 3) 19% of the injuries occurred while performing a deceleration/landing maneuver. For the transition from running to jumping or a stance position to occur safely, the athlete must have good control of muscular activity. During landing/deceleration activities, flexion moments are occurring at the knee and hip. At the same time, the quadriceps and hamstrings are contracting eccentrically to decelerate the horizontal velocity of the body.[17] According to Palmitier et al,[17] the hamstrings contract eccentrically to stabilize the hip, while the quadriceps contract eccentrically to stabilize the knee. Activity in the hamstrings muscle, induced for hip stability, helps neutralize the tendency of the quadriceps to cause anterior tibial translation.[17] When the stabilizing influence of muscle is not present, inert internal tissues, such as ligaments, cartilage, and bone, become more vulnerable. Therefore, a deficit in eccentric hamstrings strength relative to eccentric quadriceps strength could predispose an athlete to an ACL injury.

Significant differences between groups were also noted for Q-angle when measured with the knee in 30° of flexion ($P <$ .05), with the males exhibiting smaller angles than the females.

Xerogeannes et al[20] found that the greatest magnitudes of force were incurred by the ACL at 30° of knee flexion. Q-angle is often associated with increased tibial internal rotation.[21] The ACL functions to prevent internal tibial rotation; thus, at 30° of flexion, if internal rotation is increased in females and the eccentric hamstrings-to-eccentric quadriceps strength ratio is diminished, during deceleration the knee is incurring two forces that compromise the integrity of the ACL and is lacking in one restraint mechanism. The combination of structure and strength may predispose females to a greater incidence of ACL injuries. Further research investigating landing mechanics and possible strengthening techniques to address eccentric hamstrings deficits is warranted. Additionally, longitudinal data regarding these variables as reliable predictors are needed.

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Injuries in the Sport of Racewalking

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Objective: To examine the nature and incidence of injuries suffered by racewalkers.

Design and Setting: A total of 682 questionnaires were distributed to racewalkers in the San Diego/Long Beach, CA area, participants in a national qualifying race held in Washington, DC, and subscribers to *The Ohio Racewalker*.

Subjects: Four hundred questionnaires were returned to the investigators, for a return rate of 58.7%.

Measurements: Questions addressed demographics, exercise patterns, competitive history, walking surfaces, types of footwear normally used for training and competition, and injuries suffered during racewalking. Questionnaire results were tabulated and chi-square analyses were used to test for interrelationships. A stepwise discriminant analysis was used to develop a model for the prediction of injury in racewalking.

Results: Racewalking participation peaks in the 30- to 39-year-old age group, while the proportion of injured participants is greatest in those under 30. Most injuries involved the lower extremity, but the "average" racewalker suffered only one serious injury every 51.7 years. Those participants who trained six or seven times per week were most likely to be injured; those who trained three or fewer times per week were least likely to be injured. The percentage of injured participants increased progressively with weekly training mileage. A model based on the data from this investigation correctly predicted membership in either the injured or uninjured group in only 64.1% of cases and is, therefore, of limited use to the researcher or clinician.

Conclusions: Although the rate of injuries in racewalkers is low, more systematic research is necessary before sports medicine professionals can confidently recommend consistently effective injury prevention procedures.

Key Words: walking surfaces, footwear, training, injury prediction

The popularity of racewalking has increased steadily ever since the sport was first included in the Olympic Games in 1908. International competitors have been drawn from countries all over the world, but the two Olympic events (20 km and 50 km) are currently dominated by athletes from Mexico, Italy, and countries that were formerly part of the Soviet Union. Racewalking has not yet attracted large numbers of participants in North America, but there appear to be indications that the sport is growing in popularity. Racewalking events of 5 and 10 km are becoming increasingly popular for casual athletes, and successes in these relatively short events have encouraged some newcomers to attempt progressively longer races.

A number of walking enthusiasts have attributed the rising popularity of racewalking to a decline in the popularity of jogging and a concomitant increase in the number of people who are taking part in exercise walking programs. It is presumed[1–3] that this trend has been influenced by the widespread belief that racewalking is a sport providing opportunities for competition, as well as valuable health and fitness benefits, without significant risk of injury.

A review of the literature revealed that little has been documented about injuries associated with racewalking. Palamarchuk[4] questioned 31 racewalkers and concluded that the individuals in his small sample were prone to the same kinds of injuries as runners. The primary complaint was blisters of the heels and toes. Hamstring injuries were the next most common, followed in decreasing order of incidence by medial knee pain, nonspecific hip pain, plantar fasciitis, shin splints, stress fractures, and groin strains. In view of the increasing popularity of racewalking, we reasoned that a survey of a larger group of participants would provide additional objective data that would be useful to the athletic training and coaching communities.

METHODS

A detailed questionnaire was designed, field tested, and modified before being administered to subjects used in the investigation. In addition to questions of a demographic nature, the instrument elicited responses about exercise patterns (including racewalking and any other physical activities), competitive history, and the walking surfaces and types of footwear normally used for training and competition. Finally, questions were asked about injuries suffered during participation in racewalking. A distinction was made between injuries that respondents believed to have been the direct result of participation in racewalking and injuries that were assumed to have been associated with prior orthopaedic history.

In an effort to establish a means of communicating with a broad representative sample of the racewalking population, an informal survey was carried out before the present investigation. The survey revealed that there was considerable variability in the available estimates of the size of the population of racewalkers in the United States, especially with respect to the number of casual athletes involved in the sport. For example, estimates of the size of the total racewalking population provided by various individuals associated with the United

States Olympic Committee and the Athletic Congress varied from 2,000 to 6,000 participants. Preliminary inquiries also indicated that the racewalking population is widely distributed throughout the nation.

Therefore, two different methods were used in an attempt to obtain a representative sample from this sparse and widely distributed population.

One of the investigators (N.M.R.) met personally with potential subjects at competitions held at two widely separated geographic locations. Seventy prestamped and preaddressed questionnaires were distributed to competitors in the San Diego/Long Beach area in California. An additional 100 questionnaires were randomly distributed at a national qualifying race held in Washington, DC. Finally, in an effort to contact participants in other areas of the United States, a mailing list was obtained from the editors of a racewalking newsletter (*The Ohio Racewalker*), and questionnaires were distributed to all 512 individual subscribers. Thus, the total number of potential subjects was 682.

RESULTS

Data analysis was carried out when a total of 400 completed questionnaires were received by the investigators, which represented a return of 58.7%. On the basis of available estimates, the present investigation was based upon a sample of approximately 7% to 20% of the entire population of racewalkers in the United States. All data were coded and analyzed so as to obtain descriptive and inferential statistics.

Demographic Information

The sample consisted of 294 males and 106 females whose ages ranged from 12 to 88 years (mean = 44 years). History of participation in the sport for the individuals in the sample ranged from 3 months to 62 years (mean = 8.04 years). The sample included participants from all but five states. About one third of the subjects (34.6%) indicated that they began racewalking after being injured in another sport. Of these subjects, 89% indicated that running was the activity responsible for the earlier injuries. The remaining subjects indicated that they had suffered injuries while taking part in a variety of other activities, of which football, bicycling, and soccer were reported most frequently.

Exercise Habits

Most respondents (357 = 89.3%) indicated that they took part in competitive walking events ranging in distance from 1 mile to the marathon, but it was apparent that the level of participation varied greatly. Figure 1 summarizes the average frequency, duration, and weekly mileage of the racewalking exercise of the subjects. The variability clearly indicates that the sample included participants who ranged from casual racewalkers to serious competitors.

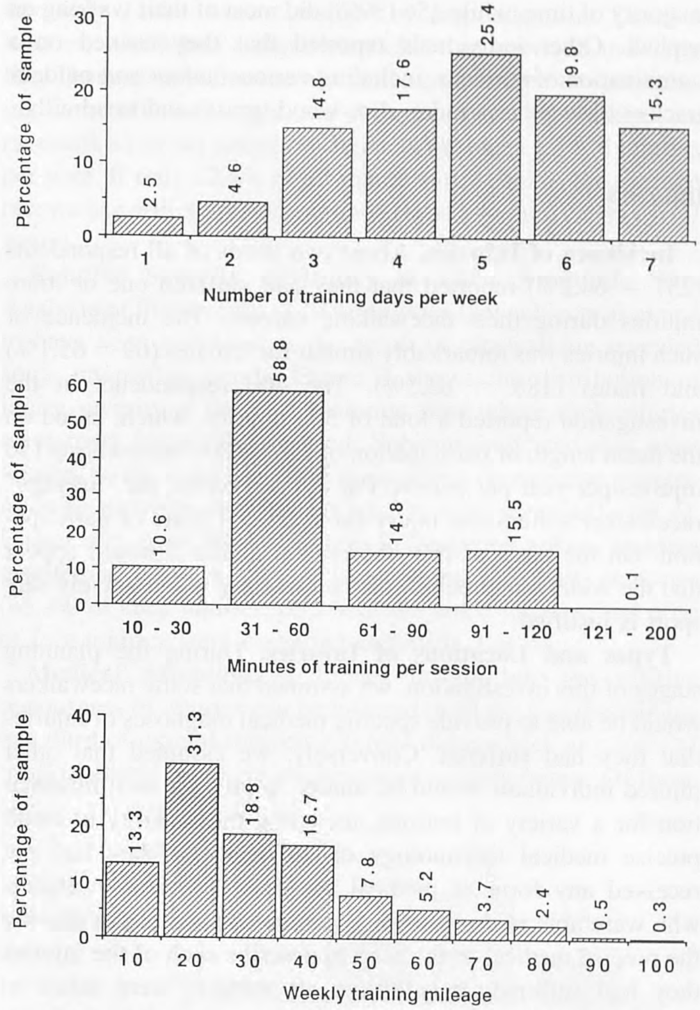

Fig 1. Frequency and duration of training sessions and average weekly mileage of 400 racewalkers.

Most participants reported that they were concurrently participating in other athletic activities, of which running, bicycling, swimming, and weight training were the most common. The great majority of participants (83%) indicated that they took part in some form of stretching program in conjunction with their racewalking programs. Almost two thirds of the subjects (213 = 63.2%) reported that they stretched both before and after exercise.

Footwear and Walking Surfaces

A little more than one third (150 = 37.5%) reported that they normally used shoes designed for racewalking during training and competition. However, more than half of the respondents (239 = 59.8%) wore shoes that were designed for running. The remainder reported that they normally wore a variety of types of footwear, including shoes designed for court and racquet sports.

Most respondents (61%) indicated that they exercised almost exclusively on a single type of ground surface. Almost half of these individuals (195 = 48.8%) performed on concrete for the majority of time, while 156 (39%) did most of their walking on asphalt. Other individuals reported that they trained on a combination of surfaces, including various indoor and outdoor tracks (all-weather, cinder, dirt, wood, grass) and treadmills.

Injuries

Incidence of Injuries. About two thirds of all respondents (257 = 64.2%) reported that they had suffered one or more injuries during their racewalking careers. The incidence of such injuries was remarkably similar for females (69 = 65.1%) and males (188 = 63.5%). The 400 respondents in the investigation reported a total of 502 injuries, which, based on the mean length of participation of 8.04 years, represents 0.156 injuries per year per person. Put in other terms, the "average" racewalker suffers one injury for every 6.4 years of participation. On the basis of this observation alone, it would appear that the widely held belief that racewalking is a relatively safe sport is justified.

Types and Locations of Injuries. During the planning stages of this investigation, we assumed that some racewalkers would be able to provide specific medical diagnoses of injuries that they had suffered. Conversely, we assumed that other injured individuals would be unable to provide such information for a variety of reasons, including the inability to recall precise medical terminology or the fact that they had not received any form of medical attention. Therefore, subjects who were able to do so were given the opportunity to provide the precise medical terms used to describe each of the injuries they had suffered. In addition, all subjects were asked to identify the anatomic location of injuries that they had suffered.

About half of all reported injuries (247 = 49.2%) were identified with specific diagnoses (Table 1). In apparent agreement with the observations of Palamarchuk,[4] we found that many of these injuries are similar to those suffered by runners. The most common injuries reported by runners appear to be patellofemoral pain syndrome, tibial stress syndrome, Achilles peritendinitis, plantar fasciitis, and patellar tendinitis.[5,6] However, the most commonly reported injury in our investigation was hamstring strain. A number of subjects indicated verbally that they frequently suffered from blisters of the heels and toes, but only six cases were reported in response to the questionnaire. Many racewalkers appear to regard a blister as an inconvenience rather than an injury.

Table 2 lists the anatomic locations and frequency of occurrence of all the injuries counted in this investigation. It has been reported that the knee is the site most commonly associated with injury in runners.[6–9] However, the foot and knee were almost equally affected by injury among the racewalkers in our investigation. During informal discussions, several competitors stated that racewalkers rarely if ever suffer knee injuries. However, this contention was not supported by our data. Even though hamstring strain was the most frequently reported specific injury, the knee, shin, hip, and back were more commonly affected by a variety of nonspecific injuries than was the hamstring musculature.

Table 1. Specific Diagnoses of Injuries Reported by Subjects

Injury	Frequency
Hamstring strain	24
Shin splints	19
General ligament sprains	17
Other muscle strains	17
Tendinitis, foot	16
Spinal injuries	10
Tendinitis, knee	9
Iliotibial band syndrome	8
Sciatica	8
Plantar fasciitis	8
Chondromalacia patella	7
Groin pull/strain	6
Anterior tibial tendinitis	6
Arthritis, knee	6
Ligament strain, knee	6
Stress fracture, foot	6
Blisters, foot	6
Arthritis, other locations	6
Stress fractures, other locations	5
General tendinitis	5
Sesamoiditis	5
Nonspecific pain	5
Bursitis	5
Anterior compartment syndrome	4
Muscle spasm	2
Other conditions	31
Total	247

Table 2. Locations of Injuries Reported by 400 Racewalkers

Location	Frequency	Percentage of All Injuries at This Location With No Prior Orthopedic History
Knee	107 (21.3%)	66.0%
Foot	104 (20.7%)	75.0%
Shin	64 (12.7%)	94.2%
Hip	58 (11.6%)	74.5%
Back	46 (9.2%)	41.5%
Hamstring	41 (8.2%)	81.1%
Ankle	37 (7.4%)	84.6%
Groin	13 (2.6%)	
Thigh	9 (1.8%)	
Shoulder	6 (1.2%)	
Neck	4 (0.8%)	
Abdomen	2 (0.4%)	
Iliotibial band	1 (0.2%)	
Pelvis	1 (0.2%)	
Other	9 (1.8%)	
Total	502 (100.1%)	

* Total (100.1%) due to rounding all percentages to one decimal place.

Initial Occurrence of Injuries. For each injury reported, subjects were asked to indicate whether they believed that the injury had occurred as a direct result of participation in racewalking or whether the injury had occurred as a result of some other activity and had been aggravated or reinjured by subsequent participation in racewalking. Table 2 shows the percentage of injuries at each anatomic site that were not associated with prior orthopaedic history: that is, injuries respondents assumed to have been a direct result of participation in racewalking. Our analysis has been restricted to those sites that include at least 5% of all reported injuries. Data generated from subsets that included only a handful of cases appear to be of dubious value.

In total, about four fifths of all injuries reported at the seven most commonly injured sites were not associated with prior orthopaedic history, but a closer examination of the data reveals some interesting trends. For example, more than half of the injuries involving the back (58.5%) had been associated with prior orthopaedic history. However, most injuries to the shin (94.2%), ankle (84.6%), and hamstring (81.1%) were not associated with prior orthopaedic history. On the basis of these observations, we inferred that many back pain sufferers "bring their injuries to the sport," but there appear to be cause-and-effect relationships between racewalking and many injuries to the shin, ankle, and hamstring.

Severity of Injuries. Subjects were asked to designate the level of severity of each of the injuries that they had suffered, based upon the following scale:

- Level 1. Pain only after exercise.
- Level 2. Pain during and after exercise, but little change in exercise patterns or daily activities.
- Level 3. Pain resulting in changes in exercise patterns and affecting some daily activities.
- Level 4. Pain all the time, eliminating all exercise and affecting many daily activities.

Only 15.5% of respondents reported more than two injuries, and in most instances where more than two injuries were reported, the additional injuries were classified by respondents as Level 1 (pain only after exercise). Therefore, we limited subsequent analysis to the most serious injury and the second most serious injury for subjects who reported two or more injuries (Fig 2). About half of all the injuries (49.5%) can be regarded as relatively trivial, since they created few or no changes in exercise patterns or daily activities. Of the remainder, only 12.4% were classified by respondents as Level 4 injuries, which had a significant effect on exercise and daily life. These observations reinforce the contention that racewalking is a relatively safe activity. As indicated earlier, the racewalkers in our sample suffered an average of 0.156 injuries per year. If only 12.4% of all injuries are Level 4, the average racewalker will suffer one serious (Level 4) injury every 51.7 years!

Relative Severity of Injury at Each Anatomic Site. Analysis of the severity of those injuries that subjects assumed to have been sustained as the result of racewalking revealed some interesting trends. Figure 3 shows the distribution of injury severity at the four anatomic sites where such injuries were most frequently reported. Subjects indicated that most injuries to the shins had little or no effect on exercise patterns or daily activities and that only 6.3% were serious (Level 4). Conversely, over half the injuries to the knees, ankles, and feet resulted in changes to exercise patterns and daily activities (65.3% of knee injuries, 65.2% of the ankle injuries, and 60% of foot injuries were classified as Levels 3 or 4).

Medical Attention. A further insight into the relative seriousness of injuries can be inferred from the fact that almost one third of injured subjects (30.6%) did not seek any form of medical treatment even for their most serious injury. Of those

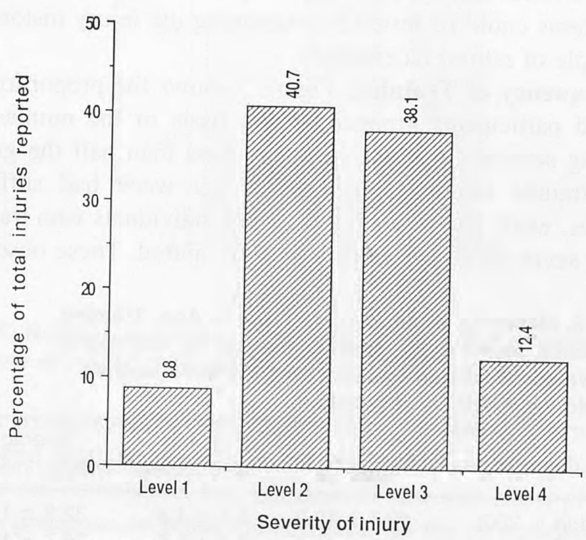

Fig 2. Distribution of severity of all reported injuries.

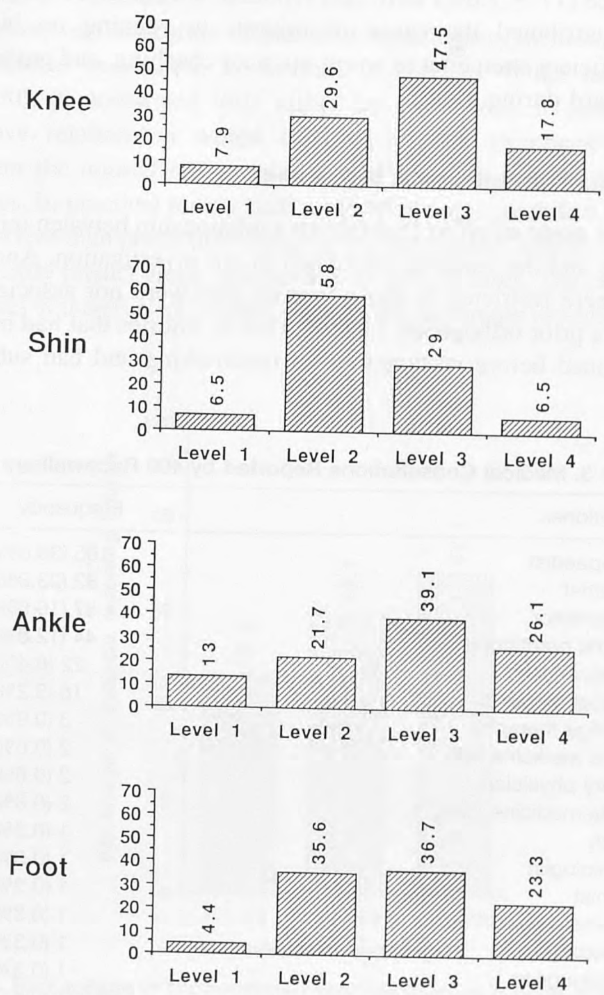

Fig 3. Relative severity of injuries reported at four anatomic sites.

subjects who did seek treatment, some subjects sought medical advice from more than one source. In all, 343 sought medical consultations (Table 3). The specific treatments recommended are listed in Table 4. It is apparent that only a limited number of subjects sought attention from athletic trainers (6.4%), which we assume is due to a lack of opportunities for racewalkers in the high school and collegiate settings. However, we suggest that athletic trainers who have an interest in racewalking injuries should make local physicians aware of their willingness to accept referrals of injured athletes.

Perceived Causes of Injuries. Subjects were given the opportunity to attempt to explain the causes of their injuries. These data must be regarded with some reservations. However, in the absence of information about the precise circumstances associated with each of the injuries reported, it can be argued that the subjects' perceptions might provide better insights than the researcher's or clinician's speculations.

For 225 of the 502 reported injuries (44.8%), subjects believed that they could identify the cause of their injuries. Almost two thirds of all of these "accountable" injuries (146 = 64.9%) were attributed to either a significant increase in the amount of exercise that was done (97 = 43.1%) or postural or anatomic deficiencies (49 = 21.8%). Improper technique (29 = 12.9%), improper shoes (19 = 8.4%), and improper surface (17 = 7.6%) were also reported. One or more subjects also attributed the cause of injuries to running on hills, insufficient stretching or warm-up, poor coaching, and pushing too hard during a race.

Cross-Tabulation Of Variables

We made an effort to establish a relationship between injury status and the variables examined in our investigation. Analyses were restricted to those injuries that were not associated with a prior orthopaedic history. That is, injuries that had been sustained before participation in racewalking and had subsequently been aggravated or reinjured by participation in racewalking were excluded from the remainder of the analyses.

Results of a chi-square analysis indicated significant relationships between injury status and three of the variables examined. These were age of subjects ($P = .0001$), the number of training sessions in a typical week ($P = .009$), and the weekly training mileage ($P = .02$). Table 5 shows the means and standard deviations for each of these three variables for both injured and noninjured subjects.

Age and Injury. Figure 4A shows the distribution of ages of subjects in this investigation. Participation peaks in the range of 30 to 39 years of age and declines steadily thereafter. Figure 4B shows the percentage of individuals in each of the age groups who reported injuries. The greatest proportion of injuries was reported by individuals under the age of 30 (42 injured out of 57 subjects = 73.7%), and the proportion of injured participants tends to decline thereafter.

Interpretation of this observation is open to some speculation. However, on the basis of the mean ages of injured and noninjured participants (40.7 and 48.2 years of age, respectively), it might be argued that those participants who are prone to discomfort and injuries are more likely to give up the sport earlier than those who are injury free. In this sense, older participants can be regarded as having "survived" by virtue of genetic factors such as mechanically sound biomechanics and by behavioral factors such as prudent training practices. This hypothesis could be tested by examining the injury history of a sample of retired racewalkers.

Frequency of Training. Figure 5 shows the proportion of injured participants grouped on the basis of the number of training sessions in a typical week. Less than half the group who trained three or fewer times per week had suffered injuries, while about two thirds of the individuals who trained six or seven times per week had been injured. These observa-

Table 3. Medical Consultations Reported by 400 Racewalkers

Practitioner	Frequency
Orthopaedist	105 (30.6%)
Podiatrist	82 (23.9%)
Chiropractor	57 (16.6%)
General practitioner	44 (12.8%)
Athletic trainer	22 (6.4%)
Physical therapist	18 (5.2%)
Massage therapist	3 (0.9%)
Sports medicine MD	2 (0.6%)
Military physician	2 (0.6%)
Sports medicine clinic	2 (0.6%)
Coach	1 (0.3%)
Kinesiologist	1 (0.3%)
Internist	1 (0.3%)
Rheumatologist	1 (0.3%)
Osteopath	1 (0.3%)
Neurosurgeon	1 (0.3%)
Total	343 (100%)

Table 4. Treatments Prescribed as the Result of Consultations Listed in Table 3

Recommended Treatment	Frequency
Reduced activity	83 (24.2%)
Physical therapy	68 (19.8%)
Medication	55 (16.0%)
Complete rest	45 (13.1%)
Surgery	45 (7.3%)
Other treatments	63 (18.4%)
No treatment	4 (1.1%)
Total	343 (99.9%)*

* Total (99.9%) due to rounding all percentages to one decimal place.

Table 5. Means (± Standard Deviation) of Age, Training Frequency, and Average Weekly Mileage for Noninjured Racewalkers and Racewalkers Who Suffered Injuries With No Prior Orthopedic History

	Age (y)	Training (sessions/wk)	Average (weekly mileage)
Injured (*n* = 200)	40.7 ± 13.2	5.1 ± 1.4	32.3 ± 17.9
Noninjured (*n* = 143)	48.2 ± 15.3	4.7 ± 1.6	26.7 ± 18.4

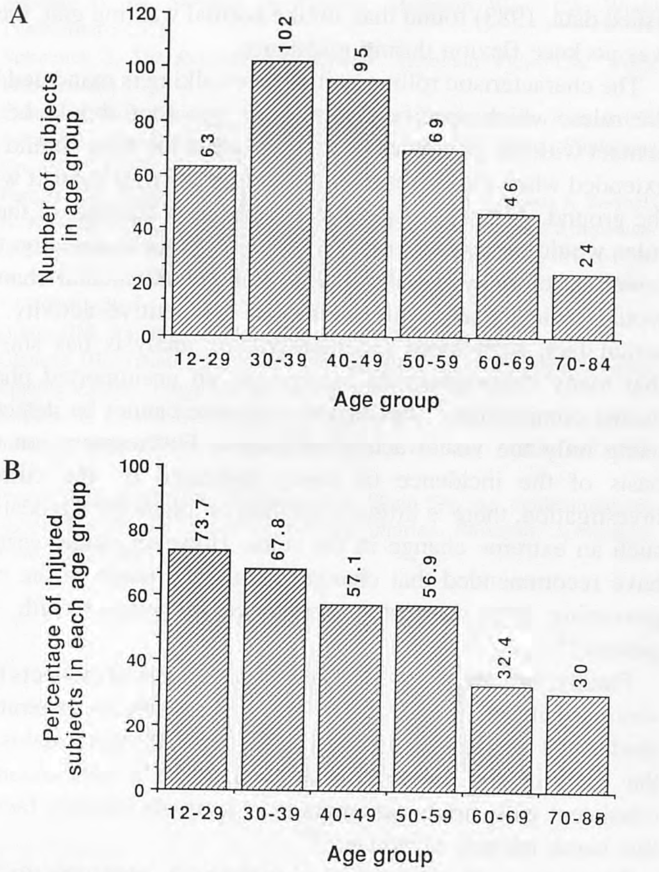

Fig 4. A, Age distribution of 40 racewalkers. B, Percentage of injured racewalkers in each of the age groups shown in A.

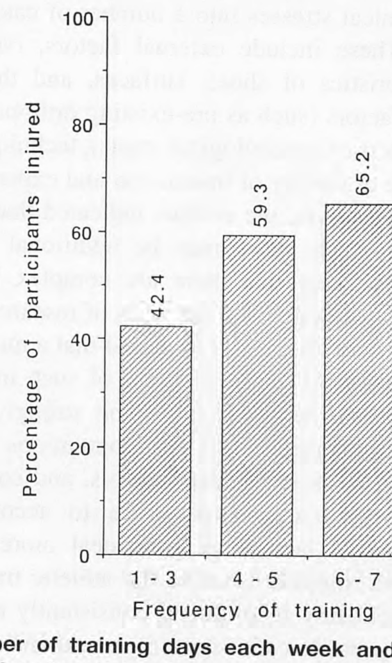

Fig 5. Number of training days each week and corresponding number of injured participants.

tions appear to reflect cumulative stress disorders. It is widely believed that the potentially injurious effects of mechanical stress are cumulative, but that days of rest will allow physiologic processes to repair microtrauma to the musculoskeletal system.

Weekly Training Mileage. The average weekly training mileage reported by injured subjects (32.3 miles) was greater than the mileage reported by uninjured subjects (26.7 miles). Figure 6 indicates that the greatest proportion of injured individuals occurred among the group whose members accrued more than 50 miles each week, and the smallest proportion of injured individuals occurred among those who restrict weekly training to 15 miles or less. This observation is consistent with the conclusion of Powell et al,[10] who reviewed three epidemiologic studies of running injuries and reported, "Of all the possible causes of injury, the number of miles run per week is most clearly associated with the incidence of running injuries."

Discriminant Analysis of Variables Related to Injury

We used a stepwise discriminant analysis to determine which linear combination of variables examined would best discriminate between injured and uninjured racewalkers. Results indicated that years of participation in racewalking (Y), the duration of the average training session (D), the frequency of training sessions in a typical week (F), and age (A) were significant ($P < .05$). A model for the prediction of injury in racewalking was established: $D = 0.28(Y) + 0.27(D) + 0.34(F) - 0.83(A)$

However, indicators of practical significance, including the canonical correlation coefficient (0.32) and Wilks lambda (0.90), demonstrated little utility for the model. In fact, the above relationship would correctly predict membership in either the injured group or uninjured group in only 64.1% of cases. In practical terms, such a model is not a great deal more effective than prediction based upon coin tossing, which would correctly predict group membership in 50% of cases. The current model is therefore of limited value to the researcher or clinician.

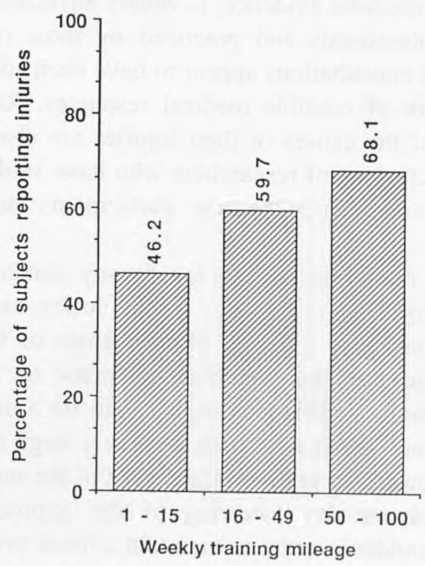

Fig 6. Percentage of racewalkers reporting injuries in each of three groups based on weekly training mileage.

DISCUSSION

Our investigation provided demographic data that are of interest to the athletic training community. Specifically, overall participation peaks among the 30- to 39-year-old age group. This finding is likely to reflect the passage of the "age wave" of baby boomers in our society, but the total number of participants under the age of 20 years (16, 4%) revealed that racewalking appears to have limited appeal to younger individuals. In a study conducted on behalf of the Athletic Footwear Association,[11] Ewing and Seefeldt questioned more than 8,000 young people and found that there was a steady decline in interest in track sports between the ages of 10 and 18 years. Subjects indicated that the mean reason for participation was "having fun." In commenting on the sociologic implications of Ewing and Seefeldt's observations, Danish[11] stated, "What is enjoyable for individuals will change with age. Even though boredom or anxiety may produce a drop-out, the individuals may well turn to the same or another sport later on, especially if they can find something important about themselves in the activity."

On the basis of our data, it would appear that racewalking has exemplified this state of affairs. The cross-training habits of many participants are clearly appropriate for goals other than success in competition, and long-term commitment to the sport is common. The widespread use of footwear that was designed for activities other than racewalking may be indicative of the limited selection of racewalking shoes available. However, this observation could also indicate that many participants have a relatively informal attitude to the activity when compared with many dedicated runners and dance-exercise enthusiasts, who tend to be fiercely loyal to specific models of activity-specific shoes.

Participants appear to be well informed about current sports medicine practices. The injury-prevention benefits of stretching have not been objectively demonstrated, but stretching, on the basis of anecdotal evidence, is widely advocated by sports medicine professionals and practiced by most racewalkers. Most medical consultations appear to have been sought within the framework of credible medical resources. Racewalkers' perceptions of the causes of their injuries are also consistent with the conclusions of researchers who have studied injuries to runners and dance-exercise participants and instructors.[7,8,12,13]

The injury rate in the sport is low by any standards, and the nature and location of injuries to the lower extremity are somewhat consistent with the biomechanics of the activity. Fenton[5] found that the mediolateral forces on the feet of racewalkers were significantly higher than for a normal walking gait. Payne[14] attributed these relatively large mediolateral forces in racewalking to the straightening of the supporting leg and the compensatory lowering of the opposite hip and ipsilateral shoulder in order to maintain a linear progression of the center of mass. Corrallo et al (V. Corrallo, L. Downes, K. Hogan, T. King, K. Larsen, J. O'Dwyer, and A. Peck, unpublished data, 1983) found that, unlike normal walking gait, there was no knee flexion during midstance.

The characteristic rolling gait of racewalking is mandated by the rules, which specify that at least one foot should be in contact with the ground at all times and that the knee should be extended when the corresponding foot makes first contact with the ground. Although a significant change in the first of these rules would predictably reduce some mechanical stress on the lower extremities, it is likely that such a fundamental change would radically alter this traditional competitive activity. In actual fact, high-speed cinematographic analysis has shown that many racewalkers do incorporate an unsupported phase during competition,[15] but that the practice cannot be detected using only the visual acuity of judges. Furthermore, on the basis of the incidence of injury indicated by the current investigation, there is little compelling rationale for advocating such an extreme change in the rules. However, some writers have recommended that changes should be made in the rule governing knee extension during initial impact with the ground.[16]

Finally, even with the relatively large sample of subjects that was used in our investigation, we were unable to generate a model that would provide good prediction of injury status on the basis of the variables examined. Such a conclusion is consistent with similar attempts to objectively identify factors that cause injuries to runners.[10]

In an attempt to provide a systematic approach to the identification of factors that contribute to injuries, Nigg et al[17] proposed a system that classifies the sources of potentially injurious mechanical stresses into a number of categories and subcategories. These include external factors, (such as the various characteristics of shoes, surfaces, and the environment), internal factors (such as pre-existing orthopaedic status and various aspects of psychological status), technique (including the influence of history of instruction and experience), and training habits. However, the authors indicated that even with a systematic approach, there may be additional factors involved, and it is likely that there are complex interactions between the various factors. On the basis of research involving running injuries, Powell et al[10] concluded that a number of the factors widely believed to be causative of such injuries have not been objectively demonstrated to be strongly related to injury status. Furthermore, human populations cannot be readily subjected to experimental controls, and so it is inevitably either impractical or impossible to account for all potentially causative factors. A great deal more systematic research must be completed before the athletic training community can confidently recommend consistently effective injury prevention procedures in sport in general and racewalking in particular.

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Temperature Changes in Human Patellar Tendon in Response to Therapeutic Ultrasound

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Objective: To determine the rate and magnitude of temperature change in response to ultrasound in human patellar tendon for two treatment sizes.

Design and Setting: A thermistor was inserted into the medial aspect of each subject's right patellar tendon, and the baseline temperature was recorded. Using stratified random sampling and using a transducer head with an effective radiating area (ERA) of 4.5 cm^2, we had eight subjects each undergo either the 2- or 4-ERA ultrasound treatment first. Each subject received a 3-MHz continuous ultrasound treatment at 1 W/cm^2 for both the 2- and 4-ERA treatment sizes.

Subjects: Sixteen subjects (8 males, 21.3 ± 1.9 years, and 8 females, 21.0 ± 2.8 years) participated.

Measurements: We moved the sound head at a speed of 2 to 3 cm/sec while recording the tendon temperature every 30 seconds during, and for 20 minutes after, the 4-minute treatment. Twenty minutes after the treatment, we applied the second treatment to the other ERA treatment size.

Results: At the end of the treatment, the mean temperature increase was significantly different (P = .006) between treatment sizes (8.3°C ± 1.7°C (2 × ERA) and 5.0°C ± 1.0°C (4 × ERA)). The rate of increase was also significantly different (P < .001). The heating rate per minute for the 2-ERA treatment was 2.1°C ± 0.4°C and 1.3°C ± 0.3°C for the 4-ERA treatment. There was a significant difference in the cooling between treatment sizes (P = .001). The rate of temperature decrease between treatment sizes was significantly different only during the first 5-minute interval post-treatment.

Conclusion: Three-megahertz ultrasound at an intensity of 1 W/cm^2 significantly increased patellar tendon temperature at both 2 and 4 × ERA, but our results confirm that the 2-ERA treatment size provided higher and longer heating than the 4-ERA treatment size.

Key Words: thermal effects, effective radiating area

Therapeutic ultrasound is one of the most often used modalities in treating soft tissue injuries.[1] The therapeutic effects of ultrasound are classified as thermal and nonthermal. The nonthermal effects of ultrasound are desired when treating acute soft tissue injuries where heating should be minimized.[2] The nonthermal effects of ultrasound increase cellular diffusion and membrane permeability, as well as fibroblastic activities, such as protein synthesis, that speed up tissue regeneration.[3] The thermal effects of ultrasound are desired in treating chronic soft tissue injuries that result in inflammation.[4,5] Like other heating modalities, ultrasound changes nerve conduction velocity,[6] increases enzymatic activity,[7] changes contractile activity of skeletal muscle,[8,9] increases collagen tissue extensibility,[10,11] increases local blood flow,[7,12] increases pain threshold,[13,14] and reduces muscle spasm.[15,16]

Prominent authors[4,17] agree that the factors affecting the absorption of ultrasound energy in tissues high in collagen include frequency and intensity of ultrasound, duration of treatment, movement speed of the transducer, coupling agent used, type of tissue being treated, and size of treatment area. Most of these factors have been scientifically studied, but research has focused primarily on ultrasound penetration in animal and human muscle.[18–23] Investigation of target tissues other than muscle that are high in collagen, such as tendons, has been performed only on animals.[11,24–27]

Of the factors affecting ultrasound energy absorption, size of treatment area has received little investigation. Lehmann et al[28] indicated that the absorption of ultrasound energy by the tissue is directly related to the size of the treatment area. Draper et al[29] reported that ultrasound administered at two times the effective radiating area (ERA), at a frequency of 3 MHz, heats muscle 0.6°C/min at a depth of 0.8 cm, at 1 W/cm^2. Since tendon is more collagenous than muscle, it is speculated that the absorption of ultrasonic energy by tendon should be more efficient.[30] This is the first in vivo study to examine the ability of ultrasound to heat human tendon. Our study determined the magnitude, rate, and effect of treatment size on temperature change in human patellar tendon during and after a 3-MHz ultrasound treatment.

METHODS

Subjects

Sixteen college students (8 males, 21.3 ± 1.9 years, and 8 females, 21.0 ± 2.8 years) participated in the study. Each subject was informed of the treatment procedures before signing a Brigham Young University Human Subject's Institutional Review Board-approved consent form. We used stratified random sampling so that 8 subjects underwent the 2-ERA treatment first, while the other 8 underwent the 4-ERA treatment first.

The right patellar tendon of each subject was chosen as the treatment site because of minimal subcutaneous fat and ease of accessibility. Subjects were excluded if they exhibited localized infection, swelling, or injury to the area. Before treatment, we administered 500 mg of cephalexin hydrochloride (Keftab, Dista Products and Eli Lilly Company, Indianapolis, IN) to reduce the chance of infection. We also instructed each subject to take three more doses at 6-hour intervals.

Instruments

We used the Omnisound 3000 (Accelerated Care Plus-LLC, Topeka, KS) ultrasound unit at a frequency of 3 MHz. The transducer head measured 5 cm^2 and contained a lead zirconate titanate crystal, with a beam nonuniformity ratio of 1.8:1 and an ERA of 4.5 cm^2. The ultrasound unit was recently calibrated via a digital power meter. Aquasonic 100 Ultrasound Transmission Gel (Parker Laboratories, Orange, NJ) kept at room temperature (24.5°C ± 1.2°C) was our coupling medium. We made templates of two and four times the size of the transducer head to standardize the treatment areas. These defined our 2- and 4-ERA treatments. We used a 2-cm long, 26-gauge hypodermic thermistor needle (Phystek MT-26/2, Physitemp Instrument, Clifton, NJ) connected to a monitor (Physitemp BAT-10, Clifton, NJ) that displayed the temperature to the nearest 0.1°C.

Procedures

The procedures for this study closely followed those reported in recent publications of human in vivo ultrasound studies.[18,19,22,29] The skin over the subject's right patellar tendon was shaved and then cleansed with a Betadine Scrub (The Purdue Frederick Company, Norwalk, CT) and 70% isopropyl alcohol. While the subject was lying supine with the knee slightly flexed, we palpated the patellar tendon to determine its size and location. The midpoint of the patellar tendon was determined by drawing an imaginary line from the apex of the patella to the tibial tuberosity. We then inserted the thermistor into the subject's patellar tendon medially in the frontal plane, approximately 1 cm below the apex of the patella, to the vertical midpoint of the tendon (Figure 1).

After the thermistor was inserted, we connected it to the monitor and waited for the temperature to remain unchanged for approximately 1.5 minutes. We recorded this as our first

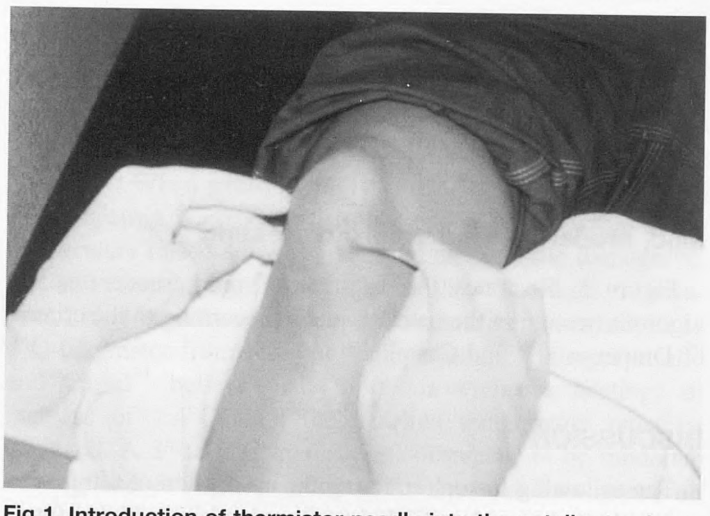

Fig 1. Introduction of thermistor needle into the patellar tendon.

Fig 2. Template, cut at 2 × ERA, applied to the patellar area, which served to standardize the treatment area.

Fig 3. Template, cut at 4 × ERA, applied to the patellar area, which served to standardize the treatment area.

baseline temperature. We applied a 2- or 4-ERA template (Figures 2 and 3), then applied coupling gel to the area.

Each subject received a 3-MHz continuous ultrasound treatment at 1 W/cm^2. We moved the sound head at a speed of 2 to 3 cm/sec, while recording the tendon temperature every 30 sec during the 4-minute treatment. After the first 4-minute treatment, we waited for the treated area to cool for 20 minutes while recording temperature decay every 30 seconds.

After a 20-minute cool down, we switched templates to provide a different standardized treatment area. Previous research[18] and our pilot study indicated that tissue temperature would return to baseline or below within this time frame. After recording the new baseline temperature, we repeated the procedure as above. Upon completion of both treatments, we removed the template and thermistor and cleansed the subject's knee with 70% isopropyl alcohol.

Design and Analysis

Our independent variables were treatment size and time. Our dependent variable was temperature. To determine significant differences ($P < .05$) within and between treatment size and time, we performed two two-factor, repeated-measures analyses of variance (one for heating and one for cooling). We used Tukey's post hoc tests to examine differences in treatment size at 1-minute intervals during heating and at 5-minute intervals during the cool down. Tukey's post hoc tests were also used to analyze differences in temperature change over the same time intervals within each treatment size. Additionally, we used paired *t* tests to assess the effect of treatment size on the rate of heating and Tukey's post hoc tests to analyze differences in the rate of cooling between treatment sizes.

RESULTS

The magnitude and rate of temperature change during the treatment and cool down for both the 2- and 4-ERA treatment sizes are illustrated in Figure 4.

Treatment

There was a significant difference in increase in temperature between treatment size ($F_{4,60} = 90.58$, $P < .001$) during the treatment. The 2-ERA treatment increased 8.3°C ± 1.7°C, while the 4-ERA treatment increased 5.0°C ± 1.0°C over the 4-minute treatment. Tukey's post hoc analysis revealed there were significant temperature differences between and within treatment sizes at each time point analyzed (1-minute intervals), except at the beginning of the treatments.

There was a significant difference in the rate of temperature increase between treatment sizes ($t(15) = 9.58$, $P < .001$). The heating rate per minute for the 2-ERA treatment was 2.1°C ± 0.4°C and 1.3°C ± 0.3°C for the 4-ERA treatment.

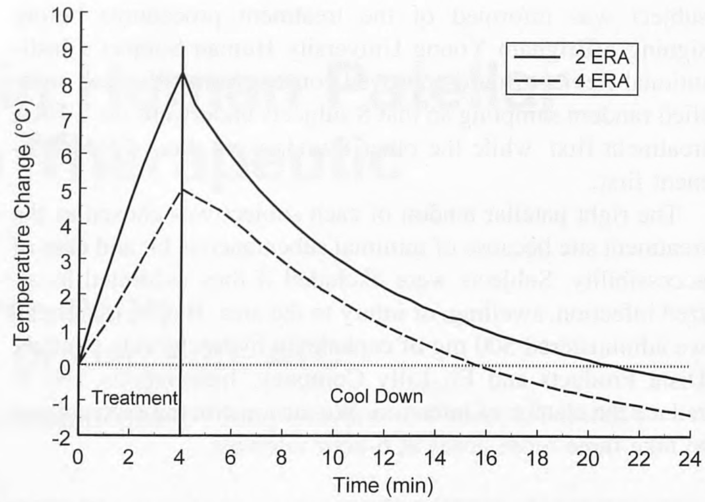

Fig 4. The magnitude and rate of patellar tendon temperature change from baseline during and after 2- and 4-ERA ultrasound treatments.

Cool Down

There was a significant difference in temperature decrease between treatment size ($F_{4,60} = 19.15$, $P < .001$) during the cool-down period. The 2-ERA treatment temperature decreased 4.6°C ± 1.2°C, 2.1°C ± 1.3°C, 1.2°C ± 1.5°C, and 0.8°C ± 1.6°C over each successive 5-minute cool-down period, respectively. The 4-ERA treatment temperature decreased over the same periods 2.6°C ± 1.2°C, 2.0°C ± 1.2°C, 1.2°C ± 1.3°C, and 0.7°C ± 1.2°C, respectively. Post hoc analysis revealed there were significant differences in temperatures at each time point analyzed during the cool down (5-minute intervals) between and within treatment sizes. Overall there was a significant difference in the rate of temperature decrease between treatment sizes ($F_{3,45} = 29.18$, $P < .001$). Post hoc analysis revealed that the rate of cooling between treatment sizes was significantly different only during the first 5 minutes of the cool-down period. The mean decrease in temperature per minute for this interval was 0.9°C ± 0.3°C and 0.5°C ± 0.2°C for the 2- and 4-ERA treatments, respectively.

After the 20 minutes of cool down, 6 of our 16 2-ERA treatment temperatures did not return to their baselines (average of 1.2°C above baseline temperature). Only 2 4-ERA treatment temperatures remained above their baselines after the cool-down period (average of 0.4°C above baseline temperature).

Mild, Moderate, and Vigorous Heating

Figure 5 illustrates the duration of mild, moderate, and vigorous heating in the patellar tendon according to the criteria of Draper et al[29] and Castel.[31]

DISCUSSION

The following factors affecting the absorption of ultrasound energy have been identified: frequency and intensity of ultra-

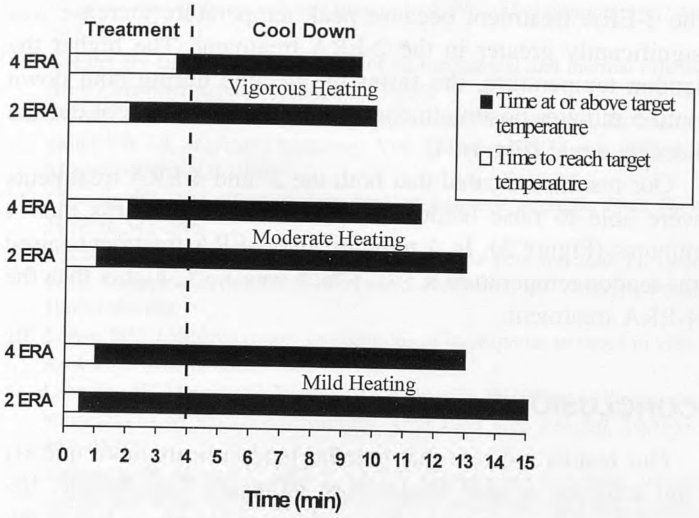

Fig 5. The duration of mild, moderate, and vigorous heating of the patellar tendon during and after 2- and 4-ERA ultrasound treatments. Mild heating is defined as an increase from baseline of at least 1°C, moderate heating is an increase from 2°C to <4°C, and vigorous heating is an increase of ≥4°C.

sound, duration of treatment, movement speed of the transducer, coupling agent used, type of tissue being treated, and size of treatment area. Most of these factors have been scientifically studied, but research has focused primarily on ultrasound penetration in animal and human muscle.[18–23] Investigation of target tissues other than muscle that are high in collagen, such as tendons, has been performed on animals.[11,24–27]

Lehmann et al[28] believed that four factors determine the extent of physiologic reaction to heat: 1) amount of increase in tissue temperature, 2) rate of temperature rise in tissue, 3) duration of the tissue temperature elevation, and 4) size of the area to be treated. Our study is the first to examine these factors with a 3-MHz ultrasound treatment on living human patellar tendon.

Amount of Temperature Increase

We found mean tendon temperature increases of 8.3°C ± 1.7°C and 5.0°C ± 1.0°C from baseline (29.7°C ± 1.9°C and 29.7°C ± 2.4°C) with the 2- and 4-ERA treatment sizes, respectively. Some authors suggest tissue temperature must be elevated to between 40°C and 45°C to be within the therapeutic range.[28,32] When treatment fails to raise tissue temperature to 40°C, heating is considered to be only mild,[4,32] while tissue temperature raised above 45°C could cause tissue damage.[4,33] Recent research suggests therapeutic thermal effects of ultrasound may be achieved from temperature increases of 1°C to 4°C or greater from baseline temperature.[29,31] Draper et al[29] and Castel[31] believe that, to obtain vigorous heating, an increase of ≥4°C from the baseline temperature must be achieved. A 2° to 3°C increase is considered to be moderate heating and is said to increase local blood flow and pain threshold. They also classified a 1°C increase as mild heating, which is thought to accelerate the local metabolic rate in treating mild inflammation.

Even though our results revealed that 3-MHz ultrasound at the intensity of 1 W/cm^2 did not raise the mean patellar tendon temperatures to the therapeutic range of 40°C to 45°C found in Lehmann et al[28], we were able to raise the tendon temperature ≥4°C (Fig 4), from the baseline. According to the criteria of Draper et al[29] and Castel,[31] we achieved vigorous heating in the patellar tendon at both 2 and 4 × ERA.

Very few ultrasound studies on human soft tissue have been able to produce temperatures that approached even the lower end of Lehmann's therapeutic range.[19–21] One explanation may be the physiologic differences in dead or anesthetized animals, used by Lehmann et al[11,34] and others,[26,27] compared with in vivo human tissue.[18–20,29] For example, when living tissue is heated, a cooling mechanism is initiated. Vasodilation occurs, followed by an increase in blood flow to maintain the homeostasis and functions of the body.[35] This maintenance does not exist in dead animal tissue. Thus, free from pain or the homeostasis phenomenon, anesthetized or dead animal tissue could be heated to much higher temperatures than in vivo human tissue.

Rate of Temperature Increase

Our results agreed with the speculation of most authors that tendon absorbs more ultrasound energy than muscle due to its higher collagen content.[30] A recent study investigating the heating rate of 3-MHz ultrasound at 1 W/cm^2 administered at 2 × ERA on human muscle at a depth of 0.8 cm reported a 0.6°C increase per minute.[29] Using the same parameters, we observed a heating rate in the patellar tendon of 2.1°C ± 0.4°C per minute for the 2-ERA treatment size. This rate of temperature increase in tendon is 3.45 times faster than that in muscle. Even at 4 × ERA, the rate of increase was 1.2°C per minute, double the rate of increase in muscle. It should also be noted that the temperature increase was almost perfectly linear for both treatment sizes throughout the treatment (Figure 4).

Duration of Temperature Increase

Most clinical protocols suggest a 5- to 10-minute ultrasound treatment for chronic soft tissue injuries.[17,36,37] According to Castel[31] and Lehmann et al,[28] vigorous heating is beneficial in treating chronic joint contracture and soft tissue stretching. The duration of vigorous heating during and after ultrasound treatment is therefore a concern. Lehmann et al[28] suggested that the minimum effective treatment time in the therapeutic range is from 3 to 5 minutes, with optimal reactions occurring after exposure of approximately 30 minutes. Along with recent researchers,[18,22] Lehmann et al[11] agreed that soft tissue stretching should be accompanied by vigorous heating. Lehmann et al[11] also pointed out that the stretch load should be maintained after peak heating is achieved or else the tendon length tends to return to normal within 10 minutes after the elongation. Draper and Ricard[18] applied 3-MHz ultrasound to human muscle at a depth of 1.2 cm until a 5°C temperature increase was obtained. They hypothesized that this protocol created a "stretching window" that lasted about 3 minutes posttreatment. They defined this stretching window, or optimal time for tissue elongation, to be the time that muscle temperature was raised >3°C and maintained.

Although both our 2- and 4-ERA treatments were able to raise the tendon temperature ≥4°C, the duration of the tissue temperature elevation after treatment was significantly longer in the 2-ERA treatment than in the 4-ERA treatment. The 2-ERA treatment maintained vigorous heating (≥4°C increase) for 4 minutes posttreatment, while the 4-ERA treatment maintained vigorous heating for only 2 minutes posttreatment (Figure 5). If we define our stretching window conservatively, as a period of time posttreatment in which the tendon was ≥4°C above its baseline, our 2-ERA treatment produced a 4-minute stretching window. This is over 120% of that reported in muscle, even considering the more liberal definition used.[18] Research has indicated that it is the combination of heating and stretching that is effective in treating such limitations of movement attributed to collagenous tissue as joint contractures, scar tissue, and adhesions.[11,26] Therefore, this prolonged stretching window is the optimal time frame for transverse friction massage or stretching therapy. Since the 2-ERA treatment raised tendon temperature ≥4°C in 2 minutes, ultrasound treatment for patellar tendon should be at least 2 minutes but probably no longer than 4 minutes (Figure 5). We ended our ultrasound treatments at 4 minutes to prevent periosteal pain. Three of our 16 subjects experienced minimal discomfort by the end of the treatment, and those who did so had tendon temperatures that exceeded 40°C (40.6°C, 40.7°C, and 41.5°C). Furthermore, the 2-ERA treatment maintained moderate heating (2°C to 3°C increase) posttreatment 2.5 minutes longer than the 4-ERA treatment, and it similarly held mild heating (1°C increase) posttreatment 3 minutes longer than the 4-ERA treatment (Figure 5). These results could be explained by the size of the area treated, the last factor suggested by Lehmann et al[28] that determines the extent of physiologic reaction to heat.

Size of Treatment Area

As expected, the size of the treatment area was significant with regard to temperature increase during treatment. The magnitude of temperature increase for the 4-ERA treatment was 60% of that achieved in the 2-ERA treatment. Interestingly, one would expect that, if all else remained constant, the 4-ERA treatment would achieve only 50% of the heating that the 2-ERA treatment achieved because the total energy output was the same for both treatments. Further research is warranted to explain this phenomenon.

Even though the initial cooling rate in the 2-ERA treatment was significantly faster than that in the 4-ERA treatment, the temperature increase from baseline was maintained longer in the 2-ERA treatment because peak temperature increase was significantly greater in the 2-ERA treatment. The higher the tendon temperature, the faster the decline during cool down until 5 minutes posttreatment; at this point, the rates of decline became equal (Figure 4).

Our results indicated that both the 2- and 4-ERA treatments were able to raise tendon temperature >4°C in less than 4 minutes (Figure 5). In 4 minutes, the 2-ERA treatment raised the tendon temperature 8.3°C, which was 3.3°C higher than the 4-ERA treatment.

CONCLUSIONS

Our results indicate that patellar tendon heats more quickly and achieves greater temperature increases than muscle. Because the time required to obtain vigorous heating is less in this tendon than in muscle, treatment time for the patellar tendon should be less than that commonly used when treating muscle. Second, the patellar tendon maintains vigorous heating temperatures longer than muscle, thereby prolonging the period in which tendon can be optimally elongated by various stretching procedures. Additionally, the stretching window can be significantly extended (by 50%) if stretching is performed during ultrasound treatment. We recommend further investigation on the heating properties of other tendons by ultrasound to see if our results are consistent for other depths and locations of the body.

Finally, we conclude that for both 2- and 4-ERA treatments, 3-MHz ultrasound at the intensity of 1 W/cm^2 significantly increases patellar tendon temperature. However, the results confirmed that the 2-ERA treatment provided faster and higher heating than the 4-ERA treatment. We recommend that ultrasound treatment of the patellar tendon be administered at 3 MHz at 1 W/cm^2 for approximately 4 minutes at 2 × ERA.

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Temperature Rise in Human Muscle During Ultrasound Treatments Using Flex-All as a Coupling Agent

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Objective: To determine if Flex-all 454, as advertised, is effective as a thermal ultrasound couplant.

Design and Setting: Research design was a one-factor analysis of variance. Subjects received three (alternating order) ultrasound treatments (1 MHz at 1.5 W/cm^2 for 10 minutes) using the following couplants: 50% Flex-all mixed with 50% ultrasound gel; 100% ultrasound gel; and sham ultrasound with 100% Flex-all. Data were collected in a ventilated laboratory.

Subjects: Fifteen male and female students (mean age = 24.2 ± 3.7 years).

Measurements: Muscle temperature was measured via hypodermic microprobes inserted 3 and 5 cm deep in the medial triceps surae. A visual analogue scale was used to measure perceived heat.

Results: At 3 cm, the increases for the gel, 50/50 mixture, and sham were 3.2°C, 2.6°C, and −0.82°C, respectively. At 5 cm, the increases were 2.17°C, 1.80°C, and −0.50°C, respectively. Subjects rated the sham treatment as mild heating (although the temperature dropped) and perceived treatments using the 50/50 mixture to be warmer than treatments using 100% gel couplant.

Conclusion: Ultrasound treatments delivered with a 50/50 Flex-all/gel couplant felt warmer to subjects; however, identical treatments with 100% ultrasound gel produced higher muscle temperatures. Clinicians desiring optimal thermal effects should use 100% ultrasound gel as the couplant.

Key Words: modalities, topical analgesics

Thermal ultrasound delivered in a continuous mode is used therapeutically to heat muscles and joint capsules to obtain specific physiologic responses.[1] The physiologic effects of ultrasound include reduced scar tissue and adhesions,[2] increased metabolism,[3] increased tissue healing,[2–5] decreased inflammation,[6,7] and reduced pain.[4,8,9]

Ultrasound transmission requires that a couplant be placed between the ultrasound transducer and the skin.[10–12] This medium is mainly water in a gel form that serves to conduct sound waves into the tissues.[4,10,11,13,14]

Cameron and Monroe[13] studied the transmission qualities of several media, including two topical analgesics, Thera-gesic (Mission Pharmacal Company, San Antonio, TX) and Myoflex (CibaGeneva Pharmaceuticals, Summit, NJ), which manufacturers promoted for both their analgesic and penetration qualities. According to their results, Thera-gesic was shown to have excellent ultrasound conducting medium qualities, whereas Myoflex exhibited no conducting capabilities.[13]

To date, no studies have investigated the effectiveness of Flex-all (Ari-Med Pharmaceuticals, Tempe, AZ) as a conducting medium. Flex-all is a topical analgesic of 7% menthol in an aloe vera base. Its intended use is for the temporary relief of minor aches and pains in muscles and joints. It is usually massaged into the area, although, for the past 5 years, the manufacturer of Flex-all has promoted the product as an effective ultrasound couplant.[15] The first advertisements in trade journals promoted the use of Flex-all alone as a conducting medium. Then, according to Ari-Med Pharmaceuticals, complaints of hot spots by patients and the too-frequent reapplication of the product during treatment led to the recent recommendation to dilute Flex-all 50% with ultrasound gel.

We wondered if the addition of Flex-all to ultrasound gel would block the transmission of sound waves into tissue, thereby limiting the tissue temperature increase. We designed this study to measure tissue temperature rise in the triceps surae complex resulting from ultrasound treatments using Flex-all diluted 50% with gel, a 100% Flex-all sham treatment, and 100% ultrasound gel.

METHODS

Subjects

Fifteen male and female students (mean age = 24.2 ± 3.7 years) volunteered for our study and gave informed consent. Our target tissue was the left triceps surae complex because past research shows it has minimal amounts of subcutaneous fat, is easily accessible, and responds well to temperature increases.[4,16–18] We screened all subjects, and none had signs of infection or inflammation before our investigation.

Instruments

We used the Omnisound 3000 (Accelerated Care Plus-LLC, Topeka, KS) ultrasound unit, which operates at frequencies of 1 and 3 MHz. We used the 1-MHz frequency because it penetrates deeper and is the most commonly used frequency.[2,3] The transducer head was 5 cm^2 and housed a lead zirconate titanate crystal with an effective radiating area of 4.5 cm^2. The unit was calibrated before the study.

We used two 23-gauge thermistor probes (Phystek MT-23/5, Physitemp Instruments, Newark, NJ), one at 3 cm and the other at 5 cm in depth, to record the rise in tissue temperature. The probes were affixed to a monitor (Bailey Instruments BAT 10, Physitemp Instruments, Newark, NJ) that displayed the temperature in degrees Celsius.

The average muscle temperature increases derived from the treatments using 100% ultrasound gel (Ultra Phonic Pharmaceutical Innovations, Inc, Newark, NJ) served as the control group. This was compared with the 50/50 mixture (Flex-all and Ultra Phonic ultrasound gel) and the sham ultrasound treatment with 100% Flex-all. We used a modified visual analogue scale (VAS) to rate each subject's perception of heat. The VAS consisted of a continuous horizontal line 10 cm in length, with anchor points of "no heat" and "extreme heat" at the left and right ends of the line, respectively. The reliability and validity of this procedure in measuring perceived pain have been previously established.[19]

Procedures

With the subject lying prone, we cleansed a 10-cm diameter area on the subject's left medial triceps surae complex. We used a caliper to plot the depth that each thermistor was to be inserted into muscle and administered two 1% lidocaine (Xylocaine, Astra USA, Inc, Westboro, MA) injections, in the amount of 0.5 cc subcutaneously, one injection at each depth. One of us (D.O.D.) inserted sterile thermistors at 3-cm and 5-cm depths on the center of the left medial triceps surae complex. A template two times the effective radiating area of the ultrasound head was placed on the area, thus restricting all treatments to the same size. After the thermistors were inserted and connected to the temperature monitor, we waited for the tissue temperature to reach a baseline (average time, approximately 3 min) and recorded this figure.

We applied 10 cc of one of the conducting mediums to the treatment area at room temperature (25°C). We used an alternating order in which half of the subjects received the 50/50 mixture first, followed by the sham treatment, and then the ultrasound gel treatment, and the other half received the ultrasound gel treatment first, then the sham treatment, and then the 50/50 mixture. Each subject received continuous ultrasound at 1.5 W/cm^2 for 10 minutes to the posterior surface of the triceps surae complex, perpendicular to the tips of the thermistors (Figure 1). During the treatment, the ultrasound head was moved back and forth at a slow rate (approximately 3–4 cm/ sec), as proposed by other researchers.[5,6,20] During the 10-minute treatment, we recorded the tissue temperature at 30-second intervals. At the conclusion of each treatment, we waited for the temperature to return to baseline before initiating the next treatment.

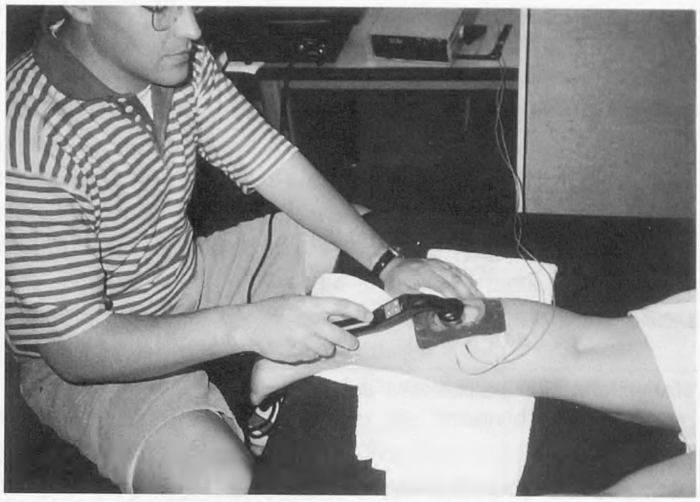

Fig 1. The treatment in progress. Temperature probes were inserted at 3 cm and 5 cm. The template was two times the effective radiating area of the ultrasound transducer head, thus ensuring that all treatments were the same size.

Each subject rated his or her perception of heat on the visual analogue scale (VAS) before and after each treatment. An identical list of instructions was read to each subject before he or she filled out the VAS. Each subject indicated the amount of heat perceived by placing a slash mark along the VAS; earlier VAS ratings were not available to the subjects. Once the VAS information had been obtained, we waited for the temperature to return to baseline and then administered the next ultrasound treatment. At the conclusion of each subject's treatments, the thermistors were removed and immersed for at least 90 minutes in a Cidex solution (Johnson & Johnson, Arlington, TX). The subject's leg was then swabbed with 70% isopropyl alcohol to clean the area, and a Band-Aid (Johnson & Johnson, Arlington, TX) was placed over the injection site.

Design and Analysis

The dependent variable in this study was the change in tissue temperature after 10 minutes of treatment. We used a time-by-groups repeated-measures analysis of variance (ANOVA) to determine any significant difference in maximal tissue temperature between the groups. Separate analyses were conducted on data from both the 3-cm and 5-cm depths and each subject's perceived heat among the three groups.

RESULTS

The average muscle temperature increases of the two conducting mediums at the two depths are displayed in Table 1. Descriptive statistics showed that the data met the assumptions required for the use of parametric statistics; thus, we measured

Table 1. Temperature Differences Among Groups

Group	Temperature (°C) 3-cm Depth	5-cm Depth
1 (50/50)	X = 2.60 (37.9)* SD = 0.48	X = 1.80 (37.9) SD = 0.45
2 (Sham)	X = −0.82 (34.8) SD = 0.27	X = −0.50 (35.8) SD = 0.17
3 (Gel)	X = 3.20 (38.6) SD = 0.58	X = 2.17 (38.3) SD = 0.53

* Temperatures in parentheses are peak values. X = mean. SD = standard deviation.

three different sets of comparisons. The first comparison was overall temperature change of the three groups (100% gel, 50/50 mixture, sham). The differences in temperature from baseline to the termination of the 10-minute treatment period were significant at both 3-cm and 5-cm depths for all groups. A repeated-measures factorial ANOVA of time × group interaction for all three groups at both depths was significant ($F_{2,42} = 30.12$, $P < .0001$).

The next comparison was the average temperature increase at both depths between the Flex-all 50/50 mixture and the ultrasound gel groups. Using a repeated-measures factorial ANOVA of time × group, we found a significant difference in terminal temperatures between the gel (mean = 2.69) and 50/50 mixture (mean = 2.2) ($F_{1,28} = 10.00$, $P < .0001$), when increases at the two depths were averaged.

Last, we compared mean temperature increases obtained at the two depths. At 3 cm (Figure 2), the 100% gel (mean = 3.20), the 50/50 mixture (mean = 2.60), and the sham treatment (mean = −0.8) produced significantly different temperatures ($F_{2,42} = 328.65$, $P < .0001$). At 5 cm (Figure 3), however, there was no significant difference between the 100% gel (mean = 2.17) and the 50/50 mixture (mean = 1.80), although both were significantly greater than the sham treatment (mean = −0.500) with $F_{2,42} = 180.30$, $P < .0001$.

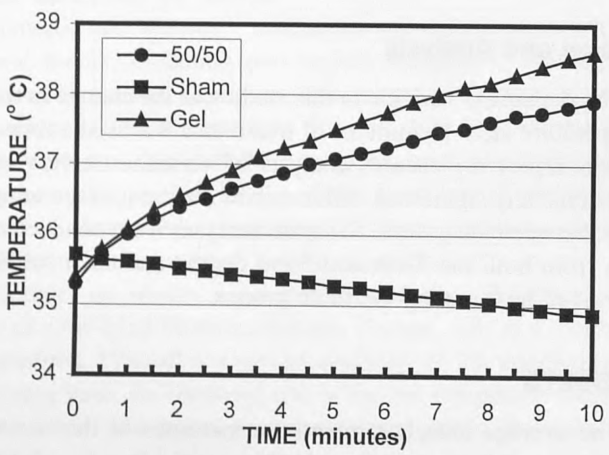

Fig 2. Time and temperature differences at 3 cm ($F_{2,42} = 328.65$, $P < .0001$). Note: Both the gel and 50/50 treatments heated at the same rate until 2 to 3 minutes into the treatment.

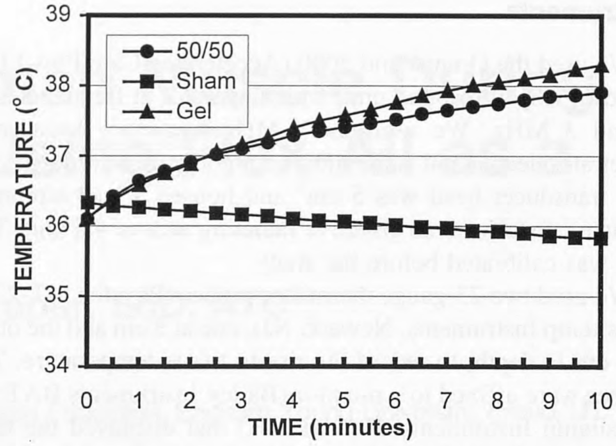

Fig 3. Time and temperature differences at 5 cm. There was no significant difference between the 100% gel and the 50/50 mixture, although both were significantly greater than the sham treatment ($F_{2,42} = 180.30$, $P < .0001$).

Perceived Heat

Table 2 displays the average pretreatment and posttreatment scores of the subjects' perceptions of heat produced from the three treatments. Measurement from the left end point ("no heat") to the slash drawn on the line by each subject represented how warm he or she believed the muscle got as a result of the ultrasound treatment (Figure 4). Perception of heat of the 50/50 mixture was slightly greater than that of the 100% gel, although the differences were not significant ($F_{1,28} = 0.55$, $P < .5787$). Perceived heat of both the 100% gel and the 50/50 mixture was significantly greater than that of the sham treatment ($F_{2,42} = 8.48$, $P < .0008$).

DISCUSSION

Several researchers[10,21,22] have studied the conducting qualities of ultrasound mediums. In many of these studies, researchers used a receiving transducer spaced 3 cm from a transmitting transducer, with various coupling agents placed between the two. Reid and Cummings[21] were the first to use this technique. They reported that thixotropic gel transmitted the most ultrasound energy output at 70%, with glycerin at 68% and degassed water at 60%. Cameron and Monroe[13] later discovered that mineral oil transmitted 97% of ultrasound energy output compared with ultrasound gel at 96%. Reid and

Table 2. Perception of Heat Among Groups on the Modified VAS*

Group	Before Treatment	After Treatment
1 (50/50)	X = 0.52 SD = 0.63	X = 6.03 SD = 2.52
2 (Sham)	X = 0.64 SD = 0.83	X = 2.31 SD = 2.44
3 (Gel)	X = 0.94 SD = 1.68	X = 5.00 SD = 2.68

* 0 = no heat, 10 = extreme heat. X = mean. SD = standard deviation.

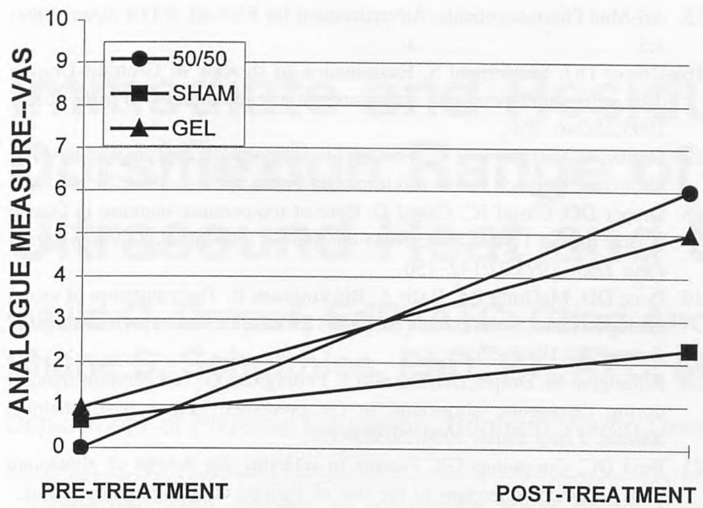

Fig 4. Time-by-group interaction: the analogue measure of the VAS. 0 = no heat, 10 = extreme heat.

Cummings[22] reported that the effects derived from an ultrasound treatment are only as good as the coupling agent used to conduct the sound energy.

The process of using topical analgesics or medications as an ultrasound medium is known as phonophoresis. Current research suggests that phonophoresis acts by opening pathways through the stratum corneum by disordering the structured lipids, allowing drug molecules into the body transcutaneously with sound wave pressure.[2,23–26] Ciccone et al[27] studied the effectiveness of a trolamine salicylate phonophoresis treatment in decreasing pain and stiffness associated with delayed-onset muscle soreness. They concluded that ultrasound treatments applied with an anti-inflammatory analgesic agent (trolamine salicylate) were not effective in reducing symptoms of delayed-onset muscle soreness. They suggested that regular ultrasound gel be used during ultrasound treatments so that pain and stiffness can be reduced as a result of increased muscle temperature. Our data support the argument drawn by Ciccone et al[27] because our greatest temperature increases occurred when ultrasound gel was the conducting medium.[16–18]

Our study was designed to objectively assess the feasibility of one couplant, whose effects are based upon the patient's perception of heat rather than actual changes in temperature within the ultrasound-treated muscle. Athletes receiving an ultrasound treatment with Flex-all might assume that the muscle is being adequately heated, although our findings refute this belief. We attribute this result to the difference in perception of heat measured on the VAS. Why did subjects believe that a 50/50 mixture of Flex-all/gel caused more heating of the muscle, when the 100% gel treatment actually produced significantly more heat? Also, why did subjects perceive a mild heat increase during the sham treatment when the muscle temperature actually dropped? These findings might be due to the counterirritant component of Flex-all; ie, chemicals bombard afferent nerve pathways, leaving a perception of heat. The drop in muscle temperature may be due to applying a room temperature gel (25°C) to the much warmer muscle. Patients may desire a Flex-all ultrasound treatment because they may feel that they are receiving more heat, but our findings do not substantiate this perception.

If the treatment goal, on the other hand, is of a nonthermal nature via pulsed ultrasound, then the analgesic effects of the treatment could be what are desired for that particular ultrasound regimen. It has been well documented that the nonthermal effects of acoustic microstreaming via pulsed ultrasound may be as beneficial as the thermal effects. Nonthermal ultrasound can aid tissue healing due to increased fibroblast activity,[28] protein synthesis, and blood flow.[29]

We see from our results that tissue temperature increase is dependent upon time: the longer the treatment duration, the greater the temperature increase. We observed this to be true at both 3 cm and 5 cm. Both the gel and the 50/50 mixture increased the tissue temperature at about the same rate in the first 2 minutes, but the 100% gel treatment increased tissue temperature at a significantly greater pace for the last 8 minutes of the treatment. If the gel ultrasound treatment were to continue past 10 minutes, we might see a continued increase either until the temperature plateaus or until the patient is unable to continue the treatment due to excessively increased heat. Further research is needed to address ultrasound treatment in excess of 10 minutes.

Temperature Differences at Depths

The temperature rise at 3 cm was greater than the temperature rise at 5 cm. We attribute this to tissue absorption and the half-value layer, which, according to Stewart,[30] is the depth by which 50% of the ultrasound beam intensity is absorbed into the tissue, reducing the intensity as it travels through tissue. For example, if we were to perform a 1-MHz ultrasound treatment at 1 W/cm^2, 50% of the energy intensity would be 0.5 W/cm^2 at the 2.3-cm depth in the muscle. Half the energy again would be absorbed at twice its depth, reducing the energy intensity to 0.25 W/cm^2 at the 4.6-cm depth. Therefore, our lower temperatures at the 5-cm depth are due to the half-value phenomenon and not to the composition of the two couplants.

Some clinicians are currently using Flex-all as a conducting medium for thermal ultrasound treatments, although researchers[31–33] report that ultrasound gel coupling agents are most effective with regard to electrical impedance, attenuation, and viscosity. We suggest that, if a thermal ultrasound treatment is desired, 100% gel be used as the conducting medium or perhaps warm tap water with the treatment head immersed in a container for small and hard-to-reach areas.[34] This study measured muscle temperature increase with 50% Flex-all mixed with 50% ultrasound gel. The results of our research led to the recommendation that future studies be conducted to find the optimal mixture of Flex-all to ultrasound gel. We propose that this research be repeated but with a higher gel-to-Flex-all ratio. We hope this will reveal an optimal ultrasound couplant that produces analgesia while allowing the ultrasound to generate significant heating of tissues. In the interim, if the clinician desires the analgesic effects of Flex-all in combination with ultrasound, we suggest that it not be mixed 50% with gel. Rather, first rub the Flex-all into the skin, then apply ultrasound couplant followed by insonation.

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Immediate and Residual Changes in Dorsiflexion Range of Motion Using an Ultrasound Heat and Stretch Routine

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Objective: With respect to increasing ankle dorsiflexion range of motion, our objective was to examine the influence, if any, of preheating the triceps surae with ultrasound before stretching.

Design and Setting: Subjects were assigned to either group A (ultrasound and stretch) or group B (stretch alone). Group A received 3-MHz ultrasound (1.5 W/cm^2, 4 times effective radiating area) for 7 minutes to the musculotendinous junction of the triceps surae before stretching. Group B rested for 7 minutes before stretching. Both groups then performed identical calf stretches for 4 minutes. Treatment for both groups was conducted at the Brigham Young University Sports Injury Research Laboratory twice daily for 5 days with at least 3 hours between procedures. We analyzed the data with a 2 × 3 × 10 factorial analysis of variance with repeated measures. A Tukey post hoc test was used to identify significant differences in range of motion.

Subjects: Forty college students (male = 18, female = 22, age = 20.4 ± 2.5 years) volunteered for the study.

Measurements: Maximal ankle dorsiflexion range of motion was measured using an inclinometer before and after each treatment.

Results: Immediate effects were that ultrasound and stretch increased mean dorsiflexion range of motion in all sessions significantly more than stretch alone in three treatment sessions. Residual effects were that dorsiflexion range of motion increased 3° in both groups after nine treatment sessions; however, neither group significantly outperformed the other.

Conclusion: As studied, an ultrasound and stretch routine may increase immediate range of motion more than stretch alone, possibly enhancing performance in practice and competition. This increased range of motion, however, is not maintained over the long term and is not more than the range of motion gained from stretching alone. A similar study using subjects with decreased range of motion after immobilization or injury should be conducted to see if the ultrasound and stretch regimen would produce lasting range-of-motion increases.

Key Words: flexibility, modalities, rehabilitation

A main goal in injury recovery is restoring normal joint range of motion. After injury or immobilization, connective tissue progressively shortens, often causing joint contractures and adhesions that restrict joint range of motion.[1–4] If controlled stress is not applied, the collagen fibers interweave and become a dense, limiting structure. This process can be seen after only 1 week of immobilization.[1]

Passive stretch alone has been effective in increasing range of motion in human subjects.[5,6] Very few studies have been performed on humans using heat to improve flexibility. Taylor et al[7] found that hamstring flexibility can be improved by using heat packs before stretching. Wessling et al[8] found that ultrasound applied to the muscle belly before stretching promoted significantly greater immediate gains in ankle dorsiflexion than stretching alone.

Thermal ultrasound is a common therapeutic modality used for treating soft tissue injury,[9] joint dysfunction,[9,10] and other musculoskeletal injuries.[11,12] Heating the tissues with ultrasound before stretching is a common practice thought to improve range of motion.[1–3,8–13] Research performed on rat tail tendons indicates that stretching while the tissue is heated to temperatures between 39°C and 45°C (an increase of 3°C to 8°C over baseline) results in permanent elongation of the tissue.[13–16] In addition, if the stretch is applied at peak temperature, less tissue damage will result.[1,13–16]

We have found that proper application of therapeutic ultrasound can increase temperatures 3°C to 6°C in muscle[9] and 5°C to 8°C in tendons.[17] Because these temperatures are maintained for only a few minutes,[18,19] we believe that the stretch must be applied immediately after the ultrasound treatment to increase connective tissue extensibility. Before our study, this "heat and stretch" theory using correct ultrasound parameters had not been tested on human subjects with 3-MHz ultrasound. The intent of our study was to determine if this method of treatment would improve ankle dorsiflexion range of motion more than stretch alone.

METHODS

Subjects

The procedures for this investigation were approved by Brigham Young University's Institutional Review Board for

Research with Human Subjects. Forty healthy college students (male = 18, female = 22, mean age = 20.4 ± 2.5 years) volunteered for this study. They signed a consent form after being apprised of all risks involved with participation in the research. The subjects followed their normal daily routine without beginning any new exercise or stretching activities during the study.

Instruments

We used an Omnisound 3000C (Accelerated Care Plus-LLC, Topeka, KS) ultrasound unit with a 5-cm^2 transducer and an effective radiating area (ERA) of 4.1 cm^2. This machine provides a beam nonuniformity ratio of 3:1 (measured and reported by the manufacturer), which allowed us to treat at a higher output intensity with decreased risk of tissue damage.[1,13–15] This machine was new and had been calibrated just before our study.

An inclinometer was used to measure joint angle. We tested the reliability of this device in the following manner. Nine subjects were measured daily (to the nearest degree) for 3 days, and the numbers were evaluated using an intraclass correlation coefficient statistic. A correlation of 0.94 was found between measures, with a 95% confidence interval of ± 3.517 and a 68% confidence interval of ± 1.74.

Procedure

We randomly assigned 20 subjects to each group. We measured maximal dorsiflexion range of motion with the inclinometer before all treatments. We measured dorsiflexion range of motion from a standing position in order to replicate the stretches to be used. This was accomplished by placing the device on the posterior aspect of the calf while the subject was standing erect, so that the calf muscle was at a 90° angle to the floor. To insure consistent placement of the inclinometer, a semipermanent mark was drawn on each subject's calf muscle and used throughout the study. While maintaining the knee in full extension and the foot flat on the ground, the subject shifted the body over the foot as far as possible while the needle on the inclinometer moved to measure maximal dorsiflexion range of motion. After measurements were recorded, the subjects in Group A (ultrasound) assumed a prone position on the table. We attached a template cut to four times the size of the soundhead to the musculotendinous junction of the right triceps surae. Ultrasound was applied at the following parameters: 3 MHz, intensity of 1.5 W/cm^2, duration of 7 minutes. We moved the transducer in the template at approximately 4 cm/sec using longitudinal strokes.

Immediately after the ultrasound treatment, each subject stood upright and performed two stretches to the point of discomfort, but avoiding pain. First, a calf stretch was performed for 20 seconds with the knee in full extension, followed by a 10-second rest. The stretch was then repeated for 20 seconds with the knee bent 15° to isolate the soleus muscle. A 10-second rest was given to complete the cycle. This sequence was repeated three more times (4 minutes total). We then measured ankle dorsiflexion again to detect changes possibly attributable to the ultrasound and stretching treatment.

Subjects in Group B underwent the same procedures to determine dorsiflexion range of motion. Subjects then rested in a prone position for 7 minutes, after which they performed the same stretching regimen as Group A. Poststretching dorsiflexion range of motion was measured and recorded. Subjects in both groups received treatments twice daily (>3 hours apart) for 5 consecutive days.

Design and Analysis

We used a 2 × 3 × 10 factorial analysis of variance (ANOVA) with repeated measures to identify differences in the dependent variable (range of motion) between groups (ultrasound and stretching, stretching alone); residual treatment effect (sessions 1 to 10); and immediate treatment effect (before treatment, after treatment). The group factor was a between-subjects factor; the residual and immediate effects were within-treatment factors. We used a Tukey post hoc procedure to identify significant differences. Alpha was set at 0.05 for all comparisons. A separate, single-factor ANOVA with repeated measures was used to identify residual effects for both groups.

RESULTS

Measurements for both groups are displayed in the Table. Both groups began the study with 28° range of motion in dorsiflexion. Range of motion was measured before and after each session to evaluate the change in flexibility due to the treatments. Both groups showed significant improvement in dorsiflexion, measured at about 2° ($F_{1,38}$ =210.340, $P < .001$). When we compared immediate effects between the two groups, we found the average initial increase for Group A was 3°, compared with 2° for Group B. An interaction was found between the two groups (group × immediate $F_{1,38}$ = 8.248, P = .007), and post hoc tests showed that the ultrasound group

Measurements of Mean (±SD) Dorsiflexion ROM by Group and Session

	Group A (Ultrasound + Stretch)		Group B (Stretch Only)	
Session	Pre-	Post-	Pre-	Post-
1	28° ± 4°	32° ± 4°	28° ± 6°	30° ± 7°
2	29° ± 4°	32° ± 4°	29° ± 6°	31° ± 6°
3	28° ± 4°	31° ± 4°	29° ± 6°	31° ± 6°
4	29° ± 4°	32° ± 5°	30° ± 6°	31° ± 7°
5	29° ± 4°	32° ± 4°	30° ± 6°	31° ± 6°
6	30° ± 5°	32° ± 5°	29° ± 6°	31° ± 6°
7	31° ± 5°	33° ± 5°	31° ± 6°	32° ± 6°
8	31° ± 5°	33° ± 5°	30° ± 6°	33° ± 6°
9	30° ± 6°	33° ± 5°	31° ± 6°	33° ± 6°
10	31° ± 5°	33° ± 5°	31° ± 5°	33° ± 6°

achieved significantly greater increases in range of motion than stretch alone in three sessions. Measurements taken before our final session were compared with the first day to determine if any residual lengthening had occurred. After nine treatments, subjects in both groups increased range of motion by about 3°, a significant improvement from baseline measurements ($F_{9,342} = 12.612$, $P < .001$). No interaction, however, was found when the two groups were compared for residual lengthening (group × residual $F_{9,342} = 0.830$, $P = .588$). The residual × immediate effect ($F_{9,342} = 0.924$, $P = .504$) and the group × residual × immediate effect ($F_{9,342} = 1.124$, $P = .345$) also were not significant (group $F_{1,38} = 0.049$, $P = .826$). The results from our single-factor ANOVA on residual lengthening showed that the groups had gained significantly in flexibility after just five treatment sessions.

DISCUSSION

Vigorous heating via ultrasound, combined with stretching, is often used in an effort to lengthen connective tissue. Passive stretching alone has been effective in increasing range of motion in human subjects. Researchers[5,20] found that stretching for as little as 15 seconds can be just as effective as a 2-minute stretch in improving hip abduction and ankle dorsiflexion range of motion. Worrell et al[6] found that four 20-second calf stretches, repeated over 10 treatment sessions, yielded increased range of motion in ankle dorsiflexion.

There is very little evidence that "heat and stretch" procedures are effective in increasing flexibility in humans. Wessling et al[8] found that ultrasound applied to the muscle belly before stretching promoted significantly greater immediate gains in ankle dorsiflexion than stretching alone. Their changes in flexibility, however, were quite small (1° to 2.5°) by clinical standards. They also used only one treatment session; thus, they neglected to evaluate the long-term effect of repeated treatment sessions. In our study, the results from session one indicated a significant difference between the two groups as well. If we had terminated the study here, we would have been able to state, as did Wessling et al[8], that ultrasound assuredly increases flexibility. They also did not use 3-MHz ultrasound, as we did in our study. The 3-MHz frequency is more appropriate than 1 MHz for heating the musculotendinous junction of the Achilles tendon because 3 MHz is better absorbed at this superficial level.[9]

It is known that heat and stretch can effectively lengthen connective tissue permanently in animal tissues.[13–16] Vigorous heating (>3°C) of tissue before stretching is recommended for optimal lengthening.[3,11] The higher the tissue temperature, the more likely the treatment will result in improved flexibility of chronic connective tissue and joint contractures.[13–16] When ultrasound is used to vigorously heat tissues (>3°C), the tissues become more pliable.[11,12] These higher temperatures decrease the viscous properties of collagen and allow us to increase the tissue length more permanently.[2,11,14,15]

Recent research shows that continuous ultrasound can increase temperatures in human muscle[3,9,18,19] and tendon[17] to therapeutic levels. In our study, we used 3-MHz ultrasound to increase the temperature of the musculotendinous junction of the triceps surae muscle. Special attention was paid to treatment size, time, and intensity, all critical when trying to reach peak temperatures.[8,17–19] We used a treatment size of four ERA to enable us to treat the large musculotendinous junction. Based on our previous research,[9,17] we estimate that the temperature increased as much as 3°C in muscle and 8°C in tendon. These therapeutic temperatures should be adequate to allow tissue lengthening, if the tissues are stretched immediately after the treatment. Based on our studies of the stretching window,[17,18] we believe that tissue temperatures remained at therapeutic levels for 2 to 4 minutes, which is why we applied the stretch immediately after the treatment, taking advantage of these higher temperatures.

There were greater immediate effects from the use of ultrasound before stretching in session 1 (ultrasound and stretch = 3°, stretch alone = 2°) and sessions 4 and 5 (ultrasound and stretch = 3°, stretch alone = 1°). However, with alpha set at 0.05, we would expect 1 of 20 sessions to be positive due to chance. These findings may be important in considering the use of ultrasound to treat athletes before practice or competition. By temporarily increasing flexibility in this population, we may reduce the occurrence of injury and improve performance for a given event.

Each subject was treated 10 times over a 5-day period to determine if changes in range of motion would carry over from day to day. Testing for these residual effects was the main focus of our study. We found that both groups increased dorsiflexion about 3° (an 11% increase) over nine treatment sessions. Our results indicated that ultrasound before stretching was not more effective than stretching alone in increasing residual dorsiflexion range of motion in a healthy population.

Limitations

There were a few limitations in our methods. To begin with, we assumed that critical temperatures were reached in the tissues being treated. Since the tissue temperature was not measured, we do not know for certain that these levels were achieved. Very few studies on human tissue have raised tissue temperatures to Lehmann's therapeutic range of 40°C to 45°C.[12] Draper et al[9] increased muscle temperature to the lower end of this range, but human subjects experienced pain before levels >42°C were reached. The cooling mechanism of living tissue may also have prohibited temperature increases of this nature to be reached and maintained. In addition, we also treated a relatively small area. The gastrocnemius-soleus complex is a very large muscle group, and the musculotendinous junction is hard to define and treat with an ERA of four.

We also elected to use a stretch that was not controlled. Subjects were instructed to stretch to tolerance, and, since each subject possessed different size characteristics, this may have affected our results. In future studies, perhaps a percentage of each person's body weight could be used as a control measure.

Finally, the subject sample was conveniently selected from a healthy population of college students and, thus, cannot be generalized to a clinic population. Our subjects already possessed, on average, 28° of ankle dorsiflexion as a baseline measurement, which perhaps left little room for improvement. If our sample had been taken from a population limited in flexibility due to contractures or adhesions, the results might have been different.

Future Research

Further studies should be conducted using a population experiencing tightness due to scarring or other adaptive shortening that limits range of motion. Other joints that allow for greater increases in range of motion, such as the hip or shoulder, could also be evaluated. These studies could also include other common therapies, such as heat packs or cold treatment before stretching. This heat and stretch regimen could also be studied using shortwave diathermy, since this modality heats a larger area than ultrasound.

CONCLUSIONS

According to some researchers, heating tissue before stretching will lead to improved range of motion of chronic connective tissue and joint contractures.[13–16] When ultrasound is used to vigorously heat tissues (>3°C), the tissues become more pliable,[11,12] allowing the tissues to be stretched more effectively.[2,11] Results from our study show that repeated stretching sessions can increase dorsiflexion range of motion. Using ultrasound before stretching might increase immediate dorsiflexion, but residual increases are no different than from stretching alone.

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Comparison of the Effects of Selected Dressings on the Healing of Standardized Abrasions

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Objective: To find out which type of dressing (semipermeable film, hydrocolloid, conventional method, or no dressing) allowed abrasions to heal in the least amount of time and had the greatest decrease in wound area.

Design and Setting: A 4 × 9 factorial was used for this study. There were two independent variables with four levels and two dependent variables. Research was performed at the Athletic Training Research Laboratory at Indiana State University.

Subjects: Fourteen subjects (eight males, six females), ages 23 to 34 years, participated in this study.

Measurements: From daily photographs, the day the wounds were healed was determined. The photographs were also used to measure wound area on the first and last days of the study. Subjects received four treatments (dressings and control), and placement of the dressings was determined by random assignment.

Results: Data were analyzed using a repeated-measures multivariate analysis of variance to determine if differences existed among treatment groups for healing time and change in area. Student-Newman-Keuls post hoc testing was performed to determine specifically where the differences occurred. Our results indicate that healing time is affected by covering the wound, and area is decreased by using DuoDerm or Bioclusive.

Conclusions: Bioclusive should be used in the athletic training setting. Bioclusive and DuoDerm are equally effective, but Bioclusive is less expensive. Bioclusive is more expensive than Coverlet, but it is also more effective in reducing the area of the wound.

Key words: occlusive dressings, wound care management

Athletic trainers commonly deal with athletes who have sustained abrasions. There are several theories about the best treatment methods. If not handled correctly, wounds can be reinjured and infected and can become debilitating to the athlete.

Occlusive dressings are becoming more widely used in wound care management. There are three main types of occlusive dressings: semipermeable films, hydrogels, and hydrocolloids. They have been shown to be more effective than conventional dressings for several reasons. Scab formation is prevented,[1] perceived pain from exposed nerve endings is lowered,[1–6] they are cost and time effective,[1] they provide a barrier against bacteria,[3,7,8] and they make wound care easier, which enables patients to be more compliant.[2,3,8] Which type of occlusive dressing is most effective in allowing wounds to heal is not known. The purpose of our study was to compare how healing time of abrasions and rate of wound area reduction are affected by using semipermeable film, hydrocolloid, conventional method, or no dressing.

METHODS

A 4 × 9 factorial was used for this study. The factorial was obtained from the two independent variables, which were dressing type and observation. There were four levels to the independent variable dressing type: Bioclusive transparent dressing, a semipermeable film (Johnson & Johnson, Skillman, NJ); DuoDerm, a hydrocolloid (ConvaTec, Princeton, NJ); Coverlet adhesive bandage (Beiersdorf, Norwalk, CT) with Bacitracin antibiotic ointment (The Purdue Frederick Company, Norwalk, CT), currently the standard of care; and control. The dependent variables were healing time, as measured in hours, and the change in area of the wound measured in square millimeters.

Subjects

Subjects were 8 male and 6 female volunteers between 23 and 34 years of age (mean height = 175.26 cm, mean weight = 79.03 kg). Each gave informed consent to participate in the study. Subjects who reported clotting problems, were taking blood-thinning drugs (eg, heparin), or were hypersensitive to pain were excluded from the study. The study was approved by the School of Health and Human Performance Human Subjects Committee.

Procedures

Subjects filled out a questionnaire to determine whether they were fit to participate in the study. Occupational Safety and

Health Administration regulations were followed for all procedures. We wore latex gloves at all times. Sandpaper was autoclaved before use. The area to be abraded was shaved 24 hours before abrading the skin to allow for any irritation of the skin to subside before inflicting the abrasion. Emla (Astra USA, Inc, Westboro, MA), an anesthetic ointment, was used to anesthetize the area where the abrasions would be made. The area was ice massaged for 10 minutes to cool the skin, which allowed the skin to be more easily abraded, and then the area where the abrasion was to be made was cleansed with a sterile alcohol preparation.

A 25 × 10-cm template made of 100% polyester canvas was constructed for each participant. Circles were cut in the template 1.27 cm in diameter and spaced 3.81 cm apart. The template was applied to the palmar surface of the forearm of the nondominant arm. The template was secured on the dorsal side of the arm and taped in place, ensuring that the skin protruded through the holes. We then dragged a 4.09-kg sanding block with a piece of 60-grit autoclaved sandpaper on the bottom across the arm. Thirty passes were made in a unilateral motion (lateral to medial) to the time of a metronome (60 beats per minute). Two of the holes in the template were covered at a time; the procedure was repeated on the second set of two holes.

Bleeding was controlled by applying direct pressure to the abrasion with a sterile gauze pad. The abraded area was cleansed by flooding it with hydrogen peroxide and allowed to air dry. After the four abrasions were made and cleansed, the subject was sent to another investigator. A label with the subject's number and trial number was placed on the arm, and a photograph was taken of the abrasions.

Locations of the dressings were randomly assigned without replacement. Subjects drew note cards specifying a dressing type to determine the location of each dressing. A key was kept for reference. Starting proximally, wounds were labeled A through D. A subject's first selection was applied to site A, the second selection was applied to site B, etc.

The abrasions covered with Bioclusive were cared for according to the following guidelines:[8]

1. Cleanse wound with hydrogen peroxide.
2. Remove foreign bodies from wound.
3. Cut Bioclusive so that it is 1.91 cm (3/4 in) larger than the wound, and then apply it to the wound.
4. Subjects were seen once a day, at which time the dressing was removed, the wound was cleansed with saline, and a new dressing was applied.

Abrasions receiving the Coverlet bandage and Bacitracin were treated following the same protocol, except the Bacitracin was applied to the Coverlet bandage and then the bandage was applied.

Treatments with DuoDerm followed the manufacturer's guidelines, which advise changing the dressing whenever the seal has been broken between the skin and the dressing. Because observing the wound broke the seal, the dressing was changed every time the wound was observed.

The control abrasion site was cleansed with hydrogen peroxide after wound infliction and left uncovered. It was flushed with sterile saline on days 2 through 10.

Subjects were provided with a replacement for each dressing to use if any of the dressings came off, a list of instructions for caring for their wounds (including how to identify signs of infection), and phone numbers to contact the investigators if needed.

Wounds were visually inspected and photographed after the first 45 to 51 hours and then once each day, with 21 to 27 hours between observations. When subjects came in to have their wounds inspected, one investigator removed the dressings. The area around the wound was cleansed with alcohol to eliminate residue from the dressing. The wound was flushed with sterile saline and allowed to air dry. Subjects were then sent to the second investigator, who inspected and photographed the wound. The camera was mounted on a copy stand and positioned 40.64 cm (16 in) above each subject's arm from a point measured halfway between the wrist and bend of the elbow. A label was placed next to the arm for the photograph. Subjects were then sent to the third investigator, who applied the new dressing. This was always the same investigator who applied the original dressing.

At the completion of data collection, all rolls of film were developed at the same time in a process called batch developing to ensure consistency of color and clarity. From the photographs, measurements were taken. A 1-mm graph transparency was placed over the photograph, and the squares were counted. If at least half of a square was filled, it was counted as one square; otherwise the square was not counted. This allowed us to observe relative changes in size of the wound. The photographs were also used to determine when the wounds were healed based on changes in color.

At the end of data collection, subjects were asked to complete a questionnaire to assess their opinions of the dressings (Figure).

Statistical Analysis

A repeated-measures multivariate analysis of variance was used to determine if differences existed among our treatment groups for the two dependent variables. Post hoc testing was done using the Student-Newman-Keuls test to detect differences among the levels of the independent variable. For all tests, $P < .05$.

RESULTS

Of the 15 subjects who began the study, 14 completed the study. The subject who did not complete the study was unable to meet the time commitment.

Time

Differences were detected among the treatments for healing time ($F_{3,39} = 3.28$, $P = .031$; Table 1). All dressings decreased

Dressing Preference Questionnaire.

1. Please rank the dressing you liked best overall. (1 = liked most; 4 = least)

 ___Bioclusive

 ___Coverlet

 ___DuoDerm

 ___Control

2. Which dressing did you feel was most comfortable to wear?

3. Which dressing did you feel gave you the best protection?

4. Which dressing did you feel let you continue most easily with activities of daily living?

5. Prior to the beginning of this study, did you have an opinion of which dressing would be the most effective? If yes, which one?

6. Did participating in this study change your opinion? If so, how?

At the end of data collection, subjects were asked to complete a questionnaire to assess their opinions of the dressings.

healing time compared with the control condition (Student-Newman-Keuls post hoc, $P < .05$), but there were no differences between the dressing groups.

Area

Differences were detected among the treatments for change in wound area ($F_{3,39} = 5.32$, $P = .004$; Table 1). DuoDerm and Bioclusive were not different from each other. However, they were both different from the control. Coverlet showed no difference from any of the other treatment groups (Student-Newman-Keuls post hoc, $P < .05$).

Survey Results

Results of a survey completed by the subjects after treatment revealed the following (Table 2):

- Coverlet was liked best overall (45%).
- Coverlet was the most comfortable to wear (36%).
- Bioclusive and DuoDerm gave the best protection (45% each).
- Coverlet, Bioclusive, and control allowed the subjects to continue activities of daily living most easily (27%).

DISCUSSION

This is the first study to compare occlusive dressings by inflicting the abrasion to be treated. To date, experimental wound healing studies in humans have been limited to previously inflicted wounds.[2,9,10] These wounds were of different sizes, shapes, and depths; on different areas of the body; inflicted by different surfaces; and received under different conditions. In our study, we were able to study the wound size and color and the effect of the dressing or lack of dressing on the wound. The depth, area, method, speed of wound infliction, and conditions were all standardized, so the treatment groups could be readily compared.

Bioclusive and DuoDerm most effectively reduced the area of the wound. All three dressings decreased the healing time when compared with control, but there was no significant difference between the individual dressings. Previous literature supports the fact that Bioclusive and DuoDerm will heal wounds faster than other dressings or no dressing.[1,3,11–13] However, prior research addressed previously inflicted wounds and compared wounds in different subjects. We applied all treatments to all subjects using standardized wounds. Hence, we feel that our results are more valid and allow more comparisons of dressings than other studies.

Visual inspection is common in research and clinically relevant. Gorin et al[8] considered the wound healed when it was pink in color and there was no scab. This is the same method we used to determine when the wounds were healed. Gorin et al[8] established that, when wounds differ in size initially, the equation $D = A/P$ (linear healing = change in area/perimeter) could be used to calculate the linear healing of the wound edge. We did not use this equation because the wound size was standardized. We used a 1-mm graph transparency to determine the relative area of each wound by counting the number of squares covering the wound.

An abrasion occurs when the epidermis and dermis are worn away by scraping the skin against a rough surface, which exposes many blood capillaries.[13] Wounds heal in three phases. First is the inflammatory phase. In this phase, hemostasis and débridement occur and a scab is formed. In order for a wound to heal, it must be kept moist to allow for epidermal

Table 1. Average Change in Wound Area and Average Healing Time

Treatment Group	Begin Area (mm^2)	End Area (mm^2)	Change Area (mm^2)	Time (h)
DuoDerm	198.79 ± 46.33	90.21 ± 69.34	108.57 ± 69.40*	142.29 ± 43.61*
Bioclusive	186.00 ± 39.24	94.07 ± 65.29	91.93 ± 55.34*	145.71 ± 43.61*
Coverlet	216.29 ± 57.10	151.21 ± 87.87	65.07 ± 66.18	138.86 ± 79.98*
Control	189.14 ± 54.34	166.14 ± 66.06	23.00 ± 53.38	204.00 ± 69.02

* Different from control ($P < .05$).

Table 2. Subjects' Dressing Preferences (%)*

Category	DuoDerm	Bioclusive	Coverlet	Control
Best overall dressing	0	27	45	27
Most comfortable dressing	9	27	36	27
Best protection	45	45	9	0
Continue ADL most easily	18	27	27	27

* Subtotals do not equal 100% due to rounding error. ADL = activities of daily living.

cell migration, which cannot occur if a scab forms. Contrary to Christie,[10] who found that wound contraction is accelerated by wound exposure, we found that covering the wound with DuoDerm or Bioclusive resulted in a greater decrease in the area of the wound. There are several possible reasons for this finding:

- allowing healing from the sides and bottom, not the bottom only[1]
- increasing wound débridement and stimulation of granulation of tissue formation[3,8]
- increasing macrophage and fibroblast infiltration, which synthesizes collagen and binds the wound together[14–16]
- moist wound bed allows easier route for epidermal cell migration[14]

Cleansing the wound is best done with saline, water, or other noncytotoxic agents. Betadine and hydrogen peroxide are not recommended because they are toxic to newly forming skin cells.[1,3] We cleansed the wounds initially with hydrogen peroxide to rid them of bacteria. On days 2 through 10, we used sterile saline to rinse the wounds daily.

There are several types of dressing options. The dressings chosen for this study were Bioclusive, a semipermeable film; DuoDerm, a hydrocolloid; and Coverlet with Bacitracin antibiotic ointment, which is presently the standard of care.

Semipermeable films are composed of polyurethane or polyethylene and have an adhesive coating on one side.[11] Our findings agree with previous researchers, who stated that an advantage of semipermeable films is that they allow visible inspection of the wound.[4,5,11] This is contrary to what Goldenberg[1] found. He stated that exudate would block the wound. We found that the semipermeable films allowed leakage around the edges. This was especially noticeable after exercise. This leakage allowed the exudate to escape, making the wound visible. Although there was leakage, the bacterial barrier seemed to be left intact. This supposition was also supported by previous literature.[1,4,11] A disadvantage to semipermeable film is that it adheres to the surrounding skin and pulls off newly formed skin.[1] We found that the film did adhere to the wound and also caused irritation to the skin surrounding the wound. We also observed that the layer removed from the wound appeared to be brown and dead, and when it was pulled off, the skin underneath appeared to be pink and healthy. It was difficult to determine whether all the skin removed was dead.

Hydrocolloids have an outer layer of polyurethane foam and an inner layer of hydrophilic particles, such as pectin and gelatin.[1] DuoDerm has several advantages and disadvantages. Researchers have found advantages to be that it heals faster,[2] is less painful,[1] gently débrides the wound,[3,8] and has less chance of infection.[3,7,8] Disadvantages are that it is painful to remove and it irritates the skin around the wound.[2] We found that DuoDerm healed the wound at the same rate as the other dressings, but it irritated the surrounding skin. Subjects felt that DuoDerm did not adhere well around the edges after exercise. Removal of DuoDerm was painful for some subjects.

The advantages of Coverlet with Bacitracin are that it is inexpensive and readily available in athletic training rooms. When our subjects were surveyed on their perceptions of the dressings, most found Coverlet to be the best overall dressing and the most comfortable. We found that covering the wound with Coverlet allowed the wound to heal at a more rapid pace than if it was left uncovered. There was no significant difference in healing time seen with Coverlet, DuoDerm, or Bioclusive. A disadvantage we found was that the wound area did not decrease as it did with the DuoDerm and Bioclusive. Although the results of our study were not as favorable for the Coverlet and Bacitracin, our subjects preferred it. Another disadvantage of Coverlet and Bacitracin was that the wound was not completely sealed from outside elements, which could increase the likelihood of complications, such as infection.

Based on our findings, we recommend Bioclusive be used for abrasions. Bioclusive decreased the area of the wound and kept it well protected. Bioclusive and DuoDerm are equally effective, but Bioclusive is less expensive than DuoDerm. Bioclusive is more expensive than Coverlet, but it is more effective in decreasing the area of the wound. Other considerations when choosing between these dressings are that DuoDerm and Bioclusive are manufactured to be changed on the average of twice per week versus Coverlet and Bacitracin, which may need to be changed every day or even more than once per day. DuoDerm and Bioclusive would decrease the time the athletic trainer needs to spend attending to an athlete with an abrasion. They also increase patient compliance because the athlete is not required to spend as much time in the athletic training room. However, if DuoDerm and Bioclusive tend to come off during activity, some of these advantages may be lost.

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Flexible Magnets Are Not Effective in Decreasing Pain Perception and Recovery Time After Muscle Microinjury

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Objective: To assess the therapeutic effects of flexible magnets on pain perception, intramuscular swelling, range of motion, and muscular strength in individuals with a muscle microinjury.

Design and Setting: This experiment was a single-blind, placebo study using a repeated-measures design. Subjects performed an intense exercise protocol to induce a muscle microinjury. After pretreatment measurements were recorded, subjects were randomly assigned to an experimental (magnet), placebo (imitation magnet), or control (no magnet) group. Posttreatment measurements were repeated at 24, 48, and 72 hours.

Subjects: Forty-five healthy subjects participated in the study.

Measurements: Subjects were measured repeatedly for pain perception, upper arm girth, range of motion, and static force production. Four separate univariate analyses of variances were used to reveal statistically significant mean ($\pm$SD) differences between variables over time. Interaction effects were analyzed using Scheffe post hoc analysis.

Results: Analysis of variance revealed no statistically significant ($P > .05$) mean differences between conditions for any dependent pretreatment and posttreatment measurements. No significant interaction effects were demonstrated between conditions and times.

Conclusions: No significant therapeutic effects on pain control and muscular dysfunction were observed in subjects wearing flexible magnets.

Key Words: static magnetic field, magnetohydrodynamic effect, Hall voltage

The use of a magnetic field to treat musculoskeletal disorders dates back thousands of years, to when Greek, Persian, and Chinese physicians used the healing powers of magnetic energy to treat conditions such as gout and muscle spasms (E.A. Hacmac, unpublished manuscript, 1991). Since then, clinicians have been using the principles of electromagnetism to treat various musculoskeletal disorders, such as rotator cuff tendinitis,[1] osteoarthritis and rheumatoid arthritis,[2] nonunion fractures and arthrodesis,[3,4] and failed total knee arthroplasties.[5] The energy from an electromagnetic field is used to stimulate mechanisms for tissue growth and repair. Traditional units deliver electromagnetic field energy using either a pulsed or static mode, depending on the type of unit and the prescribed dosage. Sports medicine practitioners and other allied health professionals are currently prescribing commercially available flexible magnets to athletes to reduce the signs and symptoms associated with acute and chronic musculoskeletal injuries. Unpublished written reports and personal testimonies have indicated that flexible magnets promote healing and decrease pain[6–8] (Hacmac, 1991; V. Ardizzone, unpublished data, 1992; T.J. Zablotsky, unpublished data, 1989), although the efficacy of this modality has not been demonstrated experimentally.

The commercially available flexible magnet is a modified and simplified version of the original electromagnetic field unit model. The flexible magnet is constructed of silicon rubber with high-grade steel having ferromagnetic properties capable of inducing low-level, homogeneous, DC static magnetic fields. Most commercially available flexible magnets have field strengths below 0.1 T (1000 G), and the energy transmitted from the magnets is reported to produce both thermal and nonthermal physiologic effects within injured soft tissue[6–8] (Hacmac, 1991; Ardizzone, 1992; Zablotsky, 1989). The flexible magnet is applied directly over the injured area and secured with an elastic bandage or neoprene sleeve (Figure 1). The magnet is worn continuously until the patient is asymptomatic. To date, no research has been published concerning the efficacy of wearing flexible magnets. Since the magnets are being used prior to intensive background research, many questions exist concerning their effectiveness in treating musculoskeletal disorders. The purpose of our investigation was to determine if flexible magnets are effective in decreasing pain perception and recovery time after muscle microinjury.

METHODS

Subjects and Design

This experiment was a single-blind, placebo study using a repeated-measures design. Subjects were required to report to

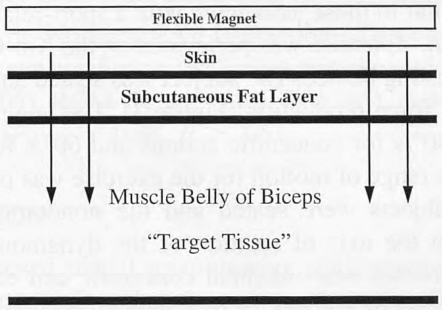

Fig 1. Flexible magnet placed directly over the target tissue.

the laboratory for five testing sessions (Table). Forty-five subjects (20 males, 25 females; mean age, 23.2 ± 2.81 years; range, 20 to 32 years) volunteered to participate in this study. Inclusion criteria consisted of a healthy nondominant arm and abstinence from upper extremity resistance training for at least 6 weeks. All subjects read and signed an informed consent explaining the risks, procedures, measurements, and benefits of participation. The protocol was approved by Oregon State University's Institutional Review Board.

Measurement Procedures

The dependent measures included pain perception, range of motion, upper arm girth, and static force production. At the first session, we took pre-exercise measurements, after which subjects performed the exercise protocol to induce muscle microinjury. We assessed postexercise measurements 24 hours later (session two), after which subjects were randomly assigned to a control (C) (n = 15), placebo (P) (n = 15), or experimental (E) (n = 15) group. We instructed subjects to refrain from analgesic and anti-inflammatory medications, physical therapy, and extensive upper arm activity until the investigation was completed. We repeated posttreatment measurements at sessions three, four, and five (24, 48, and 72 hours). Reliability and precision of measurement were obtained using intraclass correlation coefficients (ICCs) and standard errors of measurement (SEMs), respectively.

The experimental group received a flexible magnet (Nikken, Inc, Los Angeles, CA) with a field strength of 0.07 T (700 G). The placebo group received a sham magnet, which had no field strength (0 T, 0 G). The control group received no treatment. The size of the magnet/placebo was approximately 8 × 5 cm, with a thickness of 3 mm. The modality (magnet or placebo) was worn continually, except when bathing, over the midbelly of the biceps brachii muscle and supported with POWER-Flex, a high-strength, self-adhering elastic tape (Andover Coated Products, Inc, Salisbury, MA) (Figure 2).

Time Line for Study

Session	Activity
1	Completion of informed consent, pre-exercise measures, and exercise-induced muscle soreness protocol.
2	Completion of postexercise/pretreatment measurements, and treatment assignment (experimental, placebo, or control) (24 h postexercise).
3	Completion of postexercise/posttreatment measurements (24 h posttreatment).
4	Completion of postexercise/posttreatment measurements (48 h posttreatment).
5	Completion of postexercise/posttreatment measurements (72 h posttreatment).

Dependent Measures

Pain Perception. We assessed pain perception using a visual analog scale, as in previous investigations.[9] The visual analog scale has been shown to be a reliable and valid method of quantifying pain perception.[10] The visual analog scale consisted of a horizontal line 10 cm in length, with 0 at the extreme left representing "no pain" and 10 cm on the extreme right representing "pain as bad as it possibly could be" for the biceps brachii muscle. Subjects were asked to draw a vertical line at the point that most accurately corresponded to their perceived level of pain with active flexion and extension of the involved arm.

Range of Motion. We measured pain-free range of motion (ROM) for elbow flexion and extension using a standard plastic goniometer. The goniometer approximated the axis of rotation for the ulnohumeral joint and bisected the humerus and forearm.[11] We measured extension with the subject seated and the arm resting pain free at the side.[12] For flexion, subjects

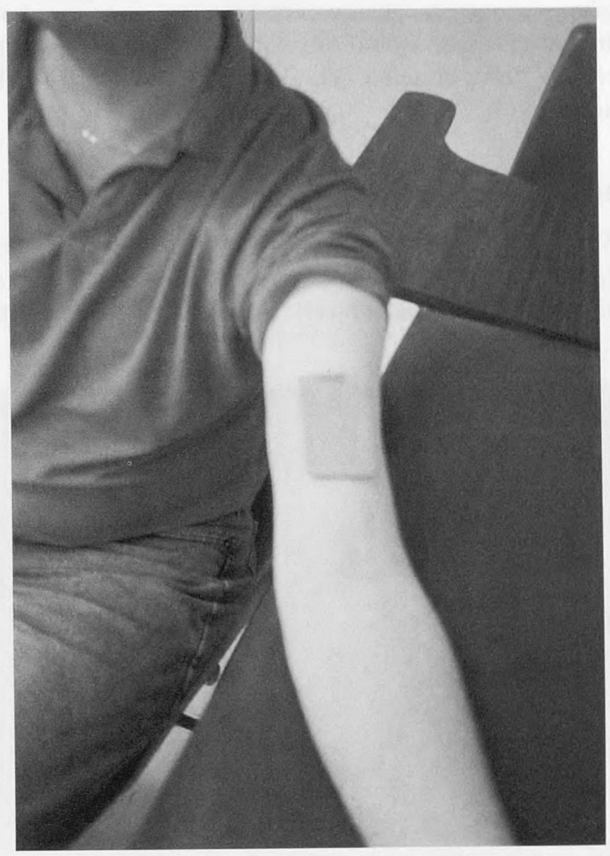

Fig 2. Fixation of the flexible magnet over the biceps brachii muscle.

were asked to flex the elbow to the point just before discomfort. This process was repeated twice for both flexion and extension, and we recorded the average score in degrees. The criterion measure for pain-free ROM was calculated by subtracting the extension score from the flexion score. Test-retest reliability was demonstrated to be ICC (2,1) = 0.92, SEM = 3.3°.

Upper Arm Girth. We measured upper arm girth as a composite score of three sites on the upper arm using a standard measuring tape.[12] The measurement sites for the upper arm included the distal and proximal musculotendinous junctions and the midpoint between the two junctions. We located and marked the sites with a permanent ink marker to ensure consistent tape placement. We also measured the sites from the medial epicondyle of the humerus, which served as the reference bony landmark. We measured girth twice at each site and recorded the average of the six measures as the criterion measure in centimeters. Test-retest reliability was demonstrated to be ICC (2,1) = 0.99, SEM = 1.0 cm.

Static Force Production. We measured static force production using the Kin-Com 500-H isokinetic testing device (Chattecx Corporation, Chattanooga, TN) (Figure 3). Subjects were seated with the nondominant arm placed in a neutral position of elbow flexion (90°). Each subject performed three maximal voluntary isometric contractions held for 2.5 s. The average of the three values was recorded as peak torque in Newtons (N). We used the midrange position as the reference angle because of the length-tension relationship.[13] The length-tension relationship demonstrates that maximal tension is generated at the midrange of elbow joint flexion due to optimal available sarcomere cross-bridging. Test-retest reliability was demonstrated to be ICC (2,1) = 0.99, SEM = 9.4 N.

Exercise-Induced Muscle Soreness Protocol

We used a concentric-eccentric exercise protocol for the biceps brachii muscle to induce muscle microinjury.[1,2,4] As a result of this exercise, subjects display signs and symptoms that are similar to those associated with a sport-related muscle-tendon strain.[5] Exercise was performed on the Kin-Com 500-H isokinetic testing device. The subject was seated and stabilized as for static force production (Figure 3). The angular velocity was set at 30°/s for concentric actions and 60°/s for eccentric actions. The range of motion for the exercise was preset at 45° to 110°. Subjects were seated and the nondominant elbow aligned with the axis of rotation of the dynamometer. Each subject performed near-maximal concentric and eccentric actions consisting of ten sets of five repetitions with 30-second recovery periods between sets.

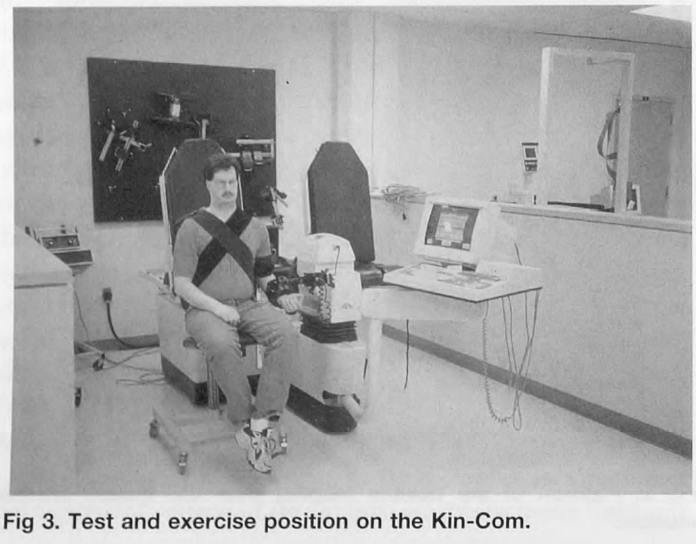

Fig 3. Test and exercise position on the Kin-Com.

Statistical Procedures

We calculated ICCs and SEMs for range of motion, upper arm girth, and static force production using the model proposed by Denegar and Ball.[16] Repeated measures were performed for each dependent variable, and the ICC (2,1) was obtained according to procedures explained by Denegar and Ball.[16]

Using preliminary statistical procedures, we analyzed the pre-exercise and pretreatment measurements. Four separate one-between (group) and one-within (time) univariate ANOVAs with repeated measures for time were performed as an a priori analysis to demonstrate that the exercise-induced muscle soreness protocol was effective in producing significant effects for pain perception, swelling, and dysfunction.

Using a one-between (group) and one-within (time) ANOVA with repeated measures for time, we analyzed pretreatment and posttreatment data. We employed four separate one-between (group) and one-within (time) univariate ANOVAs to reveal statistically significant mean (±SD) differences between variables. Interaction effects were observed using Scheffe post hoc analysis. The level of statistical significance was set at 0.05. We reduced and analyzed all data using Statview 4.1 statistical software for Macintosh (Abascus Concepts, Inc, Berkeley, CA).

RESULTS

Pre-Exercise Versus Postexercise

Preliminary analysis revealed statistically significant mean differences between pre-exercise and postexercise measures for pain perception ($F_{1,44} = 91.9$, $P < .0001$), ROM ($F_{1,44} = 46.4$, $P < .0001$), and static force production ($F_{1,44} = 34.1$, $P < .0001$). No significant pre-exercise/pretreatment differences were demonstrated for upper arm girth ($F_{1,44} = 1.5$, $P > .05$). Consequently, upper arm girth was not included in the pretreatment/posttreatment analysis.

Pretreatment Versus Posttreatment

ANOVA revealed no statistically significant ($P > .05$) mean differences between conditions for all dependent measures: pain perception ($F_{2,42} = 0.50$, $P > .05$), ROM ($F_{2,42} = 0.30$,

$P > .05$), and static force production ($F_{2,42} = 0.002$, $P > .05$) (Figures 4–6). No significant interaction effects were demonstrated between conditions and times: pain perception ($F_{6,126} = 0.65$, $P > .05$), ROM ($F_{6,126} = 1.4$, $P > .05$), and static force production ($F_{6,126} = 0.88$, $P > .05$) .

DISCUSSION

The proposed model promulgating static magnetic therapy implicates the Hall and magnetohydrodynamic effect mechanisms[6–8] (Hacmac, 1991; Ardizzone, 1992; Zablotsky, 1989). Both mechanisms are well-known physical principles that utilize the electrochemical nature of biologic tissue.[17,18] When a magnetic field of sufficient strength passes through a conductive fluid such as blood, an electromotive force, or Hall voltage, is produced (Figure 7).[17] A significant Hall voltage will cause blood ions to vigorously oscillate and collide, producing heat energy and vasodilation.[6,18] Vasodilation combined with an active magnetic field will significantly increase the flow of arterial blood to and away from the target area. The advantages of a magnetohydrodynamic effect are an increased delivery of molecular oxygen for cellular metabolism, a reduction of secondary tissue hypoxia, and local heat production[6] (Hacmac, 1991; Ardizzone, 1992; Zablotsky, 1989). Thermal effects produced by a static magnetic field would mimic those of other superficial and deep heating agents used to promote tissue healing, such as analgesia, increased blood flow, fibroplasia, and viscoelasticity[6–8] (Hacmac, 1991; Ardizzone, 1992; Zablotsky, 1989).

In direct contrast to the proposed model, recent research has demonstrated no significant thermal effects on skin and body tissue from exposure to static magnetic fields ranging from 0.015 to 1.5 T.[18,19] The field strength of most commercially available, flexible magnet models is less than 0.1 T (1000 G). Therefore, we hypothesize that the static magnetic field produced by the flexible magnet is of insufficient strength to produce significant physiologic changes in the target tissue area. Our results support this hypothesis by revealing no statistically significant therapeutic effect of the magnet on pain perception and muscular dysfunction. Additionally, the posttreatment recovery curves for pain perception, ROM, and static force production appeared to be similar among all conditions, demonstrating no significant therapeutic effects from wearing the magnet or placebo (Figures 4–6).

Without thermographic or plethysmographic evaluative equipment, it is difficult to demonstrate any direct magnetohydrodynamic effect. However, one manifestation of increased blood flow and local heat is increased tissue viscoelasticity. Increased viscoelasticity has been shown to improve soft tissue

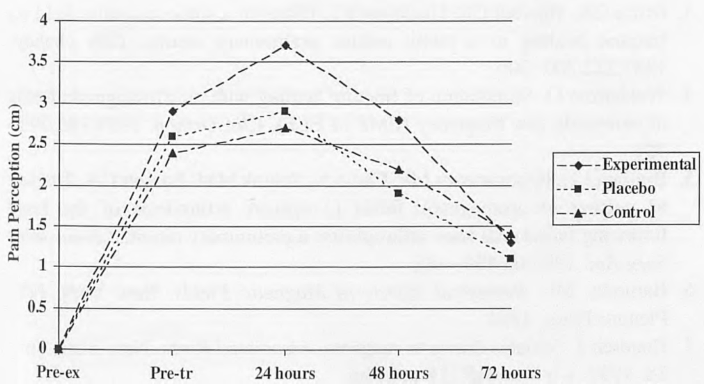

Fig 4. Change in pain perception over time between treatment groups. Repeat measures were taken at pre-exercise (Pre-ex), pretreatment (Pre-tr), and 24, 48, and 72 hours posttreatment.

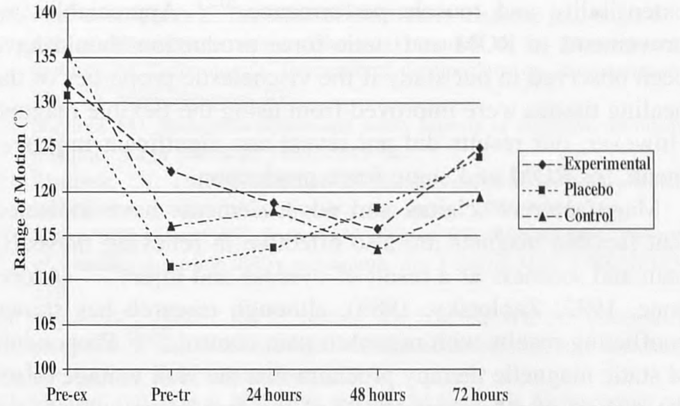

Fig 5. Change in pain-free range of motion over time between treatment groups. Repeat measurements were taken at pre-exercise (Pre-ex), pretreatment (Pre-tr), and 24, 48, and 72 hours posttreatment.

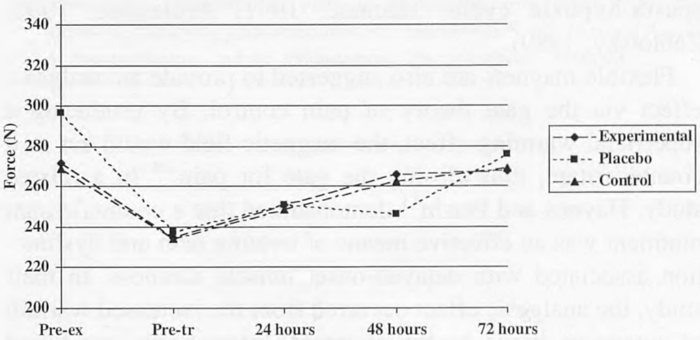

Fig 6. Change in static force production over time between treatment groups. Repeat measurements were taken at pre-exercise (Pre-ex), pretreatment (Pre-tr), and 24, 48, and 72 hours posttreatment.

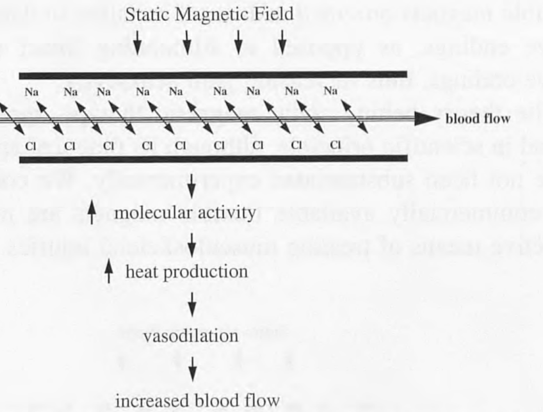

Fig 7. Paradigm depicting the magnetohydrodynamic effect.

extensibility and muscle performance.[20,21] Appreciable improvements in ROM and static force production should have been observed in our study if the viscoelastic properties of the healing tissues were improved from using the flexible magnet. However, our results did not reveal any significant improvements for ROM and static force production.

Manufacturers' claims and advertisements have indicated that flexible magnets are also effective in relieving muscular pain and soreness as a result of overuse and injury[6–8] (Ardizzone, 1992; Zablotsky, 1989), although research has shown conflicting results with regard to pain control.[22,23] Proponents of static magnetic therapy proclaim that the Hall voltage raises the resting membrane potential of the free nerve ending to a point of inhibition (Ardizzone, 1992). As a result of this shift in resting membrane potential, neural depolarization and conduction velocity is decreased (Figure 8). The proposed therapeutic benefits include analgesia and interruption of the pain-spasm-hypoxia cycle (Hacmac, 1991; Ardizzone, 1992; Zablotsky, 1989).

Flexible magnets are also suggested to provide an analgesic effect via the gate theory of pain control. By producing a superficial warming effect, the magnetic field would act as a counterirritant, thus closing the gate for pain.[24] In a related study, Haynes and Perrin[11] demonstrated that a counterirritant ointment was an effective means of treating pain and dysfunction associated with delayed-onset muscle soreness. In their study, the analgesic effect occurred from the increased warmth of cutaneous tissue by the ointment. Interestingly, we found that, although not statistically significant, the group that wore the flexible magnet in our study had a trend toward greater pain perception than the placebo and control groups. One explanation for this trend may be that the nonthermal effects of the flexible magnets provided additional irritation to damaged free nerve endings, as opposed to stimulating intact superficial nerve endings, thus increasing pain sensitivity.

The theory behind static magnetic therapy appears to be sound in scientific principle, although its practical applications have not been substantiated experimentally. We contend that the commercially available flexible magnets are not a cost-effective means of treating musculoskeletal injuries. The flexible magnet is an expense (the average cost of a magnet is approximately $60), and our results did not reveal any significant therapeutic effects from wearing flexible magnets in treating selected signs and symptoms associated with a muscle microinjury. The Food and Drug Administration places no restrictions on the use of magnetic fields under 1000 G. As a result, flexible magnets have not undergone rigorous controlled testing by reputable agencies such as the Food and Drug Administration. This has led to the unscrupulous advertisement of these products as a panacea for musculoskeletal disorders. The most prudent way of understanding the effect of static magnetic fields on biologic tissue is through controlled experimentation. Until sound evidence is provided concerning the efficacy of flexible magnets, we recommend that consumers be cautious when deciding whether to use them.

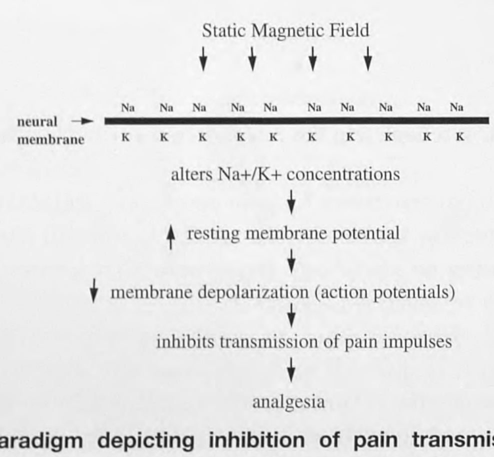

Fig 8. Paradigm depicting inhibition of pain transmission and analgesia.

CONCLUSIONS

The efficacy of flexible magnets has not been demonstrated experimentally, although many clinicians and athletes continue to recommend and use the modality. With respect to pain control and muscular dysfunction, our results reveal no significant therapeutic benefits from wearing flexible magnets. Therefore, without any experimental evidence of efficacy, the use of flexible magnets for athletes who require treatment for pain and dysfunction associated with athletic activity should be scrutinized. In order to legitimize commercially available flexible magnets as a valid therapeutic modality, extensive research and development must be conducted in order to manufacture a product that is safe and cost effective. Until this form of treatment has been substantiated experimentally, we do not recommend using flexible magnets to treat acute or chronic musculoskeletal injuries.

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Electromyographic Reliability and Analysis of Selected Lower Extremity Muscles During Lateral Step-Up Conditions

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Objective: To determine 1) the electromyographic (EMG) reliability within and between testing sessions; 2) the effect of sex on the EMG activity of the vastus medialis oblique (VMO), vastus lateralis (VL), hamstring (HS), and gluteus maximus (GM) and VMO:VL ratios during maximal voluntary isometric contraction (MVIC) and lateral step-up (LSU) conditions; and 3) the muscle recruitment and VMO:VL ratios during MVIC and LSU conditions.

Design and Setting: Subjects participated in a familiarization session and two testing sessions in which they performed a 20.32-cm (8-in) LSU with and without resistance while the EMG activity was monitored for the VMO, VL, HS, and GM muscles.

Subjects: Nineteen subjects performed LSUs holding 25% body weight (Group 25%), and 13 subjects performed LSUs holding 10% body weight (Group 10%). There were 32 subjects total: 19 males and 13 females.

Measurements: Statistical analyses included a two-way analysis of variance (ANOVA) to compare sex and testing conditions for percentage of MVIC and VMO:VL ratios; three-way repeated-measures ANOVA to compare muscle, resistance, and session factors for percentage of MVIC; and a two-way repeated-measures ANOVA to compare conditions and session factors for VMO:VL ratios. These analyses were performed for both groups.

Results: Reliability results revealed good intrasession and poor intersession intraclass correlation coefficients. No difference existed in muscle recruitment or VMO:VL ratios between males and females for either group. The three-way ANOVA revealed a significant two-way interaction (muscle $\times$ resistance) for both groups. Post hoc testing revealed the following EMG recruitment patterns: VMO > HS, GM, VL; VL > HS, GM; HS = GM for both groups. For Group 25%, the two-way ANOVA revealed greater VMO:VL ratios during MVIC for session one than for LSU.

Conclusions: Intrasession reliability was higher than intersession reliability, but similar conclusions were reached concerning muscle recruitment in both testing situations. No sex differences existed in recruitment patterns. The LSU requires greater VMO and VL recruitment than HS and GM recruitment. In addition, VMO:VL ratios varied tremendously in a group of asymptomatic subjects, which challenges the theory of a "normal" VMO:VL ratio of 1:1 in asymptomatic subjects.

Key Words: hamstring, gluteus maximus, VMO, VL, VMO:VL ratios

After knee injury and surgery, strengthening and relearning are essential to activate the quadriceps muscles. Traditionally, knee rehabilitation has focused on open kinetic chain exercises. Open chain knee extensor exercises isolate the quadriceps but increase anterior tibial translation and patellofemoral joint reaction forces.[1,2] More recently, closed kinetic chain exercises have been recommended and used after knee surgery.[3,4] Closed kinetic chain exercises decrease anterior tibial translation and patellofemoral joint reaction forces via the compressive forces and cocontractions of the muscles of the lower extremities.[1,2,5]

Since each closed kinetic chain exercise recruits many muscles across multiple joints, a thorough understanding of muscle recruitment during various closed kinetic chain exercises is needed in individuals with and without pathology. For example, the lateral step-up (LSU) exercise is often used in knee rehabilitation.[6–11] Specific contributions, however, of the vastus lateralis (VL) and gluteus maximus (GM) have not been reported for this exercise.[6–7] A complete analysis of muscle activity during the LSU will enable clinicians to understand which muscles are preferentially recruited and provide a scientific rationale for the selection of the LSU exercise.

LSUs are often recommended during rehabilitation for patients with anterior knee pain.[11] Patellofemoral pain is a common problem for athletes, especially female athletes. The vastus medialis oblique (VMO) and the VL are the dynamic stabilizers of the patella. Theoretically, if the VMO is selectively recruited, the patella moves medially, improving patellar alignment and decreasing pain.[11] Therefore, selective VMO recruitment is one of the goals of rehabilitation. The electromyographic (EMG) relationship between the VMO and the VL is reported as the VMO:VL ratio. No data exist that report

VMO:VL ratios during maximal isometric contractions compared with the LSU. In addition, no data exist that compare VMO:VL ratios for females to males during maximal isometric contractions and LSUs.

Therefore, the purposes of this study were to determine 1) EMG reliability within and between testing sessions, 2) the effect of sex on the EMG activity of the VMO, VL, hamstring (HS), and GM and VMO:VL ratios during maximal voluntary isometric contraction (MVIC) and LSU conditions, and 3) the muscle recruitment patterns and VMO:VL ratios during MVIC and LSU conditions in two testing sessions.

METHODS

Subjects

Nineteen subjects were assigned to Group 25% (13 males and 6 females, age = 25.7 ± 1.98 years, height = 175.63 ± 9.87 cm, weight = 73.39 ± 15.32 kg) and held 25% of their body weight, and 13 different subjects were assigned to Group 10% (6 males and 7 females, age = 22.0 ± 8.6 years, height = 171.55 ± 15.55 cm, weight = 69.19 ± 14.13 kg) and held 10% of their body weight. In all, 32 subjects without a history of knee surgery and without current knee pain participated in this study. Because of the demands of a familiarization session and two 1-hour testing sessions, we were unable to obtain an equal number of subjects and equal sex distribution in each group. Before participating, subjects signed a consent form that was approved by the University of Indianapolis Institutional Review Board.

EMG Equipment

Preamplified surface electrodes (D-100 assemblies, Therapeutics Unlimited, Iowa City, IA) were placed over the muscle bellies and oriented parallel to the muscle fibers of interest. Electrodes were connected to a main amplifier system (Therapeutics Unlimited). Root mean square (RMS) EMG signal (11.75-ms time constant) was analyzed with computer software (AcqKnowledge III, version 3.0, Biopac Systems, Inc, Goleta, CA) and monitored by an oscilloscope. The sampling rate was 1000 Hz. Standardized verbal instructions and cueing were given for each subject. An electrogoniometer (Therapeutics Unlimited) was used to monitor knee range of motion during the LSU.

Pretesting Procedure

The exact location of the electrodes was determined after observing the movement of skin during the MVIC and during the entire arc of movement for the LSU for each individual. Electrodes were placed in such a way that they remained over the muscle of interest during data collection because it has been reported that movement of the skin and electrodes occurs during lower extremity EMG testing procedures, which may confound the results of EMG analysis.[12] Therefore, electrode location was different for each subject. Standardization of electrode placement for each subject was accomplished by tracing the position of the electrodes with a permanent marker during the first session, which was used to determine electrode position during the subsequent testing sessions. The skin was shaved, abraded with an emery board, and scrubbed with alcohol before electrode placement. Skin resistance was less than 2 KΩ as determined by an ohmmeter. The reference electrode was placed on the proximal anterior shaft of the tibia.

An electrogoniometer was used to monitor knee range of motion during the LSU. The electrogoniometer's axis of rotation was centered directly over the lateral joint line. The proximal arm was placed on the lateral thigh and was aligned with the lateral midline of the femur, using the greater trochanter for reference. The distal arm was placed on the lateral aspect of the lower leg and was aligned with the lateral midline of the fibula, using the lateral malleolus for reference. Elastic bandages were applied to the goniometer's arms and electrodes in order to maintain proper positioning during dynamic activities. Monitoring of the electrogoniometer range of motion allowed the researchers to precisely determine the number of test repetitions of the LSU on the computer screen for the data reduction.

MVICs were recorded for 5 seconds for each muscle tested and were used as a reference for comparison of muscle activity during the LSU (ie, percentage of MVIC). Subjects performed three warm-up isometric contractions at 50%, 75%, and 100% of perceived exertion. Each contraction was held for 5 seconds, with a 60-second rest between practice repetitions. Then three 5-second MVICs were performed for each muscle group during the following conditions: VMO and VL while seated at 60° of knee flexion on a Biodex isokinetic dynamometer (Model 900-220, Biodex, Shirley, NY); hamstrings at 60° of knee flexion; and GM at 0° of hip flexion while in the prone position against manual resistance. Manual resistance was provided by the strong male tester for the HS and GM testing. Pilot testing of the manual muscle testing procedures revealed consistent EMG data for the HS and GM muscles. Therefore, no formal reliability data analysis was performed. Standardized verbal encouragement was given for all MVICs. The largest MVIC for each muscle was used for the normalization of calculations.

Lateral Step-Up Exercise

Subjects were familiarized with the testing procedure several days before data collection. During the familiarization session, subjects practiced LSUs without resistance and while holding either 25% or 10% body weight, until the correct technique was demonstrated. The correct technique was defined as maintaining the nonweightbearing foot in dorsiflexion and touching the heel of that extremity on the floor while maintaining the speed of the LSU with the metronome. Posture and position were monitored to insure consistent repetitions between conditions and subjects. We chose 10% and 25% of body weight as resistance because a previous study reported difficulties with subjects holding maximal resistance during an LSU.[13] In addition, we wanted to determine if heavier loads changed the recruitment patterns compared with no resistance. Therefore, Group 25% held 25% of their body weight, and Group 10% held 10% of their body weight (Figure 1).[13] Subjects performed five LSUs in cadence with a metronome set at 30 beats per minute, allowing one complete LSU cycle (one concentric and one eccentric contraction) in 2 seconds. A 2-minute rest period was allowed between exercises. Each group performed two trials of five LSU cycles in each testing session. Both groups were retested within 7 days. Exercise sequence was randomly assigned for both testing sessions. An electrogoniometer was used to monitor knee motion and determine repetitions in each trial of each session.

Statistical Analyses

Average normalized RMS EMG data were computed and used in data analysis for reliability determination and recruitment patterns. Intrasession reliability was determined by computing the intraclass correlation coefficient (ICC 2,1) on average RMS EMG data for each muscle during the five repetitions in Trial 1 and Trial 2.[14] Intersession reliability (ICC 2,1) was determined by comparing the average RMS EMG activity for each muscle during Trial 1 (5 repetitions) of both testing sessions. Data analysis was performed using StatView 4.5 and SupraANOVA (Abacus Concepts, Inc, Berkeley, CA).

To determine the effect of sex on the percentage of MVIC and VMO:VL ratio during MVIC and LSU conditions, a two-way mixed-model ANOVA (sex as a between factor and condition as a repeated measure: MVIC, LSU without weight, and with weight as a repeated measure) was calculated for each group.

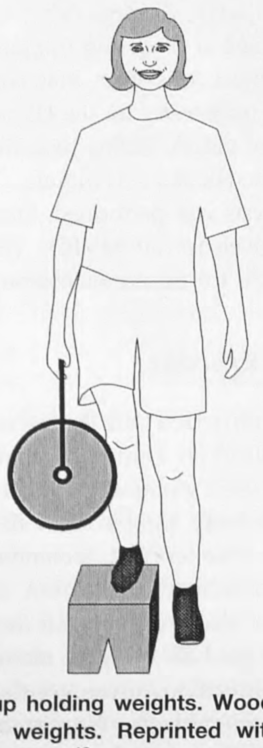

Fig 1. Lateral step-up holding weights. Wooden dowel has rope attached to secure weights. Reprinted with permission from *J Orthop Sports Phys Ther.*[13]

To compare the effect of LSU conditions (with and without resistance) on normalized EMG activity (expressed as a percentage of MVIC), a three-way repeated-measures ANOVA was used for each group (10% and 25%). The repeated-measures factors were muscles (VMO, VL, GM, HS), resistance (body weight and holding either 10% or 25% body weight), and session (1 and 2).

To compare VMO:VL ratios during the conditions (MVIC, body weight, and holding weight) between sessions 1 and 2, a two-way, repeated-measures ANOVA was used for each group.

RESULTS

Intrasession ICCs for the percentage of MVIC between trials 1 and 2 ranged from 0.67 to 0.99 for both groups (Table 1). Intersession reliability ranged from 0.06 to 0.83 (Table 2).

The two-way ANOVA revealed that no difference existed in percentage of MVIC or VMO:VL ratios between males and females during the LSU testing conditions or MVIC testing of

Table 1. Intrasession Intraclass Correlation Coefficients (ICC 2,1) for Percentage of MVIC Values for Both Groups During Both Testing Sessions

	Session 1		Session 2	
Muscles	NO WT*	WT	NO WT	WT
Group 25%				
VMO	0.89	0.94	0.96	0.97
VL	0.91	0.96	0.96	0.98
Hamstring	0.98	0.96	0.87	0.96
Gluteus maximus	0.93	0.95	0.95	0.92
Group 10%				
VMO	0.99	0.95	0.97	0.96
VL	0.98	0.99	0.96	0.97
Hamstring	0.67	0.98	0.99	0.98
Gluteus maximus	0.96	0.97	0.97	0.97

* NO WT = no weight, WT = holding weight.

Table 2. Intersession Intraclass Correlation Coefficients (ICC 2,1) for Percentage of MVIC Values for Both Groups During Both Testing Sessions

Muscles	NO WT*	WT
Group 25%		
VMO	0.27	0.06
VL	0.67	0.67
Hamstring	0.61	0.83
Gluteus Maximus	0.71	0.81
Group 10%		
VMO	0.58	0.59
VL	0.30	0.34
Hamstring	0.76	0.71
Gluteus Maximus	0.73	0.75

* NO WT = no weight, WT = holding weight.

Table 3. Percentage of MVIC (mean ± SD) for Both Groups During Both Sessions

	Session 1		Session 2	
Muscles	NO WT*	WT	NO WT	WT
Group 25%				
VMO	80 ± 27	98 ± 36	73 ± 21	87 ± 29
VL	63 ± 24	82 ± 37	58 ± 19	72 ± 26
Hamstring	12 ± 8	14 ± 6	10 ± 5	13 ± 7
Gluteus Maximus	17 ± 8	21 ± 9	15 ± 6	19 ± 8
Group 10%				
VMO	64 ± 26	71 ± 13	63 ± 23	72 ± 27
VL	49 ± 26	54 ± 29	50 ± 15	57 ± 15
Hamstring	12 ± 6	12 ± 6	14 ± 9	14 ± 10
Gluteus Maximus	23 ± 13	25 ± 13	18 ± 9	20 ± 10

* NO WT = no weight, WT = holding weight.

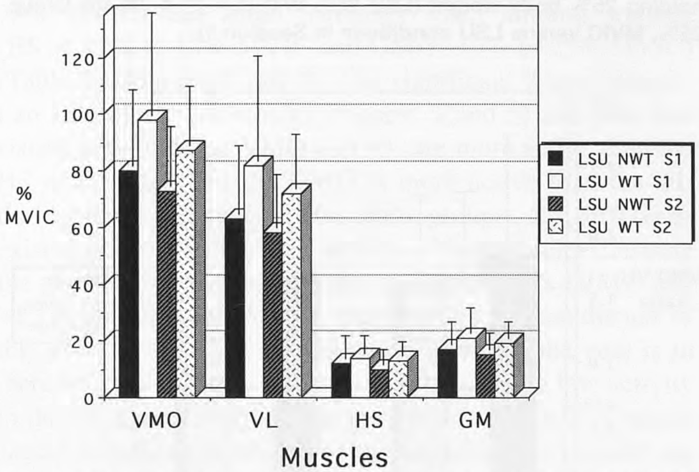

Fig 2. Group 25%, percentage of maximal voluntary isometric contraction (% MVIC) during the lateral step-up exercise in session 1 (S1) and session 2 (S2). NWT = no weight, WT = holding 25% body weight; VMO = vastus medialis oblique, VL = vastus lateralis, HS = hamstring, GM = gluteus maximus.

either group. Thus, males and females were combined for later ANOVA analyses for each group.

Descriptive data for percentage MVIC for both groups are presented in Table 3 and Figures 2 and 3. The three-way ANOVA (muscle, resistance, and session) for percentage of MVIC data revealed a significant 2-way interaction between muscle and resistance for both groups (Figures 4 and 5). Post hoc testing of the simple main effects[15] revealed identical patterns of muscle recruitment for both groups during no resistance and resistance: VMO > HS, GM, VL; VL > HS, GM; and HS = GM. No difference existed in mean muscle recruitment between testing sessions. The two-way ANOVA performed on VMO:VL ratios revealed a significant two-way interaction between condition and session for Group 25%. Post hoc testing revealed that VMO:VL ratios were greater during MVIC testing than during LSU conditions for group 25% for session 1 (Table 4, Figure 6). No difference existed for Group 10% (Table 4, Figure 7).

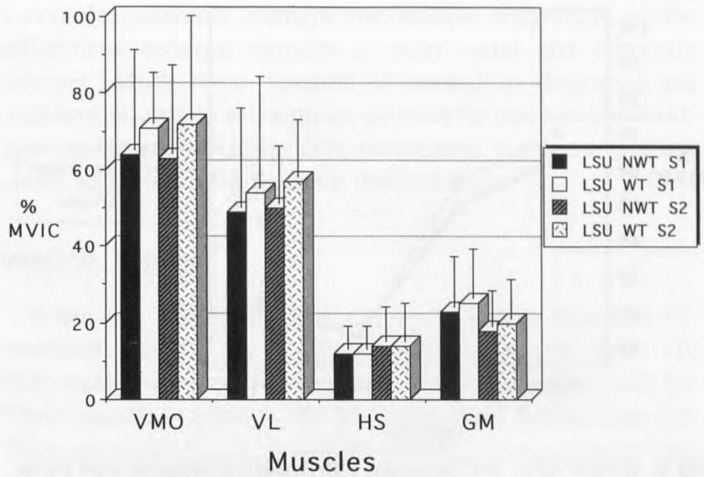

Fig 3. Group 10%, percentage of maximal voluntary isometric contraction (% MVIC) during the lateral step-up exercise in session 1 (S1) and session 2 (S2). NWT = no weight, WT = holding 10% body weight; VMO = vastus medialis oblique, VL = vastus lateralis, HS = hamstring, GM = gluteus maximus.

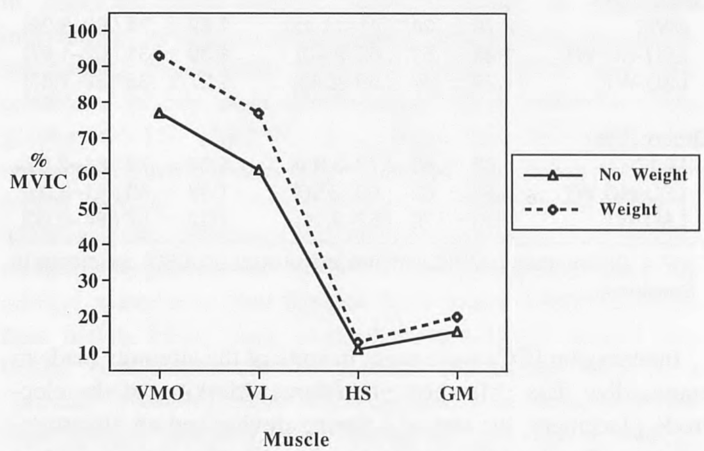

Fig 4. Group 25%, the two-way interaction of muscle and resistance factors. VMO = vastus medialis oblique, VL = vastus lateralis, HS = hamstring, GM = gluteus maximus.

DISCUSSION

Reliability

Intrasession ICCs for the percentage of MVIC during LSU exercises were generally acceptable. Only one of the 32 ICCs was less than 0.70 (Table 2). We are unable to explain this poor hamstring ICC of 0.67 during session 1 for Group 10%, which improved in later trials. Cook et al[7] reported intrasession Pearson product-moment correlation values ranging from 0.68 to 0.95 for the LSU. Pearson product-moment correlation is considered an inappropriate statistic for determining test-retest reliability because the Pearson correlation was developed for bivariate data (eg, height versus weight data).[16] Therefore, direct comparison of our data with those of Cook et al[7] is not possible. Other studies reporting muscle recruitment during closed kinetic chain exercises have not reported reliability data.[3,5,6]

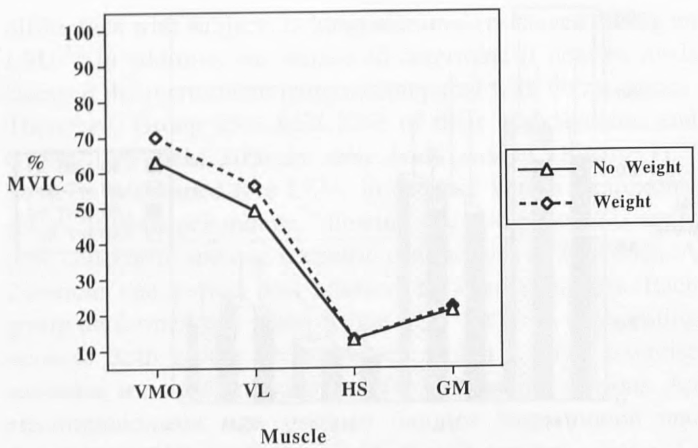

Fig 5. Group 10%, the two-way interaction of muscle and resistance factors. VMO = vastus medialis oblique, VL = vastus lateralis, HS = hamstring, GM = gluteus maximus.

Table 4. Mean ± SD VMO:VL Ratios for All Testing Conditions

Condition	Session 1 (Range)	Session 2 (Range)
Group 25%		
MVIC	2.70 ± .24* (.41–11.43)	1.82 ± .74 (.82–3.29)
LSU-NO WT	1.38 ± .51 (.62–2.43)	1.30 ± .31 (.62–1.87)
LSU-WT	1.29 ± .47 (.59–2.40)	1.27 ± .35 (.62–1.87)
Group 10%		
MVIC	1.83 ± .88 (.77–3.94)	1.68 ± .73 (.64–2.65)
LSU-NO WT	1.58 ± .69 (.69–2.90)	1.38 ± .60 (.61–3.06)
LSU-WT	1.53 ± .72 (.57–3.11)	1.32 ± .57 (.64–3.00)

* $= P < .05$ comparing MVIC with the lateral step-up (LSU) conditions in Session 1.

Intersession ICCs were poor, in spite of the attempts made to standardize data collection procedures. Marking of the electrode placement, the use of a timing device and an electrogoniometer for the LSU exercises, the use of a familiarization session, and standardizing posture during the LSUs did not effectively increase reliability. The low reliability may be due to many factors, including the complexities of muscle recruitment during a difficult motor task such as the LSU, muscle fatigue, different postures assumed during the LSU, and a learning effect from previous trials. For example, during pilot work and familiarization sessions, we observed large differences in muscle activity in the same individual caused by small changes in posture during the LSUs. Thus, many variables are difficult to control in this type of research.

Despite the low intersession ICCs, similar conclusions concerning muscle recruitment patterns within and between sessions were reached. For example, in both groups, during sessions 1 and 2, a significantly larger percentage of MVIC occurred in VMO and VL muscle activity compared with HS and GM in both no-weight and weighted conditions. Although variation existed in the exact percentage of MVIC between sessions for a given muscle, the relative magnitude of the differences was fairly consistent for VMO and VL compared with HS and GM (Table 3). Therefore, we believe intersession reliability data of this study must be evaluated not only in terms

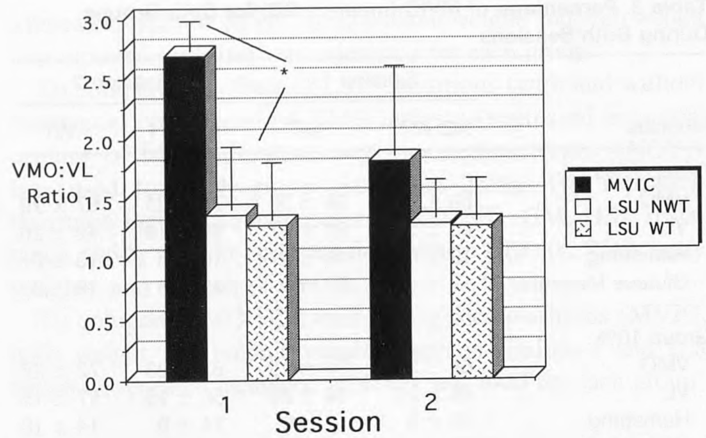

Fig 6. Vastus medialis oblique and vastus lateralis EMG ratio (VMO:VL ratio) during maximal voluntary isometric contraction (MVIC) and lateral step-ups holding no weight (LSU NWT) and while holding 25% body weight (LSU 25% WT) (* = $P < .05$ for Group 25%, MVIC versus LSU conditions in Session 1).

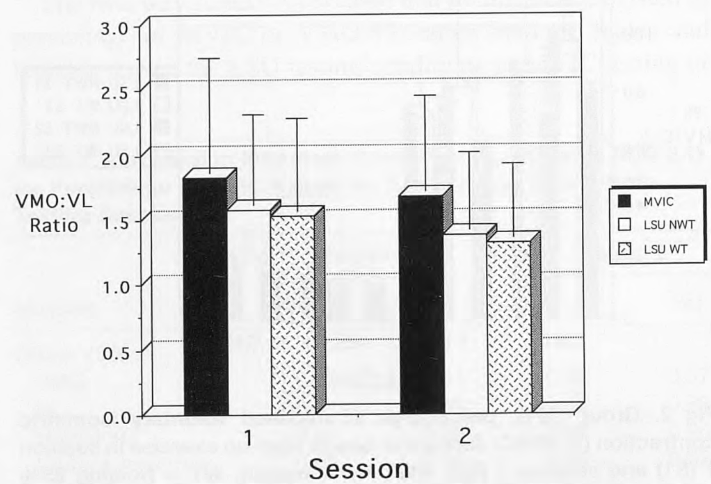

Fig 7. Vastus medialis and vastus lateralis EMG ratio (VMO:VL ratio) during maximal voluntary isometric contraction (MVIC) and lateral step-ups holding no weight (LSU NWT) and while holding 10% body weight (LSU 10% WT).

of ICCs, but also in terms of the conclusions that were reached based on the three-way ANOVA and post hoc testing. More study is needed concerning intersession EMG reliability because erroneous conclusions about muscle recruitment may be reached when testing the same subjects on different days. Thus, we believe caution should be used in interpreting EMG studies that do not report intrasession and intersession reliability data. Other authors have not reported intersession reliability.[3,5–7]

Muscle Recruitment During the Lateral Step-Up

For all subjects, percentage of MVIC during the LSU without holding weight for the VMO ranged from 63% to 80%, and the VL ranged from 49% to 82%. The VMO activity data of this study are higher, but in general agreement with others.[6,7] Brask et al[6] reported peak EMG activity for the VMO during extension and flexion phases of an unweighted LSU of 60% and 37% MVIC, respectively. Cook et al[7] reported average EMG activity for the VMO during extension and flexion phases of an unweighted LSU of 47% and 42% MVIC, respectively, with a mean activity of 45% MVIC for the entire cycle. Cook et al[7] used 60 beats per minute for the cadence of the LSU. We chose 30 beats per minute as the cadence of the LSU because our subjects were more comfortable and consistent with this slower cadence, especially holding 10% or 25% body weight.

For both groups, VMO and VL demonstrated high levels of activation during the LSU without resistance (VMO = 63% to 80% MVIC and VL = 49% to 82% MVIC), as well as relatively large increases when holding weights (VMO = 71% to 98% and VL = 54% to 82%) (Table 3) (Figures 2 and 3). Conversely, the HS and GM showed relatively consistent levels of activation during the LSU without resistance (HS = 10% to 14% MVIC and GM = 15% to 23% MVIC) and small increases when holding weights (HS = 12% to 14% MVIC and GM = 19% to 25% MVIC) (Table 3) (Figures 2 and 3). The significant 2-way interaction (muscle × resistance) (Figures 4 and 5) and post hoc testing revealed that VMO and VL are more active than the HS or GM and that the VMO is more active than the VL during the LSU exercise for both groups. No difference existed between HS or GM activity. These results illustrate the primary involvement of the knee extensors (VMO and VL) in the LSU. In addition, these results support the use of this exercise for knee rehabilitation in which the goal is to increase knee extensor muscle recruitment. The low activity in the HS agrees with similar previous research,[6,7,17] which seems to refute the ability of the hamstring to counter the effects of quadriceps contraction in this exercise. Recently, Isear et al[17] reported that, during an unloaded squat exercise, HS and GM activity were significantly lower than the VMO and VL (their percentage of MVICs were very similar to the values of our study). Isear et al[17] hypothesized that joint compressive forces are responsible for the decrease in anterior translation of the tibia rather than an increase in HS activity. More study is needed to determine the activity of the HS during various closed kinetic chain exercises because many of these exercises are theorized to increase HS activity. Perhaps joint compression is the key factor in preventing anterior translation of the tibia. More study is needed to support or refute these speculations. In addition, study of the electrical activity of the GM and the hip adductors is needed in various closed kinetic chain activities, since weakness of these muscles has been reported after knee injury and surgery.[18]

Large variations in individual recruitment patterns existed during the LSU, as revealed by the standard deviations. The coefficient of variation (SD/mean) ranged from 28.76% to 66.66% for Group 25% and 4.25% to 71.42% for Group 10%. Thus, individuals use different strategies or balance reactions, or both. Although posture, foot placement, and position of the held weight were closely monitored, large variations existed in recruitment patterns during LSUs. We conclude that the LSU is a complex exercise. Perhaps the relative magnitude of the differences between muscles is more valid and clinically relevant. Much more research is needed to determine the variation in muscle recruitment patterns for the same individuals on different testing days performing the same activity under very controlled research methodology.

VMO:VL Ratios

When the VMO electrical activity is greater than the VL electrical activity, the VMO:VL ratio is greater than 1.0. Conversely, when the VL electrical activity is greater than the VMO electrical activity, the VMO:VL ratio is less than 1.0. Thus, exercises that demonstrate VMO:VL ratios greater than 1.0 have been theorized as preferable to exercises with VMO:VL ratios less than 1.0 for patients with anterior knee pain.[11] VMO:VL ratios were greater only during MVIC testing for Group 25% in session 1 (Table 4, Figures 6 and 7). Also, the mean VMO:VL ratio varied between sessions for the same subjects performing the same activity. Thus, variability existed in VMO:VL ratios between testing sessions for the same individuals. As discussed previously, caution must be used in interpreting exact EMG VMO:VL ratios. MVIC and LSU conditions in this study demonstrated mean VMO:VL ratios greater than 1.0. VMO:VL ratios ranged from 0.41 to 11.43 in our asymptomatic population. Thus, our data refute the theoretical "normal" 1:1 VMO:VL ratio in asymptomatic subjects. Moreover, no difference existed between male and female recruitment patterns or VMO:VL ratios, which refutes the clinical assumption that females have lower VMO:VL ratios than males. More study is needed on a larger sample size before conclusions can be reached concerning what is a "normal" VMO:VL ratio. We were unable to locate literature that reported VMO:VL ratios during an LSU with or without resistance.

Clinical Relevance

The LSU exercise with or without resistance provides high levels of muscle recruitment for the VMO and VL muscles and low levels of muscle recruitment for the HS and GM muscles. Therefore, clinicians should use the LSUs for rehabilitation of the quadriceps, but not for recruiting (ie, strengthening) the HS and GM muscles. Other exercises, such as isolated knee flexion and hip extension in the open kinetic chain, selectively recruit these muscles more efficiently, as revealed by the MVIC data. Exercise selection for rehabilitation should be based on scientific data and not on anecdotal reports, in our opinion. Much more scientific work is needed to support our rehabilitation interventions.

CONCLUSIONS

Intrasession reliability was higher than intersession reliability. Similar conclusions, however, were reached regarding intrasession and intersession muscle activity for each group. No difference existed in EMG activity or VMO:VL ratios in males compared with females during any testing condition. VMO and VL recruitment increased during an LSU while holding weight, when compared with an LSU while not holding weight. Based on the results of our study, we conclude that the LSU primarily recruits the VMO and VL compared with the HS and GM and that VMO activity is greater than VL activity. VMO:VL ratios were greater during MVIC testing compared with LSU holding 25% weight in session 1. VMO:VL ratios ranged greatly, from 0.43 to 11.43 in this asymptomatic population. More research and study are needed concerning VMO:VL ratios in asymptomatic subjects and patients with anterior knee pain before valid conclusions can be reached. This study provides the scientific basis for the use of the LSU exercise in knee rehabilitation where the goal is to increase the recruitment of the VMO and VL muscles.

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The Use of Alcohol Among NCAA Division I Female College Basketball, Softball, and Volleyball Athletes

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Objective: To identify and describe alcohol use among NCAA Division I female college basketball, softball, and volleyball players and to determine to what extent the players have been exposed to alcohol or other drug education programs.

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

Subjects: NCAA Division I athletic trainers of ten female basketball teams, ten female softball teams, and eleven female volleyball teams received questionnaires. A total of 371 participants returned questionnaires: 106 basketball players, 138 softball players, and 127 volleyball players.

Measurements: After reviewing the related literature, I developed a questionnaire and pilot tested it with a group of female swimmers and track and field athletes. The questionnaire consisted of three sections: demographic information, alcohol use, and alcohol education. I analyzed the questionnaires descriptively (frequencies, percentages, and means) and collectively, on the total population, and separately, on all teams. To validate and further understand information gained from the questionnaires, I conducted multiple face-to-face interviews with forty (11%) of the participants.

Results: Almost 79% of the subjects consumed alcohol, with light beers being the most popular beverage. Most started using alcohol before 18 years of age. More softball (89.1%) and volleyball (88.9%) athletes reported drinking than did basketball (63.2%) athletes. Quantity and frequency of alcohol use decreased during the competitive sport season but increased out of season. Almost 60% (55.9%) of the participants engaged in binge drinking (defined as four or more drinks per drinking episode) out of season and 35% in season. Female athletes who lived off campus drank more frequently than those who lived in residence halls, but athletes living in residence halls reported drinking in larger quantities. The most common reasons subjects chose not to use alcohol included the effects alcohol has on health and sports performance, coaches' rules, dislike of the taste of alcohol, and concerns about weight gain. Those who chose to use alcohol did so mostly for social purposes. Most subjects received 4 to 8 hours of alcohol education in lecture sessions during their college careers. The majority wanted additional education, especially with regard to the effects of alcohol on sports performance.

Conclusions: Based upon the results of this study, alcohol education has little impact on alcohol use among NCAA Division I female basketball, softball, and volleyball players, particularly out of season. Most choose to use alcohol simply to have fun. Because alcohol affects athletic performance, female athletes tend to use less alcohol in season. Future studies should address the types of alcohol prevention and intervention methods used during out-of-season and in-season periods. Correlation studies should investigate relationships between these programs and alcohol use among female athletes. A broader population of athletes from various sports (eg, field hockey, golf, gymnastics, tennis, soccer, and swimming) should also be investigated.

Key Words: drugs, substance abuse, binge drinking

Previous studies have addressed the use of alcohol and alcohol-related behaviors of women of various ages and ethnic backgrounds.[1–5] However, limited research has been conducted on the use of alcohol by female college athletes.[6–11] The most recent 1997 NCAA Study[11] surveyed the use of alcohol and other drugs by 13,914 college athletes, of whom 4722 were females. The female athletes were from all three NCAA divisions. Unlike previous NCAA studies,[6–8] female participants represented a wide range of female sports, including basketball, fencing, field hockey, golf, gymnastics, ice hockey, lacrosse, skiing, softball, soccer, swimming, tennis, track and field, and volleyball. Of the total population (including male athletes), 80.5% reported the use of alcohol. None of the NCAA reports distinguished between male and female use of alcohol other than by sport. Athletes from NCAA Division I institutions (79.2%) reported alcohol use similar to that of Division II (79.7%) and Division III (82.6%) athletes.[11] To date, there have been no documented studies that examined alcohol use exclusively among Division I female college athletes. As more and more female athletes participate in organized sports programs and continue their sport experiences into the college level, information concerning this population's alcohol use and abuse will be beneficial in creating alcohol abuse prevention and intervention programs.

The study was proposed 1) to investigate and describe alcohol use among NCAA Division I female college basketball, softball, and volleyball athletes and 2) to identify the degree to which the subjects participated in alcohol or other drug education programs.

METHODS

To examine this issue, the study used a multi-method approach, combining self-reporting questionnaires and multiple face-to-face interviews. I designed a self-reporting questionnaire based on results of previous studies[6–9] and input from health education professionals and professionals in the fields of alcohol and other drug studies. To determine clarity of questions and time required to complete the questionnaire, I conducted a pilot test with 50 female track and field and swimming athletes. After the pilot test, I made changes in the questionnaires and sent them to certified athletic trainers of NCAA Division I female basketball, softball, and volleyball teams who competed against the University of South Carolina during the 1994–1995 sports season. Certified athletic trainers of the 21 participating teams received a total of 371 questionnaires. The certified athletic trainers distributed the questionnaires to the subjects who agreed to participate in the study. All of the participants returned the questionnaires. Questions on the survey addressed 1) quantity of alcohol consumption among female athletes, 2) frequency of alcohol consumption among female athletes, 3) types of alcohol used by female athletes, 4) differences in consumption of alcohol by school residence, 5) initial age of alcohol consumption, 6) reasons for using and not using alcohol, and 7) alcohol education received by female athletes.

I computed frequency distributions, collectively and separately, on all basketball, softball, and volleyball teams using SPSS-X software (release 2.0, Chicago, IL).

After the questionnaires were completed and returned, in order to validate and further understand information gained from the questionnaires, I conducted multiple face-to-face interviews with 40 participants (11%) in the study. I sorted, categorized, and interpreted qualitative data using an inductive mode of analysis (formation of subsuming categories of information from specific raw units of data) to establish the qualitative data analysis.

RESULTS

The certified athletic trainers returned the questionnaires that all 371 participants completed. Subjects included 106 (28.6%) basketball players, 138 (37.2%) softball players, and 127 (34.2%) volleyball players from across the southeastern, eastern, and midwestern regions of the United States. Participants ranged in age from 17 to 23 years, with a mean age of 19.5 years. With reference to ethnic background, 78% (n = 291) of the participants were white, 18% (n = 67) were African American, and 3% (n = 13) were from other ethnic backgrounds. Most participants (60.1%, n = 223) started in their respective sports and 55.8% (n = 207) had grade point averages of 3.0 or higher on a 4.0 scale. Most of the participants lived in residence halls (62.2%, n = 231).

Almost 80% (78.8%, n = 292) of the subjects used alcohol. The most common alcoholic beverage used was light beer (47.6%), followed by wine coolers (27.1%) and liquor (20%), such as vodka, rum, whiskey, and mixed-drink combinations. Fewer basketball players (63.2%, n = 67) used alcohol than did softball (89.1%, n = 123) or volleyball (88.9%, n = 113) players.

Initial Age of Alcohol Use

Most of the subjects who used alcohol began before age 18 (72.6%, n = 212), with a mean age of 16.1 years. Softball (76.4%, n = 94) and volleyball (76.1%, n = 86) players reported initial use of alcohol at a younger age (before age 18) than did basketball (62.1%, n = 42) players. The mean age for initial use was 15.8 years (SD 2.1) by softball players, 16.0 years (SD 2.2) by volleyball players, and 16.5 years (SD 2.1) by basketball players.

Frequency of Alcohol Use

Frequency of alcohol use decreased during the competitive sport season and increased out of season. During the competitive sport season, 5.5% (n = 16) of all athletes who used alcohol reported drinking more than once per week. Among volleyball players who used alcohol, 2.7% (n = 3) reported drinking more than once per week in season, as did 6% (n = 4) of basketball players and 7.3% (n = 9) of softball players.

When out of season, 17.5% (n = 51) of all subjects reported drinking more than once per week. Among basketball players who used alcohol, 11.9% (n = 8) reported drinking more than once per week out of season, as did 16.2% (n = 20) of softball and 21.2% (n = 24) of volleyball players.

Quantity of Alcohol Use

While in the competitive sport season, 35.3% (n = 103) of all athletes who used alcohol drank 4 or more alcoholic beverages per drinking episode (binge drinking).[12] While in season, volleyball players binge drank the least (28.3%, n = 32), followed by basketball players (31.3%, n = 21) and softball players (41.1%, n = 51).

Out of season, binge drinking increased from 35.3% (n = 103) to 56.2% (n =164) for subjects who used alcohol. Softball players had the highest rate of binge drinking (61.8%, n = 76), followed by basketball (44.8%, n = 30) and volleyball (39%, n = 66) players (Table).

Place of School Residency and the Use of Alcohol

Most of the female athletes in this study lived in residence halls (62.2%, n = 231). Almost three-fourths of the athletes living in residence halls (74.8%, n = 173) reported using

Binge Drinking (4 or More Drinks Per Episode)

Team	Number	Percentage
In Season		
Total	103	35.3
Basketball	21	31.3
Softball	51	41.1
Volleyball	32	28.3
Out of Season		
Total	164	56.2
Basketball	30	44.8
Softball	76	61.8
Volleyball	66	39.0

alcohol. Slighty over 74% (74.3%, n = 104) of the athletes who lived off campus reported drinking. Female athletes who lived off campus used alcohol more frequently but in less quantity than did those who lived in residence halls. Slightly over one-fifth (21.1%, n = 22) of the athletes living off campus reported drinking more than once per week, compared with 13.8% (n = 24) living in residence halls. Binge drinking (58.4%, n = 101) was higher among those female athletes living in residence halls than those living off campus (52.9%, n = 55).

Why Do Female Athletes Use Alcohol?

Using a 3-point Likert scale, (1= not important, 2= somewhat important, 3= very important), the questionnaire asked female athletes to rank why they did or did not choose to use alcohol. Most female athletes (92.6%) felt that the effects alcohol has on their sports performance was a somewhat or very important reason why they chose not to drink. The second most common reason not to drink was the effects alcohol has on general health (89.1%). The athletes also included their coaches' rules about alcohol use (79.4%) and concerns about weight gain (52.1%).

When asked why they chose to drink, most athletes reported that drinking for social reasons (73.3%) and the fact that alcohol made them feel good (67.3%) were either somewhat or very important.

Alcohol Education

Most NCAA Division I female basketball, softball, and volleyball athletes (85%) participated in some type of alcohol education program during their college careers. Subjects described the programs as either single lecture (41.8%) or multiple lectures (27.8%). Single lectures were those requiring the team to listen to a speaker on a one-time basis. This type of program was usually conducted at the beginning of the academic year. The athletic department invited a professional speaker to meet with the athletes, coaches, and staff. There was usually no followup program to this session. Multiple lectures incorporated various types of sessions throughout the academic year and most often out of season. These sessions were often more holistic as various issues were presented: alcohol and performance, use of anabolic steroids, use of weight loss products, sports nutrition, and stress management. The mean education contact hours subjects received throughout their college careers was 8.75, although not all hours involved alcohol education.

DISCUSSION

Although previous studies have explored the issue of alcohol use among college athletes,[6–9,11] because of differences in sampling techniques and methods of inquiry, those results are not directly comparable with the results of this study. In addition, no previous documented studies exclusively address the issue of alcohol use by Division I female college athletes who participate in the sports of basketball, softball, and volleyball. NCAA studies[6–8,11] addressed the use of alcohol among both male and female college athletes from all three NCAA divisions. The first three NCAA studies[6–8] included the women's sports of basketball and softball but not volleyball. It was not until the most recent 1997 NCAA study[11] that volleyball and other female sports were included. The NCAA studies reported differences in the use of alcohol by sex only as it related to a particular sport.

Of the three sports addressed in this study, basketball players reported using alcohol less frequently than did softball or volleyball players, but reported the second highest incidence of binge drinking. In the 1997 NCAA[11] study, fewer basketball (78.5%) players used alcohol than did female volleyball (81.9%) or softball (81.4%) players. Previous research[11,12] indicated that African American females do not start using alcohol in quantities and frequencies comparable with white females until their mid twenties. In this study, the percentage of African American athletes was higher in basketball (47.2%) than in softball (4%) or volleyball (11%). All female athletes in this study were 23 years of age or younger. This difference in alcohol use among basketball players as compared with softball and volleyball players may be related to the ethnic makeup of basketball teams and the traditional drinking patterns found in the African American female culture.[3]

In addition to the different ethnic composition of basketball teams, qualitative data indicated that many female softball and volleyball players believe basketball players drink less due to the physical demands of basketball. Softball and volleyball players perceive the aerobic requirements of basketball as being quite demanding. Also, college basketball has a competitive season longer than that of softball or volleyball and requires more in-season time. Since basketball players have less off-season time and more holidays during their competitive season (Thanksgiving, Christmas, and for some teams, spring break), perhaps this is a reason for their less frequent use of alcohol.

Qualitative inquiry indicates that many female athletes believe that their athletic and academic schedules provide less opportunity to drink than their nonathlete peers' schedules do. In season, most female athletes drink less than once per week, while their nonathlete peers drink two or more times per week.[13] Female athletes drink less in season, but they engage in more binge drinking out of season. Forty-two percent of all college students report binge drinking,[13] while nearly 47% of college athletes who use alcohol (88.2%) binge drink. A University of Massachusetts study[13] reported that 50% of all college students drink to get drunk. Thirty-five percent of female college students report binge drinking throughout the year.[13] About 56% of female basketball, softball, and volleyball athletes binge drink out of season, a period that ranges from 6 to 8 months.

As reported in previous studies,[6–9,11] athletes used alcohol more often and in larger quantities out of season than in season. Female athletes also reported drinking in cycles. They drink more on weekends and out of season. In contrast with the results of previous studies on college students, the results of this study indicate that female athletes no longer wait until the weekend to binge drink, but are likely to do so any night or several nights of the week. Among general college students, both quantity and frequency of drinking have increased.[13,14]

Why do female athletes drink less frequently, but in similar or in greater quantity, than their nonathlete peers? Many female athletes see their athletic participation as a full-time job, and during the season this job becomes quite demanding.[15] A Commission on Alcohol and Substance Abuse (CASA)[14] study found that 70% of college students with full-time jobs reported less frequency and quantity of drinking than did students without full-time jobs. A second reason for the limited use of alcohol by female athletes during the season is that they seem to know the effects of alcohol on sports performance and choose moderation in quantity and frequency during this period. In this study, nearly 90% chose not to use alcohol because of its effects on sports performance. A third reason for alcohol nonuse is coach's rules against alcohol use during the competitive season. Female athletes know that, to keep their athletic scholarships, they must remain in good standing with the coach. Breaking the coach's rules for any reason may jeopardize their scholarships and keep them from attaining a college degree.

There is concern that intensive athletic training and the keen competition of college sports may be related to increased alcohol use among athletes. Tricker and Cook[16] refer to the environment of college athletics as the "fishbowl" experience. The "fishbowl" describes athletes as a special population, living and participating in highly charged, intense, and publicly exposed environments. While in this environment, athletes must deal with public scrutiny, media attention, and intense societal focus that often put them at greater risk for alcohol and drug use.[16] However, in this study, the number one reason for the use of alcohol was for social purposes. The 1993 and 1997 NCAA studies[6,11] and a study conducted by Selby[17] concurred with this study: that athletes attribute relatively little alcohol use to coping with college or athletic stress. Similar to the behavior of athletes in the NCAA studies, NCAA Division I female college basketball, softball, and volleyball athletes do not use alcohol to combat or cope with stress associated with being a college student-athlete. Indeed, if they were using alcohol as a coping mechanism for stress, then what could explain the more frequent and greater quantity of alcohol use during the off season?

No previous studies exist concerning differences in alcohol use among athletes who live in residence halls compared with those who live off campus. This study found that female athletes who live in residence halls drink less frequently but in larger quantities, which could be due to alcohol use rules in residence halls. Many colleges do not permit the possession or use of alcohol in dormitories; thus, there is less likelihood of alcohol in a dormitory room than in an off-campus apartment. The use of alcohol for those athletes who live in residence halls is less convenient, which in turn decreases the frequency of their drinking. In addition, athletes who live in residence halls tend to be younger. Many colleges require or encourage freshmen to live on campus the first year. The younger the college student, the greater the risk of binge drinking.[9,13] In fact, 57.6% of all 18- and 19-year-old athletes in this study reported binge drinking, compared with 52% of the 20- and 21-year-olds.

Eighty percent of college athletes who use alcohol began drinking while in junior high or high school.[6] Almost three-fourths of the female athletes in this study who use alcohol began before entering college. Of the 371 participants in this study, 79 did not use alcohol and 23 started using alcohol after age 18. Approximately 21% of these women were nondrinkers or did not begin drinking until after entering college. Alcohol abuse prevention education should be targeted at those athletes who have not started drinking. Alcohol use surveys can be used to help develop prevention and intervention programs.

Nearly all of the female athletes in this study had participated in some type of alcohol education program. Decreased frequency and quantity of drinking during the competitive season indicated that they understood and respected the negative effects of alcohol on sports performance while they were competing. Unfortunately, this knowledge had little impact on their off-season behavior, a time when 56% engaged in binge drinking. Indeed, most female athletes reported that what education they received had little impact on their behavior, particularly when they were not competing.

CONCLUSIONS

As Title IX continues to make an impact on women's sports programs, more females will participate in sports at all levels. With this increased participation will come a more diverse group of athletes, with diverse behaviors involving the use of alcohol and other drugs.

Decreasing the use of alcohol among female college athletes is a challenge. Female athletes reflect the views and practices of the larger college population, which regards the use of alcohol as an acceptable and often promoted practice. Results of this study indicate that these female athletes are aware of the short-term impact of alcohol on sports performance but seem less aware of the overall long-term effects. Certified athletic trainers, coaches, administrators, and health care professionals need to continue their efforts to develop and deliver alcohol prevention and intervention programs to athletes. A one-shot educational program is as effective as one practice before the competitive season. These programs should be integrated throughout the career of the student-athlete in a series of programs addressing concerns such as the effects of alcohol on motor performance, cognition, and affective behavior.

Since more female athletes engage in drinking during the off season, these programs should be offered during this period. The off season provides more time to promote and engage in educational and intervention activities than the competitive sport season.

As female athletes have more opportunities to compete in competitive sports programs, they should also have the opportunities and tools to develop an understanding and acceptance of how practicing good health habits can enhance their sports and academic performance, thus making their college experience more successful.

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Pneumomediastinum in a Female Track and Field Athlete: A Case Report

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Objective: To present the case of an elite female track and field athlete who suffered a pneumomediastinum resulting from a Valsalva maneuver performed while throwing the javelin.

Background: Episodes of chest pain and labored breathing in athletes may be alarming. Accurate, early diagnosis is enhanced by an awareness of those relatively rare conditions that may cause these symptoms.

Differential Diagnosis: Bronchial injury/fracture, retropharyngeal abscess, acute pulmonary disease, pneumomediastinum, pneumothorax, cardiac disease, allergic reaction.

Treatment: The athlete was given intravenous morphine for pain, prescribed oral pain medication, and restricted from strenuous activity for 6 weeks. Aerobic exercise was allowed after pain and air in the neck subsided, which was estimated at 1 week postinjury.

Uniqueness: This is a rarely reported case of a pneumomediastinum in a female and a track and field athlete.

Conclusions: Medical personnel must be aware of the possibility of pneumomediastinum in track and field athletes and in female athletes and must be knowledgeable in the followup care and the safe return of the athlete to activity.

Key Words: subcutaneous emphysema, subcutaneous air, Valsalva maneuver

Pneumomediastinum is a rare complication of athletic activity. Although the Valsalva maneuver (forced expiration against a closed glottis) occurs frequently in athletic exertion, a pneumomediastinum rarely results.[1] Pneumomediastinum occurs when alveoli surrounding a blood vessel rupture, allowing air to escape the lungs and travel along the vessels and bronchi to the mediastinum.[2,3] Few cases have been reported in medical journals. Various reported non-sports-related causes are motorcycling,[4] vehicle accidents,[5] childbirth,[2] mechanical ventilation,[2] cocaine inhalation,[6] marijuana smoking,[7] and a medical procedure to restore pressure balance in a patient with middle ear disease.[8] Most sports-related cases involve contact sports, high altitudes, or underwater activities, including rugby,[1] football,[9] soccer,[9,10] swimming,[10,11] scuba diving,[12] surf lifesaver training,[13] fast bowling in cricket,[14] tennis,[11] weight lifting,[11] and mountain climbing.[15] Pneumomediastinum in association with athletic exertion has been reported exclusively in healthy young males. For the most part, pneumomediastinum in females has been reported only as a complication of childbirth.[2]

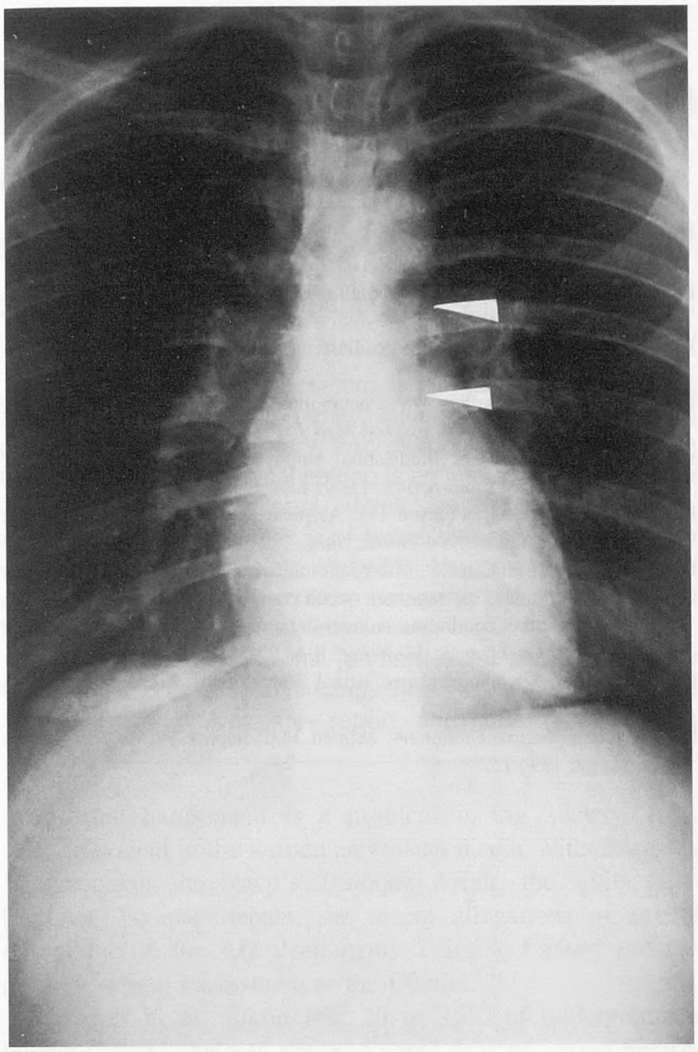
CASE REPORT

A 24-year-old Caucasian female elite track and field athlete complained of neck and chest tightness after throwing the javelin in a national track and field championship. This was associated with labored breathing and difficulty swallowing. Her teammates noticed that her neck was swollen. On-site medical personnel were concerned about the athlete's chest pain and difficulty breathing; she was sent to a local hospital, where she was admitted to the emergency department.

Physical examination revealed crepitus and tenderness in the neck. Her voice was hoarse. The patient's chest was not tender, and her lungs were clear. Cardiac examination revealed a mediastinal "crunch." Posteroanterior, anteroposterior, and lateral chest x-rays revealed subcutaneous air in the neck tissue and an outline of the descending aorta of the heart, as shown in the Figure. A barium study ruled out esophageal rupture. A fiberoptic bronchoscopy was performed to check for bronchial injury or fracture. The vocal cords and trachea appeared normal, and there was no evidence of any trauma to the bronchial trees. A drug screen was not conducted during this hospital visit.

The diagnosis was pneumomediastinum with subcutaneous air, most likely due to performing the Valsalva maneuver while throwing the javelin. The athlete was given intravenous morphine for pain relief. She was prescribed oral pain medication and released from the emergency room to the care of her family. She was instructed not to lift, grunt, or strain for 6 weeks. She was given permission to begin aerobic exercise once the pain and air in her neck subsided, which was predicted to take approximately 1 week.

Upon returning to her hometown, the athlete consulted a second physician, who concurred with the diagnosis made in the emergency room and gave more detailed recommendations for followup care and strenuous physical activity. This physician advised that cardiovascular exercise could begin at approximately 6 weeks postinjury and that light weight training



This posteroanterior radiograph shows subcutaneous air outlining the descending aorta of the heart, which is characteristic of pneumomediastinum.

could also begin at that time if the pain was minimal. The athlete was advised to gradually resume her regular weight training and exercise routine after the 6-week period, using pain as her guide to determine intensity. In addition, radiographs were taken to confirm healing and air resorption, and a CT scan was taken to insure that no permanent damage had occurred. A third physician was consulted on the recommendation of the second doctor; however, no new information was obtained and the treatment protocol remained the same.

During the first month after the injury, the athlete experienced pain with deep breaths and significant loss of energy and strength. At 5 weeks postinjury she began light stationary cycling but found that sit-ups and weight training were painful. After 2 months, light weight-training exercises, such as back rows and latissimus dorsi pull-downs, were started at low resistance and high repetitions. Finally, at 3 months postinjury she resumed her full exercise routine, including squats, cleans, and other heavy lifting, as well as treadmill and stationary cycling, without symptoms. Her only physical limitations were the inability to yell comfortably during her throwing and minor discomfort when sneezing. Sneezing has been documented as a primary cause of pneumomediastinum.[16]

Although she resumed training and remained asymptomatic, fear of reinjury presented psychological obstacles during her throwing and training. Unfortunately, the risk of injury recurrence is undocumented and unpredictable; therefore, it was difficult to communicate appropriate reassurances to the athlete.

DISCUSSION

Pneumomediastinum can be caused by many different factors. Among those noted are asthma, coughing, vomiting, and, as in most cases associated with athletics, performing the Valsalva maneuver.[2,5,7] When free air builds up in the mediastinum after alveoli rupture, air can escape into the subcutaneous tissues of the entire body,[2,3] an occurrence known as subcutaneous emphysema. Subcutaneous air in association with pneumomediastinum has been reported in the neck, chest, face, abdomen, mouth, axilla, scrotum, and back;[2,3] however, this air alone does not present any serious health threats. Pneumomediastinum may also be accompanied by pneumothorax, a much more serious complication involving air in the pleural space, which may lead to collapse of the lung.[2] Nonetheless, the subcutaneous air will create significant pain and discomfort for the patient and should be treated with respect.

The diagnosis of pneumomediastinum can be made by identifying key symptoms and on clinical examination. The most common symptom of pneumomediastinum is substernal or precordial chest pain, which may radiate to the back, neck, or shoulders.[2,5,11] This can be accompanied by labored breathing, difficulty swallowing, and hoarseness of the voice (dyspnea, dysphagia, and dysphonia, respectively).[2,5,11] Clinical evaluation includes physical examination and radiographic analysis. Physical examination may reveal a mediastinal "crunch," also known as Hamman's sign. Hamman's sign is described as a crackling or crunching sound, much like that of bubble wrap or tissue paper, which is synchronous with systole of the heart.[17,18] Furthermore, breath sounds will not present definitive signs; however, incomplete breaths may indicate a potentially related and significant pneumothorax. The most important factor in diagnosing pneumomediastinum is radiographic analysis. Free air in the mediastinum is seen as a radiolucent line around the cardiac border on posteroanterior chest radiographs; mediastinal air may also outline the aorta.[2] Subcutaneous emphysema may also be noted in surrounding tissues, most often the neck soft tissue.[5]

The fear of injury recurrence presents significant psychological implications when the athlete attempts to return to training and strive for preinjury competitive status. Longitudinal followup of this case must be encouraged, and similar cases must be documented and reported to provide adequate data on which an accurate, realistic prognosis can be based.

CONCLUSIONS

This is the first reported case of pneumomediastinum in a female or a track and field athlete. Previous case reports have indicated that, in an athletic setting, pneumomediastinum occurs only in young males. Most sports-related cases have also been limited to the performance of the Valsalva maneuver under heavy duress, such as weight lifting, or during participation in contact sports. Track and field events should be added to this list of possible sources of pneumomediastinum. Female athletes may also be at risk for this injury.

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Sexual Harassment: A Concern for the Athletic Trainer

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Objective: Sexual harassment is a vital social issue that affects the business community, educational institutions, and personnel in the U.S. military. Addressing sexual harassment in the athletic training clinical setting is an important issue for the athletic training professional. Athletic trainers need to understand the complex definitions of sexual harassment and how to identify and handle claims of sexual harassment in order to prevent sexual harassment from occurring and to prevent civil lawsuits of alleged sexual harassment.

Background: Professional journals, legal textbooks, policy handbooks, unpublished findings from the NATA Women in Athletic Training Committee report, and current news media sources were used to gain a greater understanding of this social problem.

Description: To make the athletic trainer aware of this important social issue and to offer suggestions for the athletic training staff to aid in preventing problems of sexual harassment.

Clinical Advantages: This article provides definitions and examples of sexual harassment, discussion of policy development, and suggestions for ways to eliminate sexual harassment in the athletic training environment.

Key Words: preventing sexual harassment, policy development, legal issues, interpersonal relationships

Sexual harassment is a problem in our society. It is prevalent in the written and visual media, with examples such as the Navy's Tailhook Affair, the Anita Hill-Clarence Thomas debate, the recent allegations of sexual misconduct at the Aberdeen Army Training Center, and the cases of sexual harassment at the Citadel.[1–6]

Williams et al[7] found that 20 to 30% of undergraduate female college students reported some type of sexual harassment. In a 1993 study, the American Association of University Women[8] indicated that 85% of girls and 76% of boys in grades 8 through 11 have experienced some form of sexual harassment. In addition, the study pointed out that 65% of girls and 42% of boys have been touched, grabbed, or pinched in a sexual way in school.[8]

Sexual Harassment in Athletic Training

While the media focuses on sexual harassment in business, education, and the military, sexual harassment must be a concern for the athletic trainer in the athletic training clinical setting as well.[9,10] At least two certified athletic trainers have filed sexual harassment allegations against employers in Tennessee and Georgia.[9,11] Three recent studies involving both male and female certified athletic trainers looked at the problems of sexual harassment and sex-related issues. In one study, 100 college and university athletic trainers were selected at random from states in the southeastern region of the United States. This study found that 25% of the respondent population (both male and female athletic trainers) perceived or experienced sexual harassment of one type or another.[4] Another study, conducted by the NATA Women in Athletic Training Committee, found that 37% of the female athletic trainers surveyed reported sexual harassment (NATA Women in Athletic Training Committee, unpublished data, June 1996). A separate study by this same committee found that 40% of males surveyed perceived that female athletic trainers were sexually harassed. (NATA Women in Athletic Training Committee, unpublished data, June 1997).

Sexual Harassment Defined

Various studies have characterized the process of defining sexual harassment as complicated and confusing because there is no common definition broad enough to cover the wide range of occurrences that make up sexual harassment behavior.[5,12–18] Bursik[12] reported that one problem in defining sexual harassment is that definitions of the term are usually from the victim's perspective and differ from situation to situation. Rubin and Borgers[18] concluded that a "clear definition of sexual harassment has yet to be commonly accepted." Stein[19] reported in 1995 that "sexual harassment, when it occurs in schools, is unwanted and unwelcome behavior of a sexual nature that interferes with the right to receive an equal education opportunity. It is a form of sex discrimination that is prohibited by Title IX."[19]

The Equal Employment Opportunity Commission (EEOC) has defined sexual harassment as "unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature."[20–22] Examples of how sexual harassment can be further defined are shown in Table 1. Included in the EEOC guidelines are references to Title VII of the Civil Rights Act of 1964, Title IX of the Education

Table 1. Equal Employment Opportunity Commission Definition of Sexual Harassment[21]

Behavior	Example
Unwelcome sexual advances	Submission to such conduct is made explicitly or implicitly a term or condition of an individual's employment
Requests for sexual favors	Submission to or rejection of such conduct by an individual is used as a basis for employment decisions affecting such an individual
Verbal or physical conduct of a sexual nature	Conduct has the purpose or effect of unreasonably interfering with an individual's work performance or creating an intimidating, hostile, or offensive working environment

Amendments of 1972, and the Civil Rights Act of 1991, which are all federal statutes under which the majority of sexual harassment complaints against higher education institutions and their employees have been brought to the attention of the courts.[13,14,21,23,24]

To further clarify, sexual harassment can be subdivided into two categories that the courts have used in developing guidelines against sexually harassing behaviors.[5,23] The first is quid pro quo harassment in which an employer or supervisor will offer an employee/student a benefit (salary increase, job, promotion, passing grade) in exchange for sexual favors. The other category is the hostile or offensive working environment, in which there are no benefits offered for the return of sexual favors, but rather the victim is mistreated on a daily basis. This mistreatment may be in the form of subjection to blatant posters or pictures of a sexual nature, constant jokes, stories of a sexual nature, or constant attention given to the victim.[1,5,8,23,25–27] This constant attention can take the shape of physical or verbal abuse.[4,5,8,23,25]

To summarize, although sexual harassment is currently defined by law and in policy by institutions of higher education, the definition will continue to be influenced by the courts and by further studies. In addition, perceptions of sexual harassment will continue to be influenced by a person's sex and by our society.[8,12,16,27] At present, women perceive sexual harassment more than men do, as a result of their experiences and as a result of their education by other women who have been sexually harassed.[4,6] Few men have experienced sexual harassment, and, thus, they tend to be less aware of the problem of sexual harassment than women are.[4,6] As more men experience sexual harassment, their awareness and perception levels will increase. It will be important to continue redefining sexual harassment in both business and educational institutions in the years to come.

Because sexual harassment is a complex issue, this article will address a) the definitions of sexual harassment, b) the nature of sexual harassment, c) sexual harassment and consensual relationships, d) steps to eliminate sexual harassment, e) procedures for dealing with sexual harassment, and f) sexual harassment policy development.

The Nature of Sexual Harassment

The nature of sexual harassment is complex and filled with examples that further define the term. Sexual harassment can include any form of physical assault. Assault in this sense may include any physical touching of any kind, sexual in nature or not. Any type of direct or implied threat that submission to sexual advances may favorably affect employment, work status, promotions, grades, or letters of recommendation or that

Table 2. Sexual Harassment by Various Groups or Individuals[21]

Type of Harassment	Behavior
Peer harassment (student athletic trainer to student athletic trainer or other similar-age individuals)	Physical or verbal abuse to classmates or same-age individuals. Adolescent teasing, taunts, or spreading of false rumors.
Group harassment (members of an elite group of students or team)	Verbal or physical abuse of an individual by a select group or members of a team. This may be based on an individual's sexual preference (gays or lesbians) or personal beliefs.
Adult to student (athletic trainer-student athletic trainer)	A supervisor or head athletic trainer uses the position of power to sexually harass a student under his or her supervision or care.
Student to adult (student athletic trainer-athletic trainer, or what is called contrapower harassment)	Physical or verbal abuse upon the supervisor or athletic trainer. This type of harassment may occur when a student or athlete takes advantage of an inexperienced (young) female or male supervisor/athletic trainer. This may take place as a sexual assault or rape upon the female victim or sexual advances to a male victim.
Adult peer (or colleague) harassment	Similar to student peer harassment. In this case adults of equal positions of employment or power are responsible for the sexual harassment. In addition to the taunts, innuendoes, and sexist remarks, there may be unwelcome sexual advances.
Administrator-subordinate harassment	A supervisor or head athletic trainer uses the position of power to verbally or physically abuse a member of the staff.
Subordinate-administrator harassment (contrapower harassment)	Continual covert sexual advances or physical/verbal abuse upon the supervisor or head athletic trainer.

rejection of sexual advances may negatively affect the same would constitute sexual harassment. Any direct propositions of a sexual nature or subtle pressure for sexual activity, one element of which may be conduct such as repeated or unwanted staring, would all fall in the category of sexual harassment. A pattern of conduct (not legitimately related to the subject matter of the course involved or to employment if employment is involved) that tends to bring discomfort and or humiliation, which may include comments of a sexual nature, sexually explicit jokes, statements, questions, or anecdotes, may be viewed as sexually harassing. Actions such as unnecessary touching, patting, hugging, or brushing against a person's body; remarks of a sexual nature regarding a person's clothing or body; or remarks about sexual activity or speculation about previous sexual experience may bring discomfort or humiliation to a reasonable person at whom the conduct was directed.[12,13,17,28]

Sexual harassment can occur in various ways and by different groups or individuals.[12,13,15,21,22,24,28] For purposes of discussion, Table 2 illustrates the definitions used by the EEOC to identify the ways various groups and individuals can sexually harass others.

Sexual Harassment and Consensual Relationships

Adding to the controversy surrounding sexual harassment is the issue of relationships between staff members and supervisors. An example would be an assistant athletic trainer who is having an affair with the head athletic trainer, who determines whether the assistant receives a promotion or salary increase. Although both individuals are engaged in a consensual relationship, coworkers who do not receive the same benefits, promotions, or salary increases may allege that the benefits were received based on the relationship and not on job performance. This creates a hostile environment in which the "victim" perceives that he or she must engage in a sexual relationship with the supervisor to receive the same benefits.[20] A further complication to the consensual relationship issue are the claims of sexual harassment once the relationship is ended. Pichaske[29] discussed the implications when a consensual relationship turns hostile and charges of sexual harassment are made. This form of relationship is dangerous because, if the relationship ends, charges of sexual harassment could be made against either party.[4,29]

Why Athletic Trainers Should Be Concerned About Sexual Harassment

Athletic training facilities are areas where athletes receive therapy or treatments in various stages of undress, which can create opportunities for inappropriate behavior from the athlete who is the patient or from the person providing the treatment. Recently an athletic trainer reached a settlement with her university employers over a sexual harassment issue.[10] An additional concern for our profession is the fact that supervising athletic trainers will be expected to provide a safe environment in which student athletic trainers, athletes, and other staff athletic trainers can work without the threat of harassment, whether it is of a sexual nature or not.[3,4,6,25] In addition, athletic trainers need to insure that comments, jokes, conversations, and any type of physical contact with student athletic trainers, staff athletic trainers, and athletes are not perceived as offensive or unwelcome.[4,6,25] Many times professional staff members or students fail to draw the line of respectability when engaged in jokes, stories, or conversations that may contain inappropriate language.[3,4,6] Inappropriate behavior may be perceived as sexually harassing in nature if an individual feels uncomfortable or embarrassed about the content of the conversation or any related physical contact.[12,23,30–32] Furthermore, misunderstandings do arise: comments, conversations, or incidental physical contact by athletes, student staff, or professional staff members, which were not meant to be sexually harassing, may be perceived as such. Failure to provide a safe environment free from sexually harassing behavior of any type (from athletes or staff) may result in allegations of sexual harassment, possible disciplinary action, civil lawsuits, and termination of employment.[5,9,10,13–29,31,33]

Staff athletic trainers, students, and athletes have the expectation of an environment free from harassment of a sexual or nonsexual nature.[4,6,9,10] The athletic training room is a healthcare setting in which the certified staff and student staff members are expected to act with the utmost professionalism. Interestingly enough, many previous studies of sexual harassment issues identified administrators or supervisors as the initiators of sexually harassing behavior, but a number of new studies have identified colleagues-associates and students as the responsible parties causing sexually harassing behavior.[4,6,15,28,31]

Steps To Eliminate Sexual Harassment

Athletic trainers need to be aware of ways to eliminate sexually harassing behavior before it becomes a problem in the athletic training room or athletic training clinical setting. Methods include establishing an institution-wide policy defining sexual harassment and disseminating information regarding the policy and the disciplinary actions that will be taken if the policy is violated. Also, there are times when jokes, stories, and comments are perceived as being sexual in nature and may be offensive and unwelcome. If and when blatant incidents like these occur, the athletic trainer or a staff member should take steps to correct the situation; inaction sends a signal that the offensive behavior is acceptable.[13,15,18,22–24,28,30] Failure on the part of the athletic trainer or athletic training staff to correct a blatantly offensive act may create a hostile environment. Sometimes a simple verbal statement, such as informing the individual that such language or comments are inappropriate and will not be tolerated in the training room, may be enough to enforce the policy.

Student athletic trainers and athletic training staff must be informed about the sexual harassment policy if compliance is to be achieved. The policy must be strongly worded to include the definitions of sexual harassment and to clearly state that this type of behavior will not be tolerated. In addition, the issue of prohibiting or condoning consensual relationships between supervisors and coworkers should be addressed.[29] Communicating this policy and the procedures for reporting sexual harassment can be done in various ways (Table 3).[18,21] Because it is possible that a person who has been harassed may not remember that such a policy exists or where it can be found, the policy should be posted in a number of places, all of which are accessible to everyone.[5,19,21]

Procedures for Dealing with Sexual Harassment

Formal and informal procedures should be developed to allow resolution of sexual harassment problems.[21,26,33] The formal procedure is a defined process of disciplinary action leading to a documented end, such as termination of employment or advancement to a civil lawsuit. This procedure requires the individual making the claim of sexual harassment to file a formal complaint with the appropriate individual in charge of such complaints, and then a formal hearing is held. An informal procedure is a process that allows either party to stop the proceedings and reach a resolution to the issue that satisfies all involved parties, which may include an apology to the victim or a meeting to discuss the behavior that was perceived as sexually harassing. Athletic trainers should investigate to see if a procedure has already been established by the business or institutional human resources office or affirmative action office. In the athletic training room or clinical setting, this type of procedure may allow resolution of a sexual harassment claim.

Regardless of the involvement of the athletic trainer, the informal and formal procedures should be consistent with the overall institutional sexual harassment policy statement in outlining the process for reporting an alleged incident of sexual harassment and resolving the problem. The handling of a sexual harassment allegation should incorporate the institution's internal grievance procedure for promotion and for termination of disputes.[21,26,33]

Table 3. Methods For Communicating Sexual Harassment Policies

Handbooks for employees, athletic training staff, student athletic trainers, and athletes
Athletic training room procedural handbooks
Employee/student athletic trainer and student-athlete orientation sessions
Posting in accessible areas located in or near the athletic training room (all restrooms, lounge areas, and locker rooms)

Sexual Harassment Policy Development

Many athletic trainers are unaware of a sexual harassment policy at their business or institution.[4] A recent study of athletic trainers and sexual harassment issues found that only 67% of athletic trainers surveyed knew of a sexual harassment policy at their institution.[4,6] Fourteen percent were uncertain if such a policy existed at their institution.[4] In addition, of those athletic trainers reporting the existence of a sexual harassment policy, 24% were unaware if it was a departmental policy or an institutional policy. Fewer than 50% of those who had such a policy understood its contents.[4]

These findings raise serious questions that need to be addressed by administrators and athletic trainers. If your institution does not have a sexual harassment policy, are you leaving the door open for future civil liability? If your institution does have a policy, is it understood by those in supervisory roles? Is the policy being disseminated to all employees and staff?

Athletic trainers themselves may not need to develop written policies on sexual harassment. Most educational institutions and businesses have an affirmative action office or human resources office that is charged with knowing the law and enforcing the sexual harassment policy. Athletic trainers should work closely with the individuals in these offices to see that their athletic training rooms or clinical settings are complying with the law.

Policies and procedures for dealing with the problems of sexual harassment must be effective both in handling situations in which sexual harassment is alleged and in preserving the rights and privacy of both the accused and the accuser to the extent allowed by the law.[17,19,21,22,24] For those athletic trainers who may need assistance in developing a policy, the following sample policy statement is provided to indicate the level of commitment an educational institution should have to treat sexual harassment as a serious issue:[18,25]

"The University of (institution's name) in its efforts to foster an environment of respect for the dignity and worth of all members of the University community is committed to maintaining a work-learning environment free of sexual harassment. It is the policy of the University that no member of its community shall sexually harass another. Any employee or student who violates this policy is subject to disciplinary action. The University administrative officers are directed to take appropriate steps to disseminate this policy statement to inform students and employees of procedures for lodging complaints. The University shall fully retain all rights to discipline or discharge any employee or student who engages in misconduct or other behavior which is prohibited by law or other University policy."[22]

A policy should be strongly worded to include both the institutional definition of sexual harassment and the clear message that this behavior is unacceptable and will not be tolerated.[17,18,21,22,33] Definitions such as those developed by the EEOC are acceptable for use, or the institution may wish to define sexual harassment according to its own needs. Once a

Table 4. Clinical Site Self-Evaluation for Addressing Sexual Harassment*

Does your institution or clinical setting have a policy unequivocally prohibiting sexual harassment?	YES	NO
Does your institution or clinical setting have a sexual harassment grievance procedure that is well publicized, easily accessible, and included in the staff/student handbooks?	YES	NO
Does your institution or clinical setting provide professional training for the person responsible for implementing and investigating allegations of sexual harassment?	YES	NO
Is this person well informed regarding the basic requirements of the federal and state laws dealing with sexual harassment allegations?	YES	NO
Is this individual trained to deal sensitively with the needs and difficulties of individuals making claims of sexual harassment?	YES	NO
Does your institution or clinical site conduct workshops for staff and student employees to increase awareness of these policies and procedures?	YES	NO
Do workshops provide concrete information concerning the nature of hostile environments and contrapower sexual harassment?	YES	NO
Is there a policy regarding consensual relations between staff members and an acknowledgment that there is a possibility that a consensual relationship that sours could spawn sexual harassment allegations?	YES	NO
Are policies followed when an individual lodges a sexual harassment complaint?	YES	NO

* NO answers to any of the questions indicate an area of potential risk.

policy has been developed, it must be universally adopted and disseminated to all students, employees, and staff.

Meeting the Challenges of Sexual Harassment

Athletic trainers and clinic and university administrators who are in the business of providing athletic training services to athletes or who employ athletic training personnel (both staff and students) should examine carefully and understand completely their institution's sexual harassment policy and the procedures for resolving allegations. If inservice programs to educate those in the athletic health care setting are not currently available, they should be developed.

In addition, the athletic training environment should be assessed to determine whether or not an atmosphere of sexually harassing behavior (or behavior that may be misinterpreted as sexually harassing) exists. This environment will also need to be evaluated to determine if a pattern of sexually harassing behaviors has been allowed to permeate the clinical setting.[13,26,33] This pattern, if it exists, would lead to identification as either a hostile or offensive working environment, or quid pro quo harassment.[5,8,12,19,21,22] Lastly, when the athletic trainer or staff member observes a clearly and blatantly offensive act or verbal comment, the offender should be immediately corrected and the message conveyed that such behavior will not be tolerated.

Athletic trainers will need to see if they, their institutions, and their clinics are taking the measures necessary to insure that staff athletic trainers and student staff members are free from a hostile work environment. Table 4 presents a self-evaluation to see if your institution or clinical site deals properly with the issues of sexual harassment. Athletic trainers should also see that blatant examples of sexually harassing behavior in the athletic training room are corrected. It must be obvious that such inappropriate behavior will not be tolerated. Finally, athletic trainers ought to understand that the issue of sexual harassment is not excluded from the athletic training setting, will not likely go away, and, therefore, must be dealt with through education and policy enforcement.

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1998 REQUEST FOR PROPOSALS

NATA RESEARCH & EDUCATION FOUNDATION

The NATA Research & Education Foundation is pleased to announce that $130,000 is available in 1998 for Research and Education Grants. Priority consideration will be given to proposals which include a certified athletic trainer as an integral member of the research or project team.

Research Grants

No. of Awards:	Multiple awards are available
Available:	$110,000 total, no minimum or maximum dollar amounts for individual grants
Deadlines:	March and September 1
Notification:	July and February

I. General Grants

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

II. Pediatric Sports Health Care

The Foundation encourages research studies that will have clinical relevance to the development of the pediatric athlete, and the prevention, treatment and rehabilitation of injuries sustained by the physically active pediatric participant. A great need exists for epidemiologic studies to determine pediatric injury patterns and specific populations at risk.

Background

Very little experimental evidence concerns the impact of physical activity upon the general development of the child. The recent, tremendous growth of children's participation in organized sport has outpaced efforts to clearly understand the consequences of intense physical activity on the developing young adult. The incidence of organized sports participation by preadolescents and adolescents has increased dramatically in the past two decades. Children represent the largest group of individuals engaging in organized sport in this country. However, little is known about the incidence and severity of injuries associated with child or adolescent participation in these activities.

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

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

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

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

Objectives

The Research and Education Foundation, therefore, encourages high quality research proposals that will help establish a firm scientific foundation for basic and applied programs in pediatric sports health care. Areas of interest may include but are not limited to: epidemiology of athletic injuries in children and adolescents; the role of pre-participation physical examination in the identification of injury risk factors among children and adolescents; the efficacy of specific safety equipment in preventing or reducing the incidence and severity of injury; injury mechanisms and exercise pathophysiology in children; prevention, treatment and rehabilitation of pediatric athletic injuries; conditioning of the child athlete; and musculoskeletal healing processes in children. Given the present funding available, it is expected that grant proposals emphasizing local and regional epidemiological approaches will initially be submitted with the intent to develop data bases and model approaches to injury surveillance which can lead to future large scale epidemiologic or intervention studies on a national level.

III. Doctoral Research Grants

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

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

Education Research and Program Grants

No. of Awards:	Multiple awards are available
Available:	$15,000 total, no minimum or maximum dollar amounts for individual grants
Deadlines:	March 1 and September 1
Notification:	July and February

I. Clinical Instruction and Learning Styles

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

II. Education Research Grants

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

III. Education Projects / Program Grants

Include seed money for seminars, lectures, or any other education program focusing on the health care of the physically active or athletic training education. Project and program grants may include, but are not limited to:

- educational conferences/workshops and other programs
- technology-based projects
- development of clinical assessment tools

Larger-Scale Projects

Those seeking funding for projects which exceed the dollar figures indicated in the RFP, may do so by submitting a letter of inquiry – no longer than 3 pages – outlining a statement of the problem, a description of methods, expected outcomes and estimated budget. If interested, the Foundation will request a full application. There are no deadlines for letters of inquiry.

Application Procedure

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

Abstracts

Clint Thompson, MS, ATC

Bigliani LU, Newton PM, Steinmann SP, Conner PM, McIlveen SJ. Glenoid rim lesions associated with recurrent anterior dislocation of the shoulder. *Am J Sports Med.* 1998;26:41–45.

Twenty-five shoulders with recurrent instability and associated anterior glenoid rim lesions were reviewed to 1) develop a classification system of the lesions, 2) evaluate radiographic techniques in detecting the lesions, and 3) analyze the outcome of surgery. Lesions were classified into three types: Type I, a displaced avulsion fracture with attached capsule; Type II, a medially displaced fragment malunited to the glenoid rim; and Type III, erosion of the glenoid rim with less than 25% (Type IIIA) or greater than 25% (Type IIIB) deficiency. Lesions were detected by plain radiographs (19 shoulders) or supplemental CT-arthrograms (12 shoulders) or both. In 16 Type I fractures, both the bony fragment and capsule were reattached to the glenoid rim. In five Type II and three Type IIIA lesions, only the capsule was repaired to the remaining glenoid rim. In the one Type IIIB lesion, a coracoid transfer was performed. At an average followup of 30 months, 22 shoulders (88%) had satisfactory results without recurrent instability, whereas three shoulders (12%) had postoperative redislocations. The majority of recurrent anterior dislocations with associated glenoid rim lesions can be treated by suturing the fracture fragment or capsule or both to the glenoid rim and addressing associated capsular laxity.

Reprinted with the permission of the *American Journal of Sports Medicine.*

Mack GR, Wilckens JH, McPherson SA. Subacute scaphoid fractures: a closer look at closed treatment. *Am J Sports Med.* 1998;26:56–58.

Twenty-three subacute scaphoid fractures were retrospectively reviewed to determine the efficacy of nonoperative treatment. All of the patients sought medical attention between 4 weeks and 6 months after injury, and their fractures were classified according to location and stability. Nineteen fractures were observed to radiographic union or until closed treatment was abandoned; four patients were lost to followup. Nine of ten stable subacute middle-third scaphoid fractures healed with cast immobilization in an average of 19 weeks (range, 11 to 38), and these were compared with a randomly selected group of acute middle-third fractures that healed in an average of 10 weeks (range, 6 to 13). Five of six unstable subacute middle-third fractures healed in an average of 20 weeks. One of these had a symptomatic humpback deformity treated by cheilectomy. Of three subacute proximal-third fractures, only one healed after 29 weeks of closed treatment. This study demonstrates that stable subacute middle-third scaphoid fractures will heal with cast treatment but may take twice as long to do so as stable acute middle-third fractures. Unstable subacute middle-third scaphoid fractures and subacute proximal-third fractures appear less likely to heal with closed treatment.

Reprinted with the permission of the *American Journal of Sports Medicine.*

Desio SM, Burks RT, Bachus KN. Soft tissue restraints to lateral patellar translation in the human knee. *Am J Sports Med.* 1998;26:59–65.

The purpose of this investigation was to identify and quantify the soft tissue restraints, both medially and laterally, to lateral patellar translation. These restraints to lateral patellar translation at 20° of knee flexion were tested biomechanically on a universal testing instrument in nine fresh-frozen cadaveric knees. After preconditioning the tissues, the patella of each intact knee was translated laterally to a distance at which a force of 200 N was recorded. This distance was used to translate the patella for the remaining structures to be sectioned. The contribution of each structure to the total restraining force was determined as the percent of the force to restrain the intact specimen by sectioning the restraints in a predetermined order. The contribution of each structure to the restraining force was defined as the difference between the restraining force before and after its sectioning. The medial patellofemoral ligament was found to be the primary restraint to lateral patellar translation at 20° of flexion, contributing 60% of the total restraining force. The medial patellomeniscal ligament contributed 13% of the total force, and the lateral retinaculum contributed 10%. The medial patellotibial ligament and superficial fibers of the medial retinaculum were not functionally important in preventing lateral translation. The previously unrecognized contribution of the lateral retinaculum as a restraint to lateral patellar translation may shed new light on the failures of isolated lateral release for acute lateral dislocation of the patella.

Reprinted with the permission of the *American Journal of Sports Medicine.*

Arangio GA, Cohen EW. Incidence of associated knee lesions with torn anterior cruciate ligament: retrospective cohort assessment. *J Sport Rehabil.* 1998;7:1–8.

The records of 141 consecutive patients with confirmed complete anterior cruciate ligament injuries were reviewed retrospectively. One hundred and sixty-two associated injuries were divided into 25 injury complexes. Isolated injuries to the anterior cruciate ligament occurred in 40 cases (28.4%). Injuries of the medial meniscus occurred in 62 cases (38.2%), while injuries of the lateral meniscus occurred in 37 cases (22.8%). Injuries to the medial collateral ligament complex occurred in 42 cases (25.9%). Injuries to the lateral collateral ligament, posterior deep popliteus-arcuate ligament complex, and posterior cruciate ligament were found to be positively correlated ($\rho = 0.81$, $P = .001$, and $\rho = 0.77$, $P = .001$, $n = 141$, respectively). Injuries to the medial collateral ligament and the posterior oblique ligament were likewise positively correlated ($\rho = 0.45$, $P = .001$, $n = 141$).

Reprinted with the permission of the *Journal of Sport Rehabilitation.*

Penderghest CE, Kimura IF, Gulick DT. Double-blind clinical efficacy study of pulsed phonophoresis on perceived pain associated with symptomatic tendinitis. *J Sport Rehabil.* 1998;7:9–19.

The purpose of this study was to determine the clinical efficacy of dexamethasone-lidocaine (DX-L) phonophoresis on perceived pain associated with symptomatic tendinitis. Twenty-four subjects were randomly assigned to a DX-L or placebo phoresis group. All subjects received strengthening, stretching, and cryotherapy. Five double-blind sessions were administered over a 5- to 10-day period, with 24 to 48 hr between sessions. Perceived pain was quantified using a visual perceived pain scale (VPPS) and a punctate tenderness gauge (PTG). Data were collected before stretching, strengthening, and DX-L/placebo phoresis treatments, 1 min after treatment, and 10 min after cryotherapy. There were no significant differences for VPPS or PTG between groups. There was a significant difference between treatment sessions, regardless of group or test, and there were significant decreases in perceived pain between Tests 1 and 3 and between Treatment Sessions 1 and 5. It was concluded that stretching, strengthening, and cryotherapy significantly decreased the levels of perceived pain associated with symptomatic tendinitis regardless of whether the subjects received phonophoresis.

Reprinted with the permission of the *Journal of Sport Rehabilitation.*

Slobounov S, Kraemer W, Sebastianell W, Simon R, Poole S. The efficacy of modern motion tracking and computer graphics technologies in a clinical setting. *J Sport Rehabil.* 1998; 7:20–32.

The primary purpose of this paper was to demonstrate how modern motion tracking technologies, i.e., the Flock of Birds, and computer visualization graphics may be used in a clinical setting. The idea that joint injury reduces proprioception was investigated, and data for injured subjects were compared to data for noninjured subjects (subjects in all experiments were college students). Two experiments showed that there were no significant losses in joint position sense in knee-injured subjects, and both injured and noninjured groups visually overestimated knee movements. However, injured subjects showed no significant differences when visual reproduction data were compared with actual movement data. In addition, these data indicated that injured subjects may have greater potential for apprehension than noninjured subjects, at least in terms of visual estimation of movement ranges. This is an idea that needs further testing.

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Augustsson J, Esko A, Thomee R, Svantesson U. Weight training of the thigh muscles using closed vs open kinetic chain exercises: a comparison of performance enhancement. *J Orthop Sports Phys Ther.* 1998;27:3–8.

Resistance training is commonly used in sports for prevention of injuries and in rehabilitation. The purpose of this study was to compare closed vs. open kinetic chain weight training of the thigh muscles and to determine which mode resulted in the greatest performance enhancement. Twenty-four healthy subjects were randomized into a barbell squat or a knee extension and hip adduction variable resistance weight machine group and performed maximal, progressive weight training twice a week for 6 weeks. All subjects were tested prior to training and at the completion of the training period. A barbell squat three-repetition maximum, an isokinetic knee extension one-repetition maximum, and a vertical jump test were used to monitor effects of training. Significant improvements were seen in both groups in the barbell squat three-repetition maximum test. The closed kinetic chain group improved 23 kg (31%), which was significantly more than the 12 kg (13%) seen in the open kinetic chain group. In the vertical jump test, the closed kinetic chain group improved significantly, 5 cm (10%), while no significant changes were seen in the open kinetic chain group. A large increase of training load was observed in both subject groups; however, improvements in isotonic strength did not transfer to the isokinetic knee extension test. The results may be explained by neural adaptation, weight training mode, and specificity of tests.

Reprinted with the permission of the *Journal of Orthopaedic and Sports Physical Therapy.*

Ross M, Worrell TW. Thigh and calf girth following knee injury and surgery. *J Orthop Sports Phys Ther.* 1998; 27:9–15.

Girth measures are commonly used to assess muscle atrophy or joint effusion. Little is known, however, regarding girth measurement changes following knee injury and subsequent surgery. Therefore, the purpose of this study was to compare the thigh and calf girth measurements of involved and noninvolved extremities prior to and following knee surgery for subjects with acute and chronic knee injuries. Of the 40 subjects that were studied, 22 subjects were placed in the acute group (less than 6 months from time of injury to presurgery measurement) and 18 subjects were placed in the chronic group (greater than 6 months from time of injury to presurgery measurement). Thigh and calf girth measurements were taken prior to surgery and then prior to the initiation of outpatient rehabilitation following surgery. For the acute and chronic groups, a three-way analysis of variance (ANOVA) with repeated measures on the extremity, muscle, and time factors was used to analyze the data. For each group, the three-way ANOVA revealed a significant two-way interaction between the extremity and time factors. Post hoc analysis revealed significant differences between involved and noninvolved extremities at both the pre- and post-surgery time periods for the acute and chronic groups. While thigh and calf girth measurement differences existed between the involved and noninvolved extremities prior to and after surgery, the bulk of the girth measurement differences existed prior to surgery for both groups. Based upon the results of this study, the assessment and rehabilitation of the thigh and calf following knee injury and surgery are recommended.

Reprinted with the permission of the *Journal of Orthopaedic and Sports Physical Therapy.*

Turl SE, George KP. Adverse neural tension: a factor in repetitive hamstring strain. ***J Orthop Sports Phys Ther*****. 1998;27:16–21.**

The etiology and nature of repetitive hamstring strain is complex and not fully understood. The purpose of this study was to investigate the presence of adverse neural tension in 14 male Rugby Union players with a history of grade I repetitive hamstring strain. Comparison was made to an injury-free matched control group. Adverse neural tension was assessed using the slump test. Hamstring flexibility was measured using the active knee extension in lying test. Results indicated that 57% of the test group had positive slump tests, suggesting the presence of adverse neural tension. None of the control group had a positive slump test. Analysis of variance revealed no differences in flexibility between groups or between those demonstrating a positive or negative slump test. Results suggest that adverse neural tension may result from or be a contributing factor in the etiology of repetitive hamstring strain. Residual decreased flexibility is not apparent in this subject group.

Reprinted with the permission of the *Journal of Orthopaedic and Sports Physical Therapy.*

Grubbs N, Nelson RT, Bandy WD. Predictive validity of an injury score among high school basketball players. ***Med Sci Sports Exerc*****. 1997;29:1279–1285.**

A number of strategies have been investigated in an attempt to identify those individuals most likely to be injured during participation in sports activity. One such strategy identified in the literature involved computing an "injury score" via a logistic regression equation using measures of structural symmetry to predict the likelihood of athletic injury. The purpose of this study was to investigate the predictive value of the injury score among high school basketball players. Following the establishment of reliability of measures, injury scores were calculated for 62 high school basketball players (34 females, 28 males) before the start of the season. Lower extremity injuries sustained while playing basketball were recorded throughout the season. The predictive value of the injury score equation was determined by calculating sensitivity, specificity, and positive and negative predictive values. The sensitivity and specificity were calculated to be 16.7% and 66.1%, respectively. The positive and negative predictive values were calculated to be 5.90% and 88.1%, respectively. These results indicate that the injury prediction score investigated was not a valid means of predicting injury in high school basketball players. Limitations, possible implications of these findings, and ideas for future related research are presented.

Reprinted with the permission of *Medicine and Science in Sports and Exercise.*

Wen DY, Puffer JC, Schmalzried TP. Lower extremity alignment and risk of overuse injuries in runners. ***Med Sci Sports Exerc*****. 1997;29:1291–1298.**

A group of 304 runners enrolling in a marathon training program had alignment measurements performed and completed a questionnaire on training practices and injuries over the previous 12 months. The alignment measures consisted of arch index (AI), heel valgus (HV), knee tubercle-sulcus angle (TSA), knee varus (KV), and leg-length difference (LLD). Results indicated few consistent statistical associations between these alignment measures and risk of injuries, either bivariately or multivariately: left AI with hamstring injuries; right Al with shin injuries; right HV with back injuries; left TSA with ankle injuries; KV with hip injuries; and LLD with back, ankle, and foot injuries. A few statistically significant relationships were also found between other training and anthropometric factors and injuries: mileage with hamstring injuries; interval training with shin injuries; hard surfaces with back and thigh injuries; shoe use patterns with foot and overall injuries; and body mass index with heel injuries. We conclude that lower-extremity alignment is not a major risk factor for running injuries in our relatively low mileage cohort; however, prospective studies are necessary to confirm or refute these findings.

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Book Reviews

Advanced Fitness Assessment & Exercise Prescription
3rd edition
Vivian H. Heyward, PhD
Human Kinetics, Champaign, IL
1998
323 pages
ISBN: 0–88011-483–5
Price: $42.00

The latest edition of *Advanced Fitness Assessment & Exercise Prescription* by Dr. Vivian H. Heyward contains 11 well-written chapters and 7 appendices and includes significant updates and additions. This book is designed as a primary textbook for university courses dealing with physical fitness testing and individualized exercise prescription. The information in this book flows well and is organized logically, covering important components of health-related fitness.

Chapter 1 serves as a general introduction to physical activity, health, and disease. Chapter 2 presents important information about preliminary health screening and risk classification, while chapter 3 considers critical principles of assessment, prescription, and adherence. Subsequent chapters (with the exception of the last two chapters, "Assessing Flexibility and Designing Stretching Programs" and "Assessing and Managing Stress") are arranged so that assessment chapters are followed by information related to program design. Each chapter opens with several "key questions" and concludes with "key points" to assist students in their understanding of the material. Many of the chapters covering assessment contain a separate section entitled "Sources for Equipment," listing the addresses and phone numbers of companies that supply fitness assessment products. Ample and accurate references are included at the end of each chapter for those wishing to investigate the original sources.

The book contains more than 40 photographs and many useful figures and tables. Although it is not very colorful (green is used sparingly for headings, tables, and figures), students will appreciate the publisher's limited use of color in the affordable price. Students will also appreciate the usefulness of the appendices that contain various sample forms and questionnaires, norms and exercises, electrocardiogram (ECG) tracings, equations, photographs, and assessment protocols.

I have used previous editions with success and plan to use this latest edition as well. Also available is an electronic instructor guide (not reviewed), which provides educators with tools for organizing course materials. The software is free to instructors adopting the text.

The author is well recognized in the field of exercise science, with considerable research experience in the areas of fitness and body composition assessment. Her writing is easy to read and understand.

Intended primarily for undergraduate students in the exercise sciences, this book would also be a good reference text for exercise physiologists, health educators, sports medicine specialists, clinicians, personal trainers, and allied health professionals. The book is essential reading for individuals who wish to become certified (eg, as an American College of Sports Medicine Health/Fitness Instructor) to work with healthy individuals in exercise environments. The publishers have accurately advertised the book as a text that ". . . bridges the gap between research and practice."

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Athletic Ability & the Anatomy of Motion
2nd edition
Rolf Wirhed
Mosby, St. Louis, MO
1997
171 pages
ISBN: 0–7234-2643–0
Price: $24.95

Athletic Ability & the Anatomy of Motion (2nd edition) by Rolf Wirhed combines anatomic and biomechanical principles applied to sport. The text is divided into eight chapters organized according to anatomic areas, with additional sections on mechanics and muscle stretching. The volume is designed to serve as a primary text in a lower-division introductory biomechanics course or as a supplementary text in an upper-division course. The volume is well suited for these purposes, but it would not be appropriate for a general biomechanics course because of the specific application to sport.

The text offers a unique approach to motion analysis by merging anatomic and biomechanical principles to the study of human movement in sport. The use of rehabilitation and conditioning examples provides a clinical and pedagogic perspective for the student studying sport biomechanics.

The book compares favorably with other introductory texts in sport biomechanics. It offers a succinct and discriminating approach to important concepts in biomechanics and musculoskeletal anatomy. It is not as comprehensive as some other texts in the area, due to the specific focus, but the material is functional and presented very effectively. The author integrates mechanical principles, discussed early in the text, throughout the anatomic chapters. This permits the reader to apply basic rules of biomechanics to each part of the musculoskeletal system.

The images complementing the text are quite helpful. They are stylishly drawn, yet easy to integrate with the written material. The illustrations are uncluttered, pleasing to contemplate, and readily understandable. The material flows well throughout the book as the author effectively connects the illustrations and text. Musculoskeletal anatomy is integral to the study of each lesson and, rather than separating anatomic and biomechanical principles in discrete sections of the book, the author coalesces these principles to enhance student comprehension of the material. One item that is missing from the text is the use of citations. In certain cases, references to other sources would provide the reader with an important path to a more comprehensive understanding of the material presented.

Overall, this text is a pleasant change from typical works in this field. The author effectively combines anatomy and biomechanics to help students understand movement in sport. The simplicity and clarity of the illustrations enhance the book and facilitate an understanding of the concepts presented. The book is versatile and will be of value in a variety of courses ranging from introductory biomechanics to functional anatomy and rehabilitative exercise. In addition to educators, this text would be of value as a clinical resource to athletic trainers, physical therapists, and strength coaches. It will also be of value to the clinician in physical medicine.

The cost of the volume ($24.95) is reasonable considering the quality of illustrations and depth of material presented.

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Cardiopulmonary Rehabilitation: Basic Theory and Application
3rd edition
F.J. Brannon, M.W. Foley, J.A. Starr, and L.M. Saul
F.A. Davis, Philadelphia, PA
1998
486 pages
ISBN: 0-8036-0318-5
Price: $48.95

Cardiopulmonary Rehabilitation: Basic Theory and Application is the third edition of a text designed for students and practicing clinicians in cardiopulmonary rehabilitation, although the primary intent of the text would appear to be for students in allied health professions. The text flows in a logical manner and covers the field with respect to anatomy, pathophysiology, clinical manifestations, contemporary treatment approaches, and the clinician's role in assessment and intervention.

The general content of this book helps to illustrate the converging disciplines of exercise science and physical therapy in the treatment of patients with cardiopulmonary disease. That is, the mix of clinical exercise physiology and specific therapeutic treatment techniques will be familiar to exercise physiologists and physical therapists, as well as to other allied health care practitioners. Therein lie both the strengths and weaknesses of this type of text.

Like previous editions, this text provides important overviews of a wide variety of relevant topical areas but is less expansive than one might wish, presumably in order to keep the text to a reasonable length and cost. That is not to say, however, that *Cardiopulmonary Rehabilitation: Basic Theory and Application* is not a useful text, by any means. In this latest edition, the authors have appropriately expanded and updated several sections of the text, including more relevant inpatient exercise protocols, outcomes assessment, benefits of pulmonary rehabilitation, updated transcatheter procedures and other contemporary cardiac interventions, expanded exercise assessment and therapeutic exercise guidelines, and risk factor modification. For readers interested in learning the basic methodologies and gaining an appreciation of alternative assessment and therapeutic techniques, the text meets these needs in a concise manner. Still, readers will be left wanting a more complete understanding of alternative strategies and advanced issues. For example, the text provides clear guidelines for the administration and interpretation of standard graded exercise testing using both treadmill and cycle ergometry, but does not describe the 6-minute walk test protocol, which is widely used in pulmonary patient interventions.

The illustrations throughout the book are clear and help the reader to understand the material. Consistent with the abbreviated nature of the text, however, additional illustrations that would be helpful are not included, such as in the description of oxygen therapy. Again, this may well have been done deliberately to keep the cost of the text down.

As an overview of cardiopulmonary pathophysiology, medical management and surgical interventions, and physical assessment and exercise/risk-factor interventions, this text will be satisfying to most readers. It clearly provides the essentials for assessment and exercise prescription for both cardiac and pulmonary patients. This text could be viewed as a primary textbook for a course in cardiopulmonary rehabilitation, but would require some supplementation depending on the intent of the course. For example, it would be more appealing as an entry-level physical therapy text if it included more acute care issues, especially assessment and treatment in intensive care environments. A number of relevant interventions are summarized in the last chapter of the text; however, this information should have been presented in the context of the earlier chapters devoted to exercise therapy.

Although there are a number of texts available for students and clinicians in cardiopulmonary rehabilitation, *Cardiopulmonary Rehabilitation: Basic Theory and Application* represents a concise entry-level text. While some supplementation may be necessary, it remains an excellent addition to the library of a student or practicing clinician, particularly if the clinician's professional preparation in this area was suboptimal.

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Overtraining in Sport
Editors: Richard B. Kreider, Andrew C. Fry, and Mary L. O'Toole
Human Kinetics, Champaign, IL
1998
401 pages
ISBN: 0-88011-563-7
Price $45.00

As a health professional interested in this topic, as well as a clinician, I found *Overtraining in Sport* to be a complete review of the current research in this area. This complete review includes basic definitions and the fundamental physiologic, immunologic, nutritional, and psychological considerations of overreaching and overtraining. The editors state in the preface that they hope the book will be a resource for athletes, coaches, and research scientists in the field, but I think its level is well above most athletes and coaches. Athletes and coaches would probably be most interested in monitoring strategies, but the chapter on this subject makes few helpful suggestions.

The most informative and interesting chapters in the book were chapters 10, 11, and 15: "The Effects of Athletic Endurance Training on Infection Rates and Immunity" by David Neiman, "The Effects of Overreaching and Overtraining on Immune Function" by Laurel Mackinnon, and "The Central Fatigue Hypothesis and Overtraining" by Richard Kreider. These chapters were very clear and flowed well, and I believe they have the most practical relevance. Dr Kreider, in particular, really pulled everything together in his chapter on the central fatigue hypothesis. The most difficult section to follow was section II, "Physiology of Overtraining in Strength/Power Athletes." These 3 chapters are very technical and tend to lose the reader with too much data. A few more figures and a summary of information might have helped. Finally, the section "Psychologic Considerations of Overreaching and Overtraining," containing one chapter by Andrew Meyers and James Whelan, summarized the evaluation and management of these problems through two sample cases carried through the chapter. This chapter gave more insight into monitoring and prevention strategies than the earlier chapter in the book on this subject.

The cost for the information in *Overtraining in Sport* is excellent. I highly recommend this text as a secondary reference for students at the graduate level and for health care professionals interested in this field of study.

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Psychological Approaches to Sports Injury Rehabilitation
Jim Taylor and Shel Taylor
Aspen Publishers, Gaithersburg, MD
1997
304 pages
ISBN: 0-8342-0973-X
Price: $52.00

Psychological Approaches to Sports Injury Rehabilitation is a book that addresses numerous psychological facets of the postinjury process among athletes. The target audience of the book is rehabilitation professionals or students training to be rehabilitation professionals, although injured athletes could also benefit from the book, which applies many sport psychology principles and techniques to the injury rehabilitation process. This is a worthwhile approach because many of the principles of sport psychology are never disseminated to other disciplines.

The book is divided into four sections: Section I, "Rehabilitation Assessment and Education," includes chapters on rehabilitation assessment, understanding the rehabilitation process, and the psychology of the rehabilitation process; Section II, "Psychological Problems and Referral," encompasses chapters on psychological problems in rehabilitation and making referrals (ie, how to identify and refer injured athletes who may benefit from psychological counseling); Section III, "Psychological Influences on Rehabilitation," provides chapters on confidence, motivation, anxiety, and focus; and Section IV, "Facilitating Rehabilitation," offers chapters on rehabilitation imagery, pain management, social support, returning to sport, and developing a psychological rehabilitation program.

There are many worthwhile aspects to this text. The book is written in a user-friendly style and is nicely organized. More specifically, each chapter starts with a case study that introduces the topic to be discussed. In the main portion of each chapter, the authors make ample use of worksheets and forms that could be used as is or modified as needed. Interspersed throughout the book are quotes from high-profile athletes and sports figures that do a good job of illustrating the points made in the accompanying text. Finally, each chapter concludes with summary points. Although at times some of the material seems redundant, for the most part the material flows smoothly and is easy to understand.

Another positive aspect of the book is that the authors make clear distinctions about which techniques they are presenting based on clinical experience and which have been validated through research. Although the book is largely based on scientific psychological principles, there are instances in which the rehabilitation practitioner is faced with situations that have not been addressed in the research. The authors identify these situations as such, providing the reader with the opportunity to make informed decisions regarding the implementation of certain techniques.

While the strengths of this text are not disputed, the book has several minor weaknesses. At times, the authors make somewhat simplistic statements that may be misleading. For instance, they state that the symptoms of cognitive anxiety are "easily recognizable" in athletes. Given that numerous studies have documented the difficulty in recognizing anxiety levels and that people tend to manifest anxiety in individual ways, claims such as these may be overstated.

In addition, although the book is, for the most part, easy to read, the section on focus was difficult to understand. The authors introduce the notion that athletes may have a focus style (or attentional style, as termed by R. M. Nideffer. Attentional control training. In: Singer RN, Murphey M, Tennant LK, eds. *Handbook of Research in Sport Psychology.* New York: MacMillan; 1993: 542–556) and that focus styles have implications for individuals' rehabilitation progress. Focus styles are viewed as individual preferences to concentrate on certain types of information and to be more at ease in processing certain types of information. Athletes with an internal focus style are thought to rely more on internal processes, such as thoughts, emotions, and proprioceptive responses. Conversely, it is thought that athletes with an external focus rely more on information from the environment, such as feedback from others. Based on this information, it is not clear why the authors state that "the most common responses to an external focus style are often in the form of negative thoughts, preoccupation with the injured area" (p. 182) and later state that injured athletes with an internal focus "are overly sensitive to their environment and are easily distracted by their immediate surroundings" (p. 187). Perhaps the link between these ideas will be made clearer in future printings of the book.

One criterion for evaluating a book such as this is whether it provides material that is unique. This question is particularly relevant because two other books have been published on the rather specific topic of the psychology of athletic injuries: *Psychological Bases of Sport Injuries* (Pargman D, ed. Morgantown, WV: Fitness Information; 1993) and *Psychology of Sport Injury* (Heil J. Champaign, IL: Human Kinetics; 1993). *Psychological Approaches to Sports Injury Rehabilitation* appears to target most directly the sports medicine practitioner who does not have an extensive background in psychological principles and is working on a daily basis with injured athletes.

The bottom line: This book does a very good job of delivering its intended product, ie, providing practical psychological techniques and strategies for rehabilitation professionals or entry-level students.

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Special Tests for Orthopedic Examination

Jeff G. Konin, Denise L. Wiksten, and Jerome A. Isear
Slack Inc, Thorofare, NJ
1997
276 pages
ISBN: I-55642–351-9
Price: $29.50

Special Tests for Orthopedic Examination is a pocket-size, yet comprehensive, reference that explains how to perform over 125 special tests routinely used as part of an orthopedic physical examination. The thorough written descriptions are complemented by excellent photographs that help illustrate and explain the proper procedures. This book would make a valuable addition to the professional library of students in athletic training, physical therapy, physician assisting, and chiropractic fields. Its size makes it conducive to the clinical environment.

Compared with the limited number of books known to this reviewer that comprehensively illustrate and describe special tests for the neuromusculoskeletal system, *Special Tests for Orthopedic Examination*, which is organized in sections by joint, is noteworthy for its sharp black-and-white photographs and concise description of test performance. With straightforward explanations, this text provides the reader with an understanding of the interpretation of results. And with indexed pages, you can quickly locate specific information.

At $29.50, *Special Tests for Orthopedic Examination* represents a solid value for both student and practitioner. The authors are to be commended for providing a well-illustrated, clearly written reference text that should enjoy immediate popularity with a variety of health care practitioners who deal with the neuromusculoskeletal system.

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Sport Stretch

2nd edition
Michael J. Alter
Human Kinetics, Champaign, IL
1997
232 pages
ISBN: 0–88011-823–7
Price: $15.95

Sport Stretch, 2nd edition, is a comprehensive guide to various stretching and flexibility exercises that is geared to all health care professionals, coaches, and students. A total of 311 stretching exercises for 41 sports ranging from archery to wrestling are offered. This second edition, which is mainly a book of illustrations with limited written text, includes 27 new stretches and a chapter focusing on muscle structure, stretching techniques, and the benefits of flexibility.

Sport Stretch is divided into four sections. The first section addresses the role of flexibility and its benefits to the body. Included in this section is information on frequency, duration, warm up, cool down, and delayed-onset muscle soreness. This section provides the reader with a brief overview of the most important ideas and concepts and should be used for that purpose only. The second section shows 12 stretches that cover all the major muscles in the body region. The author also includes 28 maximal isolation stretches for those who need more flexibility or specificity in a particular muscle group. The third section lists 41 sports and divides each sport into 12 body regions. The author then highlights the most common stretches (including the best stretch) for each sport. The fourth section provides the reader with illustrations, instructions, and descriptions for each stretch grouped according to body region. Throughout this section are special notations with suggested hints or strategies to follow when performing the stretches.

Sport Stretch is a comprehensive guide to various stretches that can be used in conjunction with prevention, rehabilitation, and conditioning courses. The illustrations found throughout the text are clear and precise. The tables are easy to understand and follow and are helpful in assisting the reader to find a particular stretch. The descriptions of how to perform each stretch are thorough and well written. At $15.95, *Sport Stretch* is a bargain and is recommended as a supplement for all health care professionals and college-level students.

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Human Tendons: Anatomy, Physiology and Pathology

Laszlo Jozsa and Pekka Kannus
Human Kinetics, Champaign, IL
1997
574 pages
ISBN: 0–87322-484–1
Price: $79.00

This book is intended to be a comprehensive text on the microscopic and macroscopic anatomy, physiology, and pathology of human tendons, topics that the authors state are not sufficiently covered in standard medical texts. The text is divided into five parts and 22 chapters. The parts are 1) "Tendon Anatomy and Physiology," 2) "Biomechanics, Function, and Development of Tendons," 3) "Tendon Injuries," 4) "Tendon Diseases and Other Tendon Disorders," and 5) "Diagnostic and Treatment Principles in Tendon Problems and Tendon Healing."

The text begins with some useful drawings showing the anatomic locations of human tendons, but those can also be found in other anatomy books. Many sections, such as the structure and metabolism of normal tendons, are too in-depth and not appropriate for everyday clinicians. The section on tendon injuries does provide good information on overuse injuries and the spontaneous rupture of tendons. Most of the topics in the chapter "Other Injuries of Tendons" are not applicable to athletic trainers (such as bite-, acupuncture-, and gunshot-induced injuries to tendons); however, the information on iatrogenic injuries (anabolic steroid- and corticosteroid-induced injuries) is useful, although it is brief in comparison. I also found the information on how other diseases can affect tendon tissue to be interesting, but, again, it is more than most clinicians want to know. The section on how to treat and rehabilitate tendon injuries could have been the most applicable part of the book, but it is rather basic and unremarkable. On a positive note, the information on the healing and regeneration of tendons is interesting, as are the epidemiologic data on the spontaneous rupture of tendons. The photographs of tissue stains and electron microscopy are informative, but, again, may be at a level that most athletic trainers/practitioners do not appreciate.

This advanced-level reference book may be useful to medical students or graduate students conducting research on tendons, but is too in-depth for most clinicians. The price is expensive, but may be appropriate for the amount of information that is provided. This very extensive text is not recommended for most certified athletic trainers, but can be an excellent reference and resource for orthopedic surgeons, anatomists, pathophysiologists, and other scientists.

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Current Literature

Clint Thompson, MS, ATC

ANKLE

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Authors' Guide

(Revised January 1998)

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16. The title page should also include the name, title, and affiliation of each author, and the name, address, phone number, fax number, and E-mail address of the author to whom correspondence is to be directed.
17. A structured abstract of 75 to 200 words must accompany all manuscripts. Type the complete title (but not the authors' names) at the top, skip two lines, and begin the abstract. Items that are needed differ by type of article. **Literature Review:** Objective, Data Sources, Data Synthesis, Conclusions/Recommendations, and Key Words; **Original Research** articles: Objective, Design and Setting, Subjects, Measurements, Results, Conclusions, and Key Words; **Case Reports:** Objective, Background, Differential Diagnosis, Treatment, Uniqueness, Conclusions, and Key Words; **Clinical Techniques:** Objective, Background, Description, Clinical Advantages, and Key Words. For the Key Words entry, use three to five words that do not appear in the title.
18. Begin the text of the manuscript with an introductory paragraph or two in which the purpose or hypothesis of the article is clearly stated and developed. Tell why the study needed to be done or the article written and end 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 a one- to two-paragraph review of the literature, identify and develop the magnitude and significance of the controversy, pointing out differences among 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. The active voice is preferred. For examples, consult the *AMA Manual of Style*.
19. 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 **Original Research** article consists of a methods section, a presentation of the results, and a discussion of the results. The methods 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 **Literature Review** 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 Report** 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

Authors' Guide

after return to competition), criteria for return to competition, and deviation from expectations (what makes this case unique).

d. The body of a **Clinical Techniques** 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 an explanation of why the technique should be used. The discussion concerning the *why* of the technique should review similar techniques, point out how the new technique differs, and explain the advantages and disadvantages of the technique in comparison with other techniques.

20. **Communications** articles, including official Position Statements and Policy Statements from the NATA Pronouncements Committee; technical notes on such topics as research design and statistics; and articles on other professional issues of interest to the readership are solicited by the *Journal*. An author who has a suggestion for such a paper is advised to contact the Editorial Office for instructions.
21. 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.
22. References should be numbered consecutively, using superscripted arabic numerals, in the order in which they are cited in the text. 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.
23. References to articles or books, published or accepted for publication, or to papers presented at professional meetings are listed in numerical order at the end of the manuscript. Journal title abbreviations conform to *Index Medicus* style. Examples of references are illustrated below. See the *AMA Manual of Style* for other examples.

    Journals:
    1. van Dyke JR III, Von Trapp JT Jr, Smith BC Sr. Arthroscopic management of postoperative arthrofibrosis of the knee joint: indication, technique, and results. *J Bone Joint Surg Br.* 1995;19:517–525.
    2. Council on Scientific Affairs. Scientific issues in drug testing. *JAMA.* 1987;257: 3110–3114.

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

    Presentations:
    1. Stone JA. Swiss ball rehabilitation exercises. Presented at the 47th Annual Meeting and Clinical Symposia of the National Athletic Trainers' Association; June 12, 1996; Orlando, FL.
24. Table Style: 1) Title is bold; body and column headings are roman type; 2) units are set above rules in parentheses; 3) numbers are aligned in columns by decimal; 4) footnotes are indicated by symbols (order of symbols: *, †, ‡, §, ||, ¶); 5) capitalize the first letter of each major word in titles; for each column or row entry, capitalize the first word only. See a current issue of the *Journal* for examples.
25. All black and white line art should be submitted in camera-ready form. Line art should be of good quality; should be clearly presented on white paper with black ink, sans serif typeface, and no box; and should be printed on a laser printer—no dot matrix. Figures that require reduction for publication must remain readable at their final size (either one column or two columns wide). Photographs should be glossy black and white prints. Do not use paper clips, write on photographs, or attach photographs to sheets of paper. On the reverse of each figure attach a write-on label with the figure number, name of the author, and an arrow indicating the top. (Note: Prepare the label before affixing it to the figure.) Authors should submit one original of each figure and five copies for review.
26. Authors must request color reproduction in a cover letter with the submitted manuscript. Authors will be notified of the additional cost of color reproduction and must confirm acceptance of the charges in writing.
27. Legends to figures are numbered with Arabic numerals in order of appearance in the text. Legends should be printed on separate pages at the end of the manuscript.

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

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