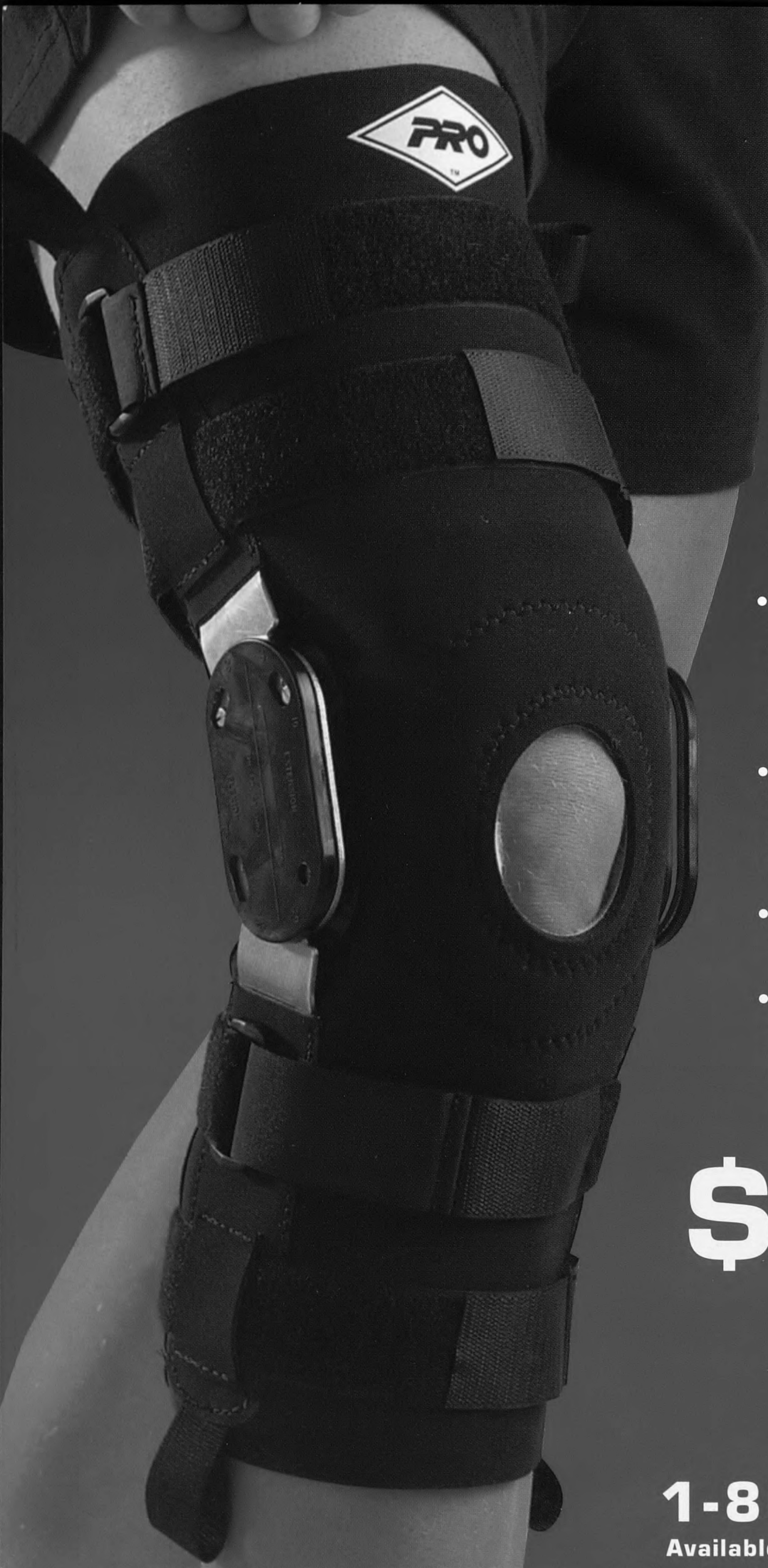
JOURNAL OF ATHLETIC TRAINING

VOLUME 31 • NUMBER 4 • OCTOBER–DECEMBER 1996

NATA

Official Publication of The National Athletic Trainers' Association


PRO

Journal of Athletic Training

Official Publication of The National Athletic Trainers' Association

Volume 31, Number 4, October-December

INDEXES: Currently indexed in Focus on Sports Science & Medicine (ISI: Institute for Scientific Information), Research Alert® (ISI: Institute for Scientific Information), Physical Education Index, SPORT Discus (SIRC: Sport Information Resource Centre, CANADA), CINAHL (Cumulative Index to Nursing & Allied Health Literature)

The *Journal of Athletic Training* (ISSN 1062–6050) is published quarterly ($32 for one-year subscription, $40 foreign) by the National Athletic Trainers' Association, Inc., 2952 Stemmons Freeway, Dallas, TX 75247. Periodicals postage paid at Dallas, TX, and at additional mailing offices.

POSTMASTER: Send address changes to: *Journal of Athletic Training* c/o NATA, 2952 Stemmons Freeway, Dallas TX 75247. CHANGE OF ADDRESS: Request for address change must be received 30 days prior to date of issue with which it is to take effect. Duplicate copies cannot be sent to replace those undelivered as a result of failure to send advance notice. ADVERTISING: Although advertising is screened, acceptance of the advertisement does not imply NATA endorsement of the product or the views expressed. Rates available upon request. The views and opinions in the *Journal of Athletic Training* are those of the authors and are not necessarily of the National Athletic Trainers' Association, Inc.

JOURNAL OF ATHLETIC TRAINING

Official Publication of The National Athletic Trainers' Association **Volume 31, Number 4, October-December**

Original Research

The Relationship of Stress, Competitive Anxiety, Mood State, and Social Support to Athletic Injury
Lynn Lavallée and Frances Flint 296

Effect of Mild Head Injury on Postural Stability in Athletes
Kevin M. Guskiewicz, David H. Perrin, and Bruce M. Gansneder 300

Salary Survey of Certified Athletic Trainers in Delaware, New Jersey, New York, and Pennsylvania
James Somerville and Michael Stanwood 309

The Effectiveness of the Aquaflex Gel Pad in the Transmission of Acoustic Energy
Brian Klucinec 313

Ankle and Thigh Skin Surface Temperature Changes with Repeated Ice Pack Application
Janice E. Palmer and Kenneth L. Knight 319

Comparison of Stretching with Ice, Stretching with Heat, or Stretching Alone on Hamstring Flexibility
Gary R. Brodowicz, Robert Welsh, and James Wallis 324

The Effects of Prophylactic Brace Construction Materials on the Reactive Responses of the MCL During Repetitive Impacts
Patrick E. Patterson and Jay Eason 329

Effect of Closed Chain Exercise on Quadriceps Femoris Peak Torque and Functional Performance
John R. Wawrzyniak, James E. Tracy, Peter V. Catizone, and Rich R. Storrow 335

Reliability of Ground Reaction Forces During a Vertical Jump: Implications for Functional Strength Assessment
Mitchell L. Cordova and Charles W. Armstrong 342

Literature Review

Evaluation of Sports-Related Temporomandibular Dysfunctions
Matthew E. Sailors 346

Case Reports

Avulsion of the Inferior Canaliculus in a Collegiate Wrestler: A Case Study
Kenneth L. Cameron, Robert D. Kersey, and Jack Ransone 352

Clinical Techniques

A Model for a Policy on HIV/AIDS and Athletics
Laurie A. Bitting, Cynthia A. Trowbridge, and Lauren E. Costello 356

Departments

Editorial 293
19th Annual NATA Student Writing Contest 358
Request for Proposals 359
Call for Abstracts 360
Abstracts 362
Book Reviews 366
Video Review 370
New Products 371
Current Literature 374
Authors' Guide 377
CEU Quiz 378
Author Index 380
Subject Index 382
Advertisers' Index 384

Editorial

Transitions

David H. Perrin, Editor-in-Chief

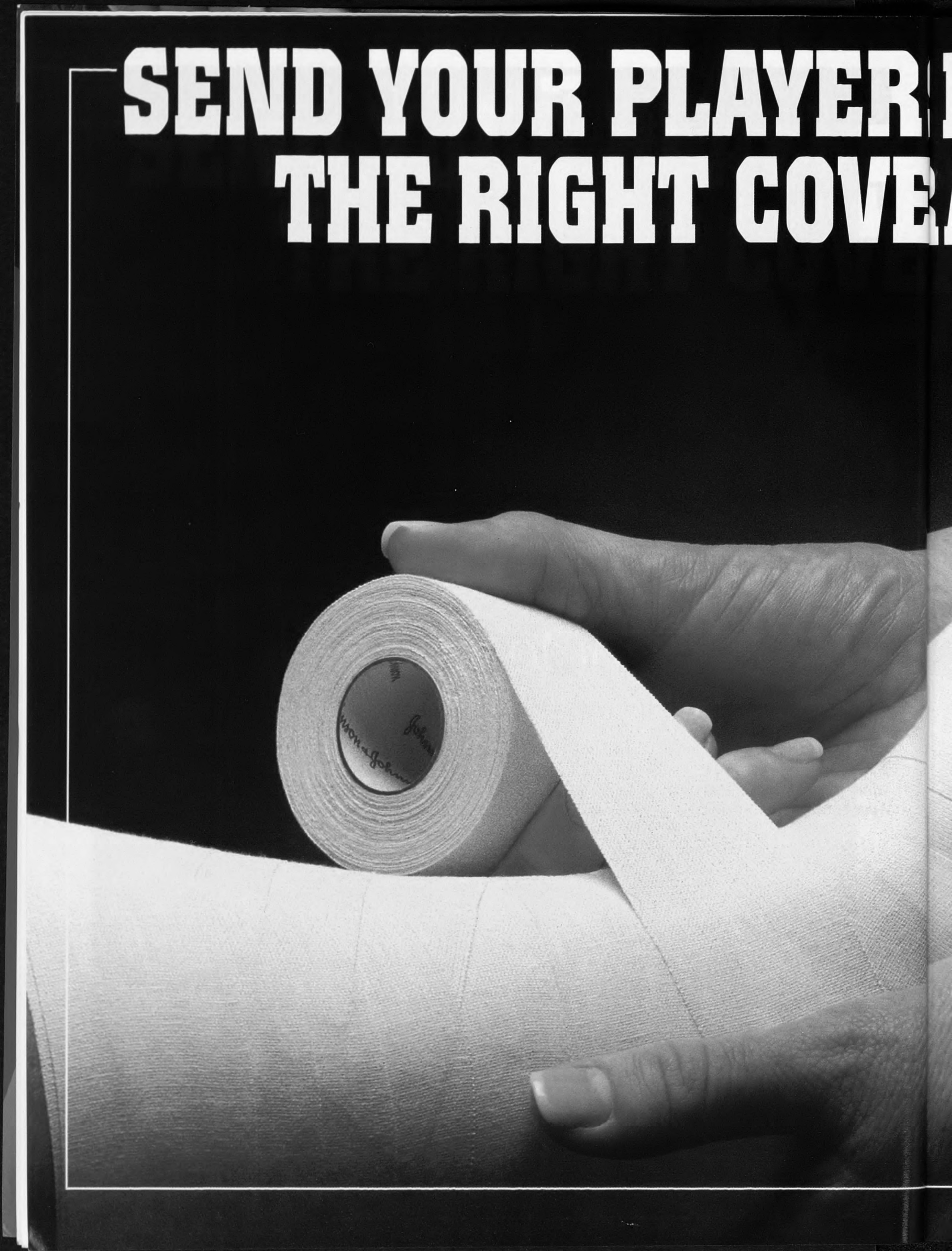
The September issue marked the end of Dr. Kenneth Knight's tenure as Editor-in-Chief of the *Journal of Athletic Training*. Over the past 11 years, Dr. Knight has transformed the *Journal* into a respected scholarly publication. Like the articles in the 40+ preceding issues of JAT, the manuscripts in this issue were reviewed and revised under Dr. Knight's supervision. Accordingly, he also deserves much of the credit for this final issue of Volume 31. We all owe Dr. Knight our gratitude for his many years of distinguished service to the *Journal of Athletic Training*.

I would be remiss if I didn't also acknowledge the significant contributions of former assistant editor Janet Brown. Everyone who has published in the *Journal of Athletic Training* has experienced firsthand her dedication and expertise.

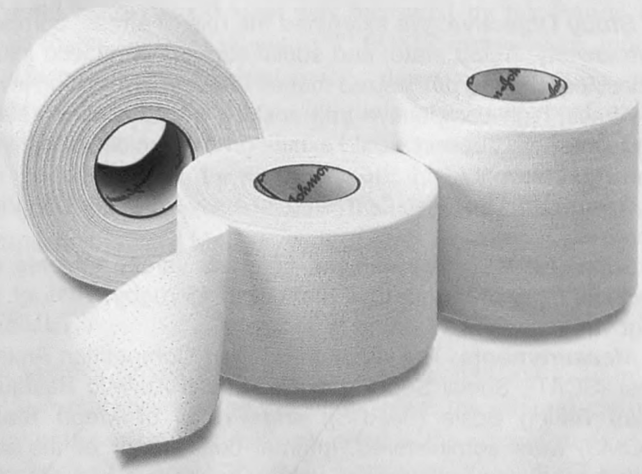
As an athletic training educator, researcher, and clinician, I can't think of a greater honor than to have been selected as the next Editor-in-Chief of the *Journal of Athletic Training*. My pledge to the Board of Directors and my athletic training colleagues is to produce not only a publication that will serve as a source of pride for our profession, but also one that will compete on an equal professional basis with all other journals in the sports medicine arena.

In a broad sense, my goal for the *Journal of Athletic Training* is to place it in the best possible position for acceptance by the leading medical indexes. Toward that end, I will enhance its scholarly image, both in appearance and content. The first issue of Volume 32 will bring about some changes in layout with respect to placement of advertisements and content of the various sections of the Journal. The Associate Editors and I will select papers based on sound scholarship that also have clinical relevance to athletic trainers. We'll also encourage other members of the sports medicine community to consider *JAT* as a forum for their writing. I want the *Journal of Athletic Training* to be the periodical of choice for both publication and discussion for all professionals involved in the health care of physically active people.

You will note from the masthead of this issue that the editorial office of the journal now resides at the Hughston Sports Medicine Foundation. I am indebted to founder Dr. Jack Hughston for including *JAT* in his overall plan for research and education in sports medicine. The Foundation also provides the expertise of Managing Editor Leslie Neistadt and Editorial Assistant Markie Gardner. This arrangement will enable me to oversee the editorial process, while at the same time developing and implementing strategies essential to the overall growth of the *Journal of Athletic Training*. In this regard, I welcome your participation, comments, and suggestions.


SEND YOUR PLAYERS
THE RIGHT COVE

JOHNSON & JOHNSON QUALITY ATHLETIC TAPES PROVIDE THE BEST DEFENSE AGAINST INJURY.



***Injury prevention**. It's the number one reason why the majority of certified athletic trainers, at all levels of competition, rely on JOHNSON & JOHNSON athletic tapes. The unbeatable fit of JOHNSON & JOHNSON provides critical support and protection against injury, giving athletes the confidence to perform at the top of their game...whatever game they play. Such superior design and performance also means consistent unwind, less waste and better value.*

Don't leave your players open for injury. Send them in with the coverage of JOHNSON & JOHNSON.

Johnson & Johnson

The Relationship of Stress, Competitive Anxiety, Mood State, and Social Support to Athletic Injury

Lynn Lavallée, BA; Frances Flint, PhD, ATC

Study Objective: We examined the role of stress, competitive anxiety, mood state, and social support in athletic injury. Specifically, we hypothesized that athletes reporting high levels of stress, high competitive trait anxiety, negative mood state, and low social support would exhibit greater incidence of injury and injury severity.

Design and Setting: Correlational analysis. Major Canadian university.

Subjects: Voluntary sample, 55 male varsity athletes (42 football, 81% of the football team, and 13 rugby, 74% of the rugby team), ages 19–28 yr ($\bar{x} = 22$).

Measurements: The inventories Sport Competition Anxiety Test (SCAT), Social Support Scale, Social Athletic Readjustment Rating Scale (SARRS), and Profile of Mood States (POMS) were administered. Internal consistency of the self-report measures was tested using Cronbach's alpha coefficient. Injury rate and severity were recorded by the head student therapist throughout the season.

Results: Correlational analyses performed using Pearson correlational coefficient revealed that competitive anxiety ($r = .29$, $p = .03$) and tension/anxiety mood states ($r = .43$, $p = .001$) were related to injury frequency, and that tension/anxiety ($r = .44$, $p = .008$), anger/hostility ($r = .30$, $p = .02$), and total negative mood state ($r = .28$, $p = .038$) were related to injury severity. Individually, the two sports yielded somewhat different results: for football, injury frequency and injury severity were related to tension/anxiety ($r = .43$, $p = .004$ and $r = .47$, $p = .002$, respectively). Vigor/activity was found to be significantly related to injury rate ($p = .02$), but since the internal consistency of vigor/activity was less than .70 on the Cronbach alpha scale, this significant finding was disregarded. In rugby, injury frequency was related to tension/anxiety ($r = .58$, $p = .04$) and depression/dejection ($r = .57$, $p = .04$).

Conclusions: These findings are useful for athletic trainers in identifying athletes who may possess psychological factors predisposing them to athletic injury. Subsequently, athletic trainers can instruct these athletes or refer them for assistance in psychological preventive interventions.

Key Words: Sport Competition Anxiety Text, Social Support Scale, Social Athletic Readjustment Rating Scale, Profile of Mood States.

The purpose of this study was to investigate the relationship among stress, competitive anxiety, mood state, social support, and athletic injury. Specifically, it was hypothesized that football and rugby varsity athletes reporting high levels of stress and competitive trait anxiety would exhibit greater incidence of injury and injury severity. It was also hypothesized that high competitive trait anxiety and negative mood states would contribute to the increase of injury rate and/or severity. Moreover, it was hypothesized that a healthy social support system would aid in dealing with life stress and, therefore, decrease the rate and severity of injury.

Sport injury can be one of the most traumatic events a competitive athlete faces during his or her career. Athletic trainers are responsible, not only for rehabilitation of the athlete, but also for prevention of injury. Therefore, athletic trainers should identify possible causes of athletic injury. Many factors can attribute to athletic injury such as environment, equipment, and physical condition of the athlete.[7] There is a growing realization that psychological factors, such as stress and anxiety, may also play a role in the frequency and extent of injury.[2,7,8,11] For this reason, it is important for athletic trainers, in an attempt to prevent injury, to identify the psychological factors that are related to athletic injury.

Based on the history of research in this field Andersen and Williams[1] proposed a model of stress and athletic injury that attempts to incorporate all possible intervening factors. This model suggests that when an athlete is faced with a potentially stressful athletic situation, there is a resultant stress response.[1] The body's response to the potentially injurious situation is a cognitive appraisal of the demands, resources, and consequences, followed by physiologic and attentional changes.[1] These physiologic and attentional changes may include increased muscle tension, narrowing of the visual field, and increased distractibility, which may have a negative impact on the stress-injury response.[1,13] The stress-injury response can be influenced by personality, coping resources, and psychological interventions, such as cognitive restructuring, distraction, desensitization, and relaxation skills.[1,5,8]

METHOD

Subjects

A total of 55 male varsity athletes from a major Canadian university participated in the study. The group comprised 42 varsity football players and 13 varsity rugby players, ranging in

Lynn Lavallée and **Frances Flint** are affiliated with York University School of Physical Education, 4700 Keele Street, Toronto, ON, Canada M3J 1P3.

age from 19 years to 28 years, with a mean age of 22 years. The relatively small sample size was due to the voluntary nature of the study. Eighty-one percent of the football team and 74% of the rugby team participated.

Procedure

The study was explained to all participants and then informed consents were signed. The inventories—Sport Competition Anxiety Test (SCAT),[9] Social Support Scale,[6] Social Athletic Readjustment Rating Scale (SARRS),[3] and Profile of Mood States (POMS)[10]—were administered before the end of the season. Due to the voluntary nature of the study and an attempt to obtain a greater sample size, inventories were accepted throughout the season. SCAT and POMS are general inventories that measure traits and do not fluctuate as immensely with life events as SARRS or the Social Support Scale.[3,6,9,10] Therefore, time of administration of the SCAT and POMS inventory is not as sensitive as the SARRS or Social Support Scale. Optimally, to allow for changes in life events, inventories should be administered before the season, at the time of injury, and at the end of the season.

Injury Recording

Recording of injuries for both sports was performed by the head student therapist of each sport according to Reid's[12] classification of injuries, specifically, Grade I, Grade II, and Grade III injuries. Contact with the student therapists for minor treatments such as blisters and prophylactic taping was not recorded. All other Grade I, Grade II, and Grade III injuries were included in the study. Some of the previous research in this field[5,7] measured injury severity by number of days missed practicing or in games, but these can be influenced by individual differences in physical and emotional responses to injury. Reid's classification of injury takes the actual injury severity into account rather than simply days of practice missed. The classification system used in this study is representative of each specific injury and attempts to rule out other possible factors that may influence days missed.

Self-Report Measures

Competitive Trait Anxiety. Competitive trait anxiety was measured by Martens'[9] Sport Competition Anxiety Test (SCAT). The SCAT is a 15-item inventory with scores ranging from 10 (low) to 30 (high). A higher score represents a higher level of trait anxiety. The SCAT has been found to have a high internal consistency ($r = .95$). Concurrent validity for SCAT is difficult to measure due to the inability to relate to other sport anxiety measures versus general anxiety ($r = .28$ to $.46$).

Social Support. Social support was measured by the Social Support Scale.[6] The seven items of the questionnaire include parents, other family members, friends, coaches, sport injury staff, instructors/professors, and teammates. Subjects determine satisfaction of perceived social support ranging from 1–5 on a Likert-type scale. A higher score represents a greater degree of satisfaction with social support.

Life Stress. The Social Athletic Readjustment Rating Scale (SARRS) was used to measure life stress.[3] SARRS lists 57 life events, giving different weighting depending on the severity of the stressor, ranging from 0–100. A total SARRS score is derived by summing all different stressors experienced during the last 12 months. The SARRS score reflects the amount of readjustment required by the subject to adapt to the life change. A higher score indicates a higher level of stress in the life of the subject. The SARRS does not distinguish eustress from distress. Internal consistency is relatively low ($r = .42$).

Mood State. Mood state was measured by the Profile of Mood States (POMS) inventory.[10] POMS measures six mood or affective states: tension/anxiety, depression/dejection, anger/hostility, vigor/activity, fatigue/inertia, and confusion/bewilderment. A total mood score, either negative or positive, can be determined by summing all the scores. Sixty-five, five-point Likert-type scales describe the mood states. Internal consistency is very high ($r = .90$).

RESULTS

A number of statistical analyses were conducted to address the research questions of the study. First, the internal consistency of the self-report measures used in the present study was tested using Cronbach's[4] alpha coefficient. Second, all injury data for the 1993–94 school year for the involved athletes were tabulated. Third, correlational analyses were performed using a Pearson correlational coefficient.

Reliability of Measures

The internal consistency reliability of SCAT and POMS were evaluated using Cronbach's[4] alpha coefficient. An alpha value of .70 or higher is considered to be an acceptable indication of scale reliability.[4] Therefore, only those scales with alpha values of .70 or higher were retained for further analysis. Both SCAT and POMS total negative mood states were found to have acceptable internal consistency. SARRS and the individual measures of vigor/activity and confusion/bewilderment of POMS were found to have unacceptable internal consistency; therefore, these results were disregarded.

Injury Data Analysis

Throughout the season, a total of 67 injuries were recorded for the football and rugby athletes who participated in the study. A total of 54 injuries were reported for football. Ten athletes (24%) were injury free, 16 athletes (38%) sustained only one injury, 10 athletes (24%) sustained two injuries, and six athletes (14%) sustained three or more injuries. Seventeen injuries were classified as Grade I, 11 injuries were classified as Grade II, and only four injuries were classified as Grade III. Most of the injuries were a result of direct contact (contusions, brachial plexus stretches, knee ligament sprains) followed by overuse-type injuries (shin splints, tendonitis, and muscular strains).

A total of 13 injuries were reported for rugby. Five athletes (38%) did not sustain any injuries, four athletes (31%) sustained only one injury, three athletes (23%) sustained two injuries, and one athlete (8%) sustained three or more injuries. Four injuries were classified as Grade I, three injuries were classified as Grade II, and only one injury was classified as Grade III. As with football, most of the injuries were a result of direct contact followed by overuse-type injuries. The frequency and grade of injury between the two sports of rugby and football were relatively comparable.

Correlational Analysis

Correlation analysis was performed using a Pearson correlation coefficient. Significant findings were obtained for football and rugby combined and individually.

Injury rate was significantly correlated to SCAT ($r = .29$, $p = .03$). This correlation is considered weak at $r = .29$. In this study, a higher score on SCAT was related to a higher rate of injury. Those athletes exhibiting high competitive trait anxiety had a higher rate of injury.

Injury rate was also significantly related to tension/anxiety on the POMS scale ($r = .43$, $p = .001$). This correlation was moderate at $r = .43$. A reported higher degree of tension/anxiety was significantly related to a higher rate of injury. Those athletes reporting high tension/anxiety had a higher rate of injury.

Severity of injury was significantly related to tension/anxiety ($r = .44$, $p = .008$) and anger/hostility ($r = .30$, $p = .02$) and total negative mood state ($r = .28$, $p = .038$) on the POMS. Tension/anxiety was moderately correlated at $r = .44$ and the correlation of anger/hostility and total negative mood state was weak at $r = .30$ and $r = .28$, respectively. A higher degree of tension/anxiety, anger/hostility, and total negative mood state was significantly related to higher severity of injury. Thus, those athletes reporting greater tension/anxiety, greater anger/hostility, and negative mood state experienced greater severity of injury.

Social support was significantly negatively related to tension/anxiety ($r = -.32$, $p = .027$) on the POMS. This correlation was moderate at $r = -.32$. The greater the satisfaction the athlete felt with social support, the lower the degree of tension/anxiety. This finding is quite significant due to the correlation found between tension/anxiety and injury. A greater satisfaction with social support may have an indirect effect on injury rate, due to influence on tension/anxiety mood state. Confusion was also found to be significantly related to social support at $p = .03$, but due to the unacceptable internal consistency as measured by Cronbach alpha, these findings were disregarded.

SCAT was significantly related to tension/anxiety ($r = .30$, $p = .027$), anger/hostility ($r = .37$, $p = .004$), and total mood state score ($r = .31$, $p = .02$). These correlations were moderate at $r = .30$ for tension/anxiety and $r = .37$ for anger/hostility. A high SCAT score was significantly related to a high tension/anxiety, anger/hostility, and total negative mood state score. Thus, those athletes exhibiting high competitive trait anxiety also had a greater degree of tension/anxiety, anger/hostility, and total negative mood state.

Individually, the sports of rugby and football were found to have similar results. For football, consistent with the findings of both sports combined, tension/anxiety was significantly related to injury rate and severity of injury ($r = .43$, $p = .004$ and $r = .47$, $p = .002$, respectively). These correlations were considered moderate. Vigor/activity was also found to be significantly related to injury rate ($p = .02$), but since the internal consistency of vigor/activity was less than .70 on the Cronbach alpha scale, this significant finding was disregarded. A higher rate and severity of injury was significantly related to a reportedly higher degree of tension/anxiety. Those football players who were under greater tension/anxiety experienced a greater frequency and severity of injury.

For rugby, the rate of injury was significantly related to tension/anxiety ($r = .58$, $p = .04$), but severity of injury was not significantly related to tension/anxiety as was found with football and both sports combined. Rather, depressed/dejected mood state was significantly related to rate of injury ($r = .57$, $p = .04$), which was not found in football or both sports combined. These correlations were considered moderate. A higher rate of injury was significantly related to a higher degree of tension/anxiety and depressed/dejected mood state. Those rugby players under greater tension/anxiety and a depressed/dejected mood state experienced a higher frequency of injury.

DISCUSSION

In support of Andersen and Williams'[1] model, high competitive trait anxiety and tension/anxiety were found to be significantly related to rate of injury, while tension/anxiety, anger/hostility, and total negative mood state were significantly related to severity of injury. High competitive trait anxiety (SCAT) also played a significant role in the degree of tension/anxiety, anger/hostility, and total negative mood state recorded by POMS.

The fact that no relationship was found between life stress and athletic injury may be due to SARRS, the inventory used to assess life stress. The Spearman rank-order correlation coefficient of SARRS reported by Bramwell et al[3] is quite low ($r = .42$). SARRS was altered from SRRS in 1975 to better fit the athletic population. Even in 1975 there were shown to be significant differences in the individual's perception of adjustment for certain life events, particularly between ethnic populations.[3] SARRS was designed over 20 years ago, and since that time views toward many life events such as marriage, divorce, and discrimination have changed dramatically. It is suggested that SARRS may not be the ideal inventory to assess life stress. Rather, due to multicultural and societal differences, an inventory should allow the individual to assess how much adaptation he or she feels is required for specific events that have been encountered.

The differences between the sports of football and rugby were not dramatic. Football players under greater tension/anxiety as measured by POMS experienced a greater frequency and severity of injury. Rugby players under greater tension/anxiety and a depressed/dejected mood state experienced a higher frequency of injury, but not a greater severity of injury. It is suggested that the lack of significance found with severity of injury can be explained by the typical "downplaying" of injury by rugby players in order to stay in the game.

Social support alone did not significantly alter frequency and severity of injury, but expression of greater satisfaction with social support correlated with a lower degree of depression/dejection as measured by POMS. This finding is quite significant given the fact that depression/dejection was found to be positively related to injury rate in rugby players. With a sound base of social support there is a reported lower degree of depression, which may have had a protective effect.

The effect of tension/anxiety, depressed/dejected mood state, anger/hostility, total negative mood state, and competitive anxiety on increased frequency and severity of injury can be interpreted in light of Andersen and Williams' model.[1] Andersen and Williams suggest that physiologic responses to stress and anxiety, such as increases in muscle tension and physical fatigue, may heighten the relationship between psychological stress and physical injury. This may also be expanded to include tension/anxiety, anger/hostility, depressed/dejected mood state, and total negative mood state. A higher total negative mood state may also contribute to increased muscle tension and physical and mental fatigue, which may promote the relationship between psychological stress and physical injury.[1]

PRACTICAL IMPLICATIONS

These findings add information to a growing body of literature that points to the contribution of psychological factors in the incidence of athletic injuries sustained in university sport. Thus, a new dimension can be added to the Andersen and Williams[1] model. Andersen and Williams[1] emphasize that information gained from research into the stress-injury response should not be used to label athletes as "injury-prone." Rather, as found by Davis,[5] the findings should serve to allow identification of high-risk athletes who may be aided by psychological intervention such as mental imagery and relaxation techniques.

It is very difficult to conduct a study including all possible variables that may influence rate and severity of injury. All research performed in the realm of the stress-injury response contributes to the Andersen and Williams[1] model. Although many causal factors have been suggested, further research in the stress-injury relationship is needed to support past findings, identify new determinants, and identify psychological intervention techniques.

Athletic trainers, medical personnel, coaches, and athletes should recognize possible psychological predisposing factors of injury and aim to instruct or refer the athlete for assistance in methods outlined in the Andersen and Williams[1] model. Psychological interventions such as cognitive restructuring, thought stoppage, and relaxation skills may be instrumental in reducing the incidence of injury in sport.[5,7]

ACKNOWLEDGMENTS

I thank Dr. Frances Flint for her guidance in advising me on my undergraduate thesis, the coach of Varsity Football and Varsity Rugby for allowing me to administer my inventories to the athletes, and the athletes at York University who participated in the study.

REFERENCES

1. Andersen MB, Williams JM. Psychological risk factors and injury prevention. In: Heil J, ed. *Psychology of Sport Injury*. Champaign, IL: Human Kinetics; 1993:49–55.
2. Blackwell B, McCullagh P. The relationship of athletic injury to life stress, competitive anxiety and coping resources. *J Athl Train*. 1990;25:23–27.
3. Bramwell ST, Masuda M, Wagner NN, Holmes TH. Psychological factors in athletic injuries: development and application of the Social and Athletic Readjustment Rating Scale (SARRS). *J Hum Stress*. 1975;1:6–20.
4. Cronbach LJ. Coefficient alpha and the internal structure of tests. *Psychometrika*. 1951;16:297.
5. Davis JO. Sports injuries and stress management: an opportunity for research. *Sports Psychol*. 1991;5:175–182.
6. Flint F. Psychological reaction to athletic injury and return to competition considerations. Presented at the annual meeting of the Association for the Advancement of Applied Sport Psychology; October, 1992; Montreal, CAN.
7. Heil J. *Psychology of Sport Injury*. Champaign, IL: Human Kinetics; 1993:49–55.
8. Kerr G, Fowler B. The relationship between psychological factors and sport injuries. *Sports Med*. 1988;6:127–134.
9. Martens R. *Sport Competition Anxiety Test*. Champaign, IL: Human Kinetics; 1977:53.
10. McNair DM, Lorr M, Droppleman LF. *Profile of Mood States*. San Diego, CA: Educational and Industrial Testing Service; 1971.
11. Petrie TA. Psychosocial antecedents of athletic injury: the effects of life stress and social support on women collegiate gymnasts. *Behav Med*. 1993;18:127–138.
12. Reid DC. *Sport Injury Assessment and Rehabilitation*. New York, NY: Churchill-Livingston Inc.; 1992.
13. Williams JM, Tonymon P, Andersen MB. The effects of stressors and coping resources on anxiety and peripheral narrowing. *J Appl Sport Psychol*. 1991;3:126–141.

Effect of Mild Head Injury on Postural Stability in Athletes

Kevin M. Guskiewicz, PhD, ATC; David H. Perrin, PhD, ATC; Bruce M. Gansneder, PhD

Objective: Athletic trainers and team physicians are often faced with the dilemma of when to return athletes to participation following mild head injury. Unfortunately, clinicians rarely have quantitative information on which to base their decisions. The purpose of this investigation was to identify postural stability changes in athletes with acute mild head injury.

Design and Setting: High school and college male athletes were prescreened for postural stability before the start of their season. Subjects suffering injury during the season returned for testing on days 1, 3, 5, and 10 following injury, and 1 month postseason. Control subjects were selected for comparisons.

Subjects: Ten prescreened subjects (age = 17.4 ± 2.2 yr; ht = 183.8 ± 8.1 cm; wt = 87.7 ± 17.3 kg) returned for testing following an injury. Ten matched control subjects (age = 18.6 ± 2.6 yr; ht = 185.7 ± 6.7 cm; wt = 84.5 ± 19.5 kg) were selected for comparisons. Additionally, nine subjects (eight male and one female) (age = 19.9 ± 4.2 yr; ht = 182.3 ± 10.9 cm; wt = 89.6 ± 25.2 kg) who had sustained a mild head injury from other varsity sports teams were recruited. Nine matched controls (age = 22.1 ± 3.3 yr; ht = 181.0 ± 9.9 cm; wt = 84.9 ± 25.6 kg) were again utilized.

Measurements: Sway index and center of balance were measured using the Chattecx Balance System during three eye conditions and three surface conditions for all subjects.

Results: Repeated measures analyses of variance (ANOVA) for each prescreened subject's sway index revealed significant differences between injured subjects and control subjects on day 1 postinjury as compared with the prescreening and/or subsequent tests. The analysis for sway index and center of balance inclusive of all 19 subjects with mild head injury and all 19 control subjects demonstrated increased postural sway compared with control subjects on day 1 postinjury during all platform conditions, and on day 3 during the foam platform condition. The analysis for center of balance using the same subjects revealed that injured subjects maintained their center of balance farther away on day 1 postinjury compared with subsequent tests ($p < .05$).

Conclusions: These findings suggest that computerized dynamic posturography is a useful tool in objectively assessing postural stability in subjects with mild head injuries. Subjects with mild head injury appear to demonstrate impaired postural stability 1 to 3 days following injury. This information should aid clinicians in determining when an athlete can safely return to participation.

Key Words: concussion, balance, postural sway

Returning athletes to competition following mild head injury (MHI) often creates a dilemma for athletic trainers and team physicians. These very important return-to-play decisions are too often based on subjective information gathered from an anxious athlete rather than from sound objective data. Athletes are often returned to activity with doubt still lingering in the mind of the clinician making the decision.

Mild head injury is becoming an increasingly important topic of discussion within the sports medicine community. The National Athletic Trainers' Association's Research and Education Foundation (NATA-REF) held a Mild Brain Injury Summit Roundtable in 1994. Goals of the summit included identifying potential risks for returning to activity following mild head injury, developing more widely accepted guidelines for treatment, and emphasizing the need for research and education in this area.[25]

Despite the considerable amount of protective equipment available to athletes today, the head and brain are still susceptible to injury during athletic competition. A high incidence of mild head injury in contact sports is well documented.[3,5,6,9,28] Gerberich[9] estimated that approximately 250,000 head injuries occur annually in high school football alone and that 20% of all high school football players suffer a concussion every season. Athletic trainers and team physicians are often faced with a difficult decision related to returning these athletes to play, while having little or no quantitative information on which to base the decision. Determination of the severity of injury is sometimes difficult, especially when there is no loss of consciousness or amnesia. Returning an athlete to competition too early has the potential to become a very costly decision–one that could lead to death. According to Cantu[7] many decisions are based simply on the judgment of a physician or athletic trainer.

Changes in simple motor skills[13,15] and postural control[2,14] accompany mild head injury. However, tests used to assess such injuries are criticized for their lack of sensitivity and objectivity. The areas of the brain that are disrupted as a result of a concussion are responsible for the maintenance of equi-

Kevin M. Guskiewicz is assistant professor and director of the Sports Medicine Research Laboratory in the Department of Physical Education, Exercise and Sport Science, The University of North Carolina at Chapel Hill, Chapel Hill, NC. At the time of this study, Dr. Guskiewicz was a doctoral candidate in sports medicine at the University of Virginia, Charlottesville, VA. **David H. Perrin** is professor and director of the program area in health and physical education, Department of Human Services for the Curry School of Education, University of Virginia, Charlottesville, VA. **Bruce M. Gansneder** is a professor in the Curry School of Education, University of Virginia, Charlottesville, VA.

librium.[1,2,12,18–20,29] Other studies[10,11,17] reveal that concussion diminishes cerebral reserve despite apparent recovery and places individuals at risk for more prolonged disability after a second such injury.

Romberg's tests of sensory modality function are frequently used to test "balance" following a head injury. Despite their wide use, there is more to posture control than just balance and sensory modality,[21–24,27,30] especially when assessing people with head injury.[2,14] The purpose of this study was to identify changes in postural stability in athletes with acute mild head injury and to develop a recovery curve based on quantitative measures for determining readiness to return to activity.

METHODS

Seventy college or high school football players between the ages of 15 and 25 years were prescreened during the preseason and first 2 weeks of their season. Players were recruited from all positions but were excluded from participation if they had a history of any severe visual, vestibular, or balance disorders. Athletes having sustained a MHI within the 6 months before testing were also excluded from the study. Ten subjects (age = 17.4 ± 2.2 yr; ht = 183.8 ± 8.1 cm; wt = 87.7 ± 17.3 kg) suffered a mild head injury and returned for testing on days 1, 3, 5, and 10 following injury, and one month postseason. A group of prescreened matched control subjects (age = 18.6 ± 2.6 yr; ht = 185.7 ± 6.7 cm; wt = 84.5 ± 19.5 kg) was selected to compare group differences.

Additionally, we recruited 8 male and 1 female subjects (age = 19.9 ± 4.2 yr; ht = 182.3 ± 10.9 cm; wt = 89.6 ± 25.2 kg) who sustained MHI from other varsity sports teams and a local health center's emergency room. These subjects and a group of matched controls (age = 22.1 ± 3.3 yr; ht = 181.0 ± 9.9 cm; wt = 84.9 ± 25.6 kg) were assessed under the same conditions as prescreened subjects on days 1, 3, 5, and 10 postinjury, and 1 month postseason.

A questionnaire that included the Galveston Orientation and Amnesia Test (GOAT)[17] and a list of 15 possible postconcussion symptoms (eg, headache, disequilibrium, blurred vision, nausea, etc) was also administered to the injured subjects within the first 8 hours following injury.

Measuring Device

We measured postural sway using the Chattecx Balance System (Chattanooga Group, Inc., Chattanooga, TN). This instrument measures vertical reaction forces using four electronic pressure transducers placed under the medial and lateral aspects of the heel and forefoot (Fig 1). The distribution of pressure over the forefoot plates shows fluctuations in weight distribution that reflect the amount of postural sway and the direction of postural sway in the forward/backward and left/right directions. Computer analysis calculates the center of balance (COB), which is the average X and Y coordinates plotted using the "normal" COB (where X = 0 and Y = 0) as a reference point.[8] The Pythagorean formula was used to calculate the distance in centimeters of the subject's COB from the "normal" COB.

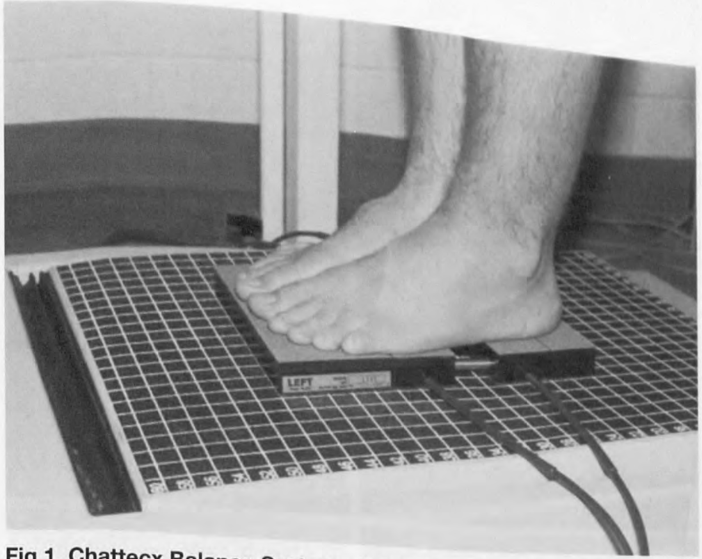


Fig 1. Chattecx Balance System allows for assessment of postural sway using four electronic pressure transducers placed under the medial and lateral aspects of the heel and forefoot.

Deviation from the COB in any direction represents postural sway, measured by the sway index (SI). Sway index (in centimeters) reflects the degree of scatter of data about the subject's center of balance. The force platform measurements are interfaced with software that filters data collected at 100 Hz so that they can be sampled and analyzed at approximately 15 Hz. Extraneous high-frequency sway oscillations are virtually eliminated using this technique. Each subject's COB and SI were measured as a representation of postural sway under the nine testing conditions (Table 1). Byl and Sinnott[4] investigated intratester and intertester reliability of the instrument and reported correlation coefficients of .92 and .90, respectively.

Protocol

Although subjects received no visual feedback during conditions 1 through 9, we provided a practice trial before testing that allowed them to observe their postural sway on the monitor in all four directions. We explained that the goal was to remain in an upright position, while attempting to minimize sway. Shoes and/or socks were removed before testing. The force plates were adjusted to fit the subjects' feet. The force plates were placed together, which allowed the subjects to assume the Romberg position (Fig 2a).

The first nine testing conditions involved 20-second Romberg tests while standing on the force transducers under

Table 1. Balance Testing Conditions Used to Isolate Sensory Modalities

1. Eyes open, normal stable platform
2. Blindfolded, normal stable platform
3. Visual-conflict dome, normal stable platform
4. Eyes open, foam-padded stable platform
5. Blindfolded, foam-padded stable platform
6. Visual-conflict dome, foam-padded stable platform
7. Eyes open, normal plantar/dorsiflexion dynamic platform
8. Blindfolded, normal plantar/dorsiflexion dynamic platform
9. Visual-conflict dome, normal plantar/dorsiflexion dynamic platform

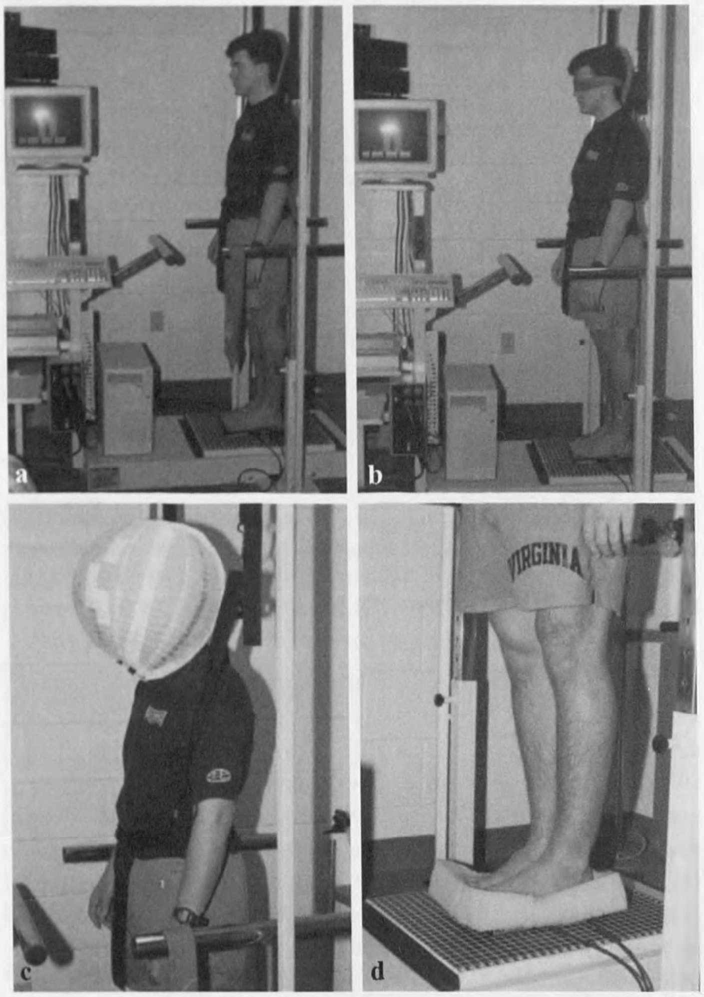


Fig 2. a) Subject tested with eyes open on a normal, stable platform; b) Subject tested with eyes blindfolded; c) Subject tested wearing visual-conflict dome; d) Subject tested on a foam platform.

varying degrees of sensory input disruption. We instructed subjects to remain as motionless as possible as they performed two trials for each condition. We used the better of the two scores for data analysis. The testing conditions were randomly administered to avoid a learning effect.

The technique uses combinations of three visual and three support-surface conditions (Table 1). Altered visual conditions include the use of a blindfold (Fig 2b) for eliminating visual input and a visual-conflict dome (Fig 2c) for producing inaccurate vestibular and visual input.[30] During the visual-conflict conditions, we instructed the subjects to stare directly at the "X" placed on the inside of the dome, approximately 10 cm from the face. Under normal visual conditions, we asked the subjects to focus on an "X" placed on a wall approximately 3 m in front of their faces. The altered support surface conditions included the use of a compliant section of medium-density foam placed between the force transducers and the feet to reduce accuracy of proprioceptive feedback (Fig 2d). Angular perturbations of the Balance System's platform were also used for three of the conditions. This produces a plantar flexion/dorsiflexion movement pattern, which also alters proprioceptive feedback about the joints of the ankle, knee, and hip.

Data Analysis

Two separate, mixed-model (1 between, 3 within), repeated measures analyses of variance (ANOVA) for sway index and center of balance were used to determine if significant differences existed for the two data sets. These analyses determined if significant differences existed across *groups* (between) and *day, eye condition, and platform condition* (within) for both measures of stability. The goal was to determine if changes in the dependent variables SI and COB with time (days following injury) and with alterations to sensory input (visual, vestibular, somatosensory) were dependent on group.

RESULTS

Descriptive statistics for subject characteristics are presented in Tables 2 and 3. Of the 19 MHI subjects, all but three suffered football-related injuries. Selection of the matched control subjects was based on a combination of baseline sway measures, sex, age, height, weight, and activity level. Level of significance ($p < .05$) was set a priori for all statistics.

Prescreened MHI and Control Subjects

The ANOVA for SI revealed a significant interaction for group by day by platform, $F(10,180) = 4.24$ (Fig 3). Additional significant two-way interactions were found for group by day, $F(5,90) = 7.09$; day by eyes, $F(10,180) = 1.87$; day by platform, $F(10,180) = 10.65$; and eyes by platform, $F(4,72) = 75.76$. Tukey post hoc analysis revealed that sway index differences >.30 cm represented significantly more postural sway, as shown in Figure 3. Significant main effects were revealed for day, eyes, and platform. Tukey post hoc analysis, however, indicated that while there were group differences on day 1 postinjury, there were no group differences after day 1. Similarly, while MHI subjects' sway measures significantly increased preinjury to postinjury, their performance returned to baseline around day 3 or day 5 postinjury. The ANOVA for COB revealed no significant group interactions ($p > .05$).

Combined Prescreened and Nonprescreened MHI and Control Subjects

The ANOVA for SI revealed a significant interaction for group by day by platform, $F(8,288) = 3.36$ (Fig 4). Additional

Table 2. Descriptive Statistics for Characteristics of Prescreened Subjects (n = 10) with Mild Head Injury (MHI) and Prescreened Control Subjects (n = 10)

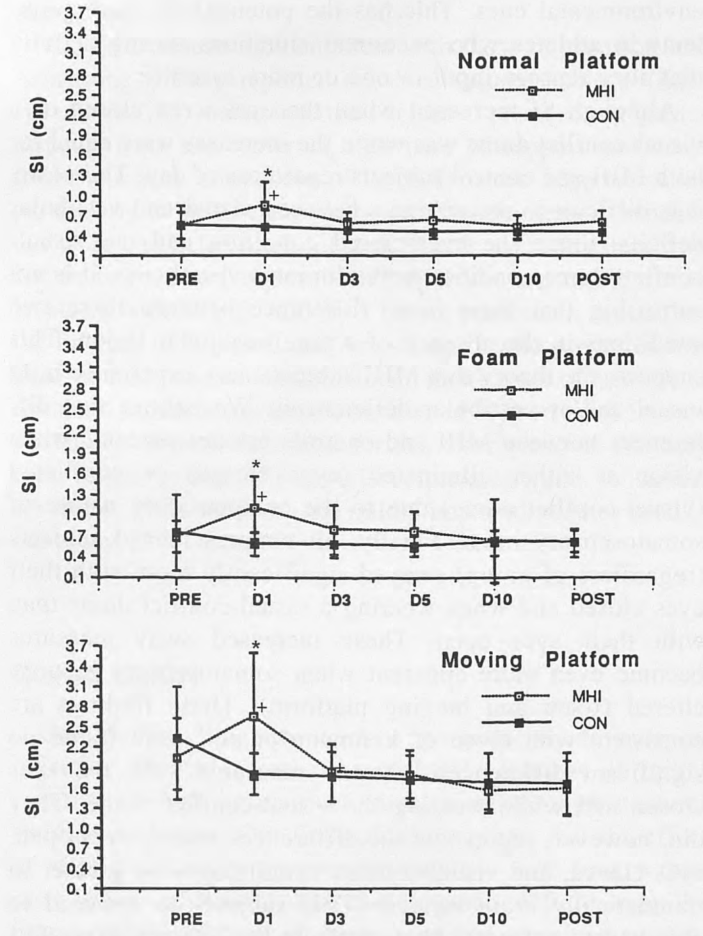
Variable	MHI	Control
Age (yr)	17.4 ± 2.2	18.6 ± 2.6
Height (cm)	183.8 ± 8.1	185.7 ± 6.7
Weight (kg)	87.7 ± 17.3	84.5 ± 19.5
GOAT Score*	94.5 ± 6.4	N/A‡
No. Postconcussion Sympt.†	5.60 ± 1.9	N/A

* Galveston Orientation & Amnesia Test = 10-item, 100-point questionnaire testing for amnesia administered immediately following injury[17]
† Number of postconcussion symptoms present during first 24 hours postinjury (15 possible)
‡ N/A, not applicable

Table 3. Descriptive Statistics for Characteristics of Nonprescreened Subjects (n = 9) with Mild Head Injury (MHI) and Nonprescreened Control Subjects (n = 9)

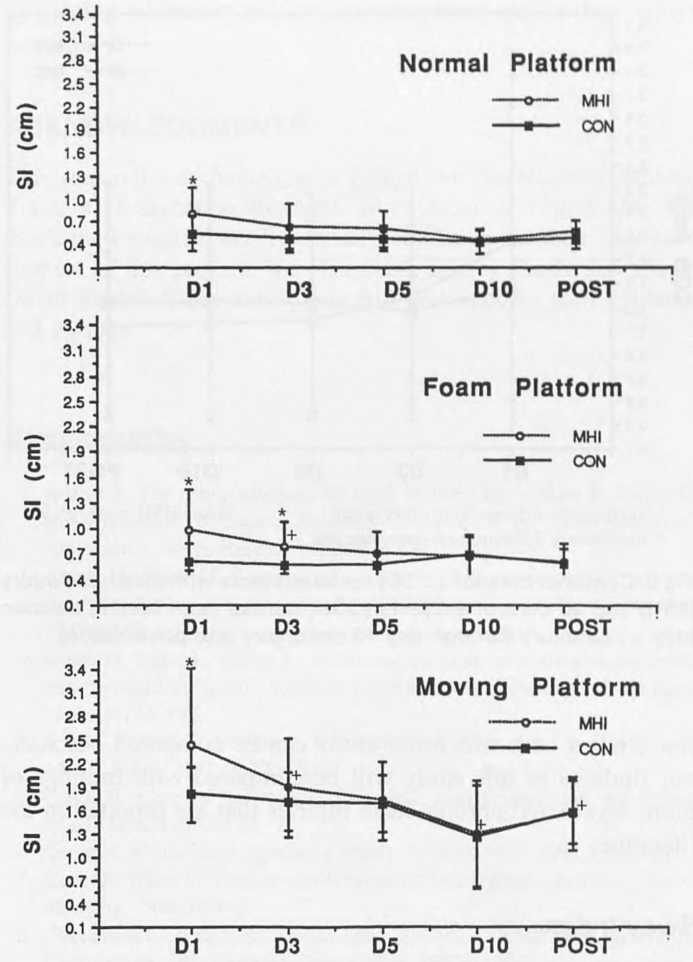
Variable	MHI	Control
Age (yr)	19.9 ± 4.2	22.1 ± 3.3
Height (cm)	182.3 ± 10.9	181.0 ± 9.9
Weight (kg)	89.6 ± 25.2	84.8 ± 25.6
GOAT Score*	91.2 ± 7.7	N/A‡
No. Postconcussion Sympt.†	6.1 ± 1.4	N/A

* Galveston Orientation & Amnesia Test = 10-item, 100-point questionnaire testing for amnesia administered immediately following injury[17]
† Number of postconcussion symptoms present during first 24 hours postinjury (15 possible)
‡ N/A, not applicable



+ significantly different from preceding test
* significantly different from other group
Tukey HSD = .30, p<.05

Fig 3. Sway Index means (± SD) for prescreened subjects with mild head injury (MHI) and control subjects (CON) across each testing session (preseason, day 1 postinjury through day 10 postinjury, and postseason).



+ significantly different from preceding test
* significantly different from other group
Tukey HSD = .21, p<.05

Fig 4. Sway Index means (± SD) for all subjects with mild head injury (MHI) and all control subjects (CON) across each testing session (day 1 postinjury through day 10 postinjury and postseason).

significant two-way interactions were found for group by day, $F(4,144) = 6.74$; day by eyes, $F(8,288) = 23.92$; day by platform, $F(8,288) = 25.85$; and eyes by platform, $F(4,144) = 62.32$. The ANOVA for COB revealed a significant interaction for group by day, $F(4,144) = 3.06$ (Fig 5).

DISCUSSION

The most important finding in this study is that athletes may have sensory integration problems during the first few days following mild head injury. The overall results of our study indicate that athletes with acute mild head injury demonstrate significantly more postural sway up to 3 days following injury. Additionally, athletes with mild head injury demonstrate increased postural sway up to 3 days postinjury as compared with matched control subjects. The results suggest that injured athletes return to baseline approximately day 3 to day 5 following injury and eventually mimic the improved scores of control subjects about day 10 following injury (Figs 3 & 4). Furthermore, the differences between MHI and control subjects are most evident when sensory input is altered through the inclusion of foam padding on the force transducers or when the platform is perturbed in a plantar flexion/dorsiflexion direction (Figs 3 & 4). Finally, although GOAT scores for injured subjects averaged only 5.50 and 8.78 points lower than noninjured subjects (Tables 2 and 3), differences in balance between the injured and noninjured subjects were more obvious. Thus, the decision to return athletes to participation based solely on cognitive tests such as the GOAT may not be as accurate.

Our study is unique in that it studied the effect of *acute* mild head injury on postural stability. Unfortunately, there are very

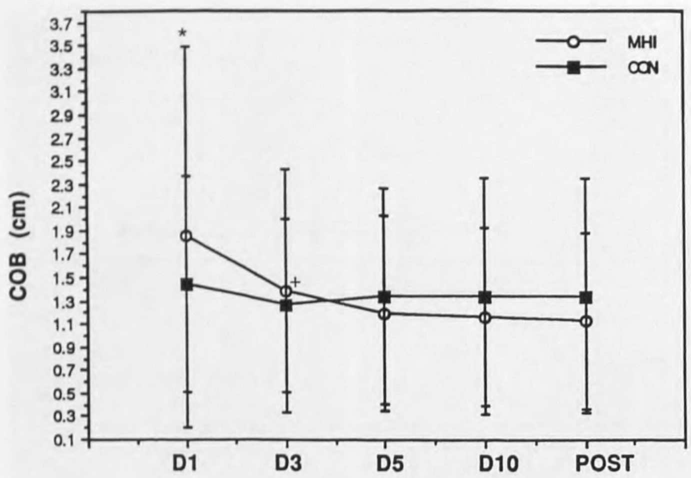


Fig 5. Center of balance (± SD) for all subjects with mild head injury (MHI) and all control subjects (CON) across each testing session (day 1 postinjury through day 10 postinjury and postseason).

few studies with which our study can be compared. As such, our findings of this study will be compared with findings of more severe and chronic head injuries that are reported in the literature.

Sway Index

Our findings for prescreened subjects (Fig 3) and combined subjects (Fig 4) are the most intriguing. The results suggest that MHI subjects sway significantly more than control subjects on day 1 following injury. This difference is greater during conditions where somatosensory input is altered. For example, the moving platform produced greater differences between the two groups than the foam platform, whereas the foam platform produced greater differences than the normal platform. MHI subjects also swayed significantly more on day 1 following injury than they swayed at preseason or on subsequent tests after day 1.

The set of data combining prescreened subjects with nonprescreened subjects increased the sample from 10 to 19 and revealed significant group differences at day 3 that were not evident in the original set of prescreened subjects. The advantage of combining the data is that doubling the number of subjects improves the statistical power; thus, smaller differences between groups may be considered significant. The disadvantage of combining these subjects is that baseline preseason measures taken on 10 of the subjects are eliminated for comparison purposes. Nevertheless, the differences between MHI subjects and control subjects can be seen for as long as 3 days following injury on a foam platform (Fig 4). MHI subjects gradually regained stability around day 5 postinjury, at which time they demonstrated a trend similar to control subjects.

The increased postural sway we found during conditions where somatosensory input was confounded suggests that MHI subjects experience sensory modality interaction problems up to 3 days postinjury. In uninjured people, the vestibular, visual, and somatosensory systems work together to control postural stability. In people with mild head injury there appears to be a communication or interaction problem that prevents the vestibular and/or visual systems from compensating for altered somatosensory (proprioceptive) feedback during the foam and moving platform conditions. Newton[26] and Shumway-Cook and Horak[30] state that sway patterns are based on the assumption that stability scores reflect the interaction of sensory systems. If a subject has difficulty balancing under conditions in which sensory modalities have been altered, it can be hypothesized that the subject is unable to ignore altered environmental conditions and therefore selects a motor response based on the altered environmental cues. This has the potential to cause problems in athletes who encounter situations during activity that alter sensory input to one or more systems.

Although SI increased when the eyes were closed or a visual-conflict dome was worn, the increases were equal for both MHI and control subjects regardless of day. Therefore, it is difficult to discriminate between visual and vestibular deficits. Since the eyes-closed condition and the visual-conflict-dome condition both eliminate visual cues, it is not surprising that there is no difference between these two conditions in the absence of a pure vestibular lesion. This supports the theory that MHI subjects may experience mild visual and/or vestibular deficiencies. We believe that differences between MHI and controls are not revealed when vision is either eliminated (eyes closed) or conflicted (visual-conflict dome) due to the compensatory nature of somatosensory input. Finally, all nonprescreened subjects (regardless of group) swayed significantly more with their eyes closed and when wearing a visual-conflict dome than with their eyes open. These increased sway measures become even more apparent when somatosensory input is altered (foam and moving platform). These findings are consistent with those of Lehmann et al,[16] who found no significant differences in sway measured with the eyes closed and while wearing the visual-conflict dome. They did, however, report that the differences among eyes-open, eyes-closed, and visual-conflict conditions were greater in traumatically brain injured (TBI) subjects as opposed to able-bodied subjects. They attribute the differences to TBI patients' relying more on visual cues from the environment than able-bodied subjects. Our study did not reveal these same group-by-eye interactions. Therefore, MHI subjects evidently do not rely as much on visual cues as TBI subjects. A better explanation might be that TBI patients, unlike MHI patients, do not have adequate somatosensory input to compensate for visual or vestibular deficits.

Our findings on altered platform surfaces are also consistent with those of Lehmann et al,[16] who reported that the difference between standing on a solid support and standing on foam is greater in the TBI population than in the able-bodied population. Our MHI subjects swayed significantly more than control subjects on day 1 postinjury (all three support surfaces) and on day 3 postinjury (on the foam surface) (Fig 4). Furthermore, the differences between groups increased as somatosensory input became more confounded (moving > foam > normal).

Center of Balance

The set of data inclusive of all 19 MHI subjects and all 19 control subjects best represents COB changes following head injury. Our results suggest that MHI subjects maintain their COB significantly farther away from their base of support (normal COB) on day 1 following injury than do control subjects (Fig 5). Additionally, MHI subjects appear to recover on day 3 following injury, since they are able to position themselves significantly closer to their ideal COB compared to day 1.

The COB results are consistent with those of Ingersoll and Armstrong.[14] They reported that head-injured subjects (injury > 1 year old) maintained their center of pressure at a greater distance from the center of their base of support and made fewer postural corrections. The differences reported were particularly evident when one or more of the sensory modalities were conflicted or eliminated. This is also consistent with our findings. The fact that MHI subjects returned to baseline levels on both SI and COB by 1 month postseason contradicts the findings of Ingersoll and Armstrong,[14] who suggested that head-injured patients could maintain their center of pressure at distances farther away from their base of support up to 9 years postinjury. A possible reason for this discrepancy is that they used several grades of head-injured patients (mild, moderate, severe) as compared with the mildly impaired athletes used in our study.

CONCLUSION

Our findings suggest there is potential to develop an objective clinical assessment of MHI in terms of initial severity as well as residual impairment through postural stability measures. Our findings also suggest that the effect of mild head injury on postural stability lasts longer than just 1 day postinjury and that balance deficits may be present in the absense of amnesia and/or other postconcussion symptoms.

Unfortunately, most clinicians do not have postural stability systems available. However, these findings can still be helpful in making decisions related to safely returning athletes to participation following a mild head injury. First and foremost, athletes sustaining a MHI should not be permitted to return to activity until all postconcussive symptoms have resolved. An athlete returning to contact sports before meeting these standards may be at risk for suffering second-impact syndrome. Unfortunately, most of the measures taken before making this decision are very subjective. Therefore, without the luxury of having a stability system, clinicians should consider holding athletes out of participation for at least 3 days following a MHI (assuming all other signs and symptoms have resolved). Clinicians should seriously consider whether or not they might be placing athletes at risk by returning them earlier than 3 days postinjury.

ACKNOWLEDGMENTS

This research was funded by a grant from the National Athletic Trainers' Association Research and Education Foundation. We thank the Research and Education Foundation for their continued support of this project. We also thank Jeffrey Barth, Joe Gieck, David Kahler, Ethan Saliba, and Bill Webright for their guidance and support.

REFERENCES

1. Adams J. The neuropathology of head injuries. In: Vinken P, Bruyn G, eds. *Handbook of Clinical Neurology: Injuries of the Brain and Skull.* Amsterdam: North-Holland Publishing Co; 1975:35–65.
2. Arcan M, Brull M, Najenson T, Solzi P. FGP assessment of postural disorders during the process of rehabilitation. *Scand J Rehabil Med.* 1977;9:165–168.
3. Bruce D, Schut L, Sutton L. Brain and cervical spine injuries occurring during organized sports activities in children and adolescents. *Prim Care.* 1982;11:175–194.
4. Byl N, Sinnott P. Variations in balance and body sway in middle-aged adults. *Spine.* 1991;16:325–330.
5. Cantu R. Cerebral concussion in sports: management and prevention. *Sports Med.* 1992;14:64–74.
6. Cantu R. Minor head injuries in sports. *Adolesc Med.* 1991;2:141–154.
7. Cantu R. When to return to contact sports after cerebral concussion. *Sports Med Dig.* 1988;10:1–2.
8. Chattanooga Group, Inc. *The Balance System: Clinical Desk Reference.* Chattanooga, TN: Chattecx Corporation: 1992:4–36.
9. Gerberich S, Priest J, Boen J, Staub C, Maxwell R. Concussion incidences and severity in secondary school varsity football players. *Am J Public Health.* 1983;73:1370–1375.
10. Gronwall D, Wrightson P. Cumulative effect of concussion. *Lancet.* Nov 22, 1975;995–997.
11. Gronwall D, Wrightson P. Delayed recovery of intellectual function after minor head injury. *Lancet.* Sep 14, 1974;605–609.
12. Guyton A. *Textbook of Medical Physiology.* 8th ed. Philadelphia, PA: WB Saunders Co; 1986:610–615.
13. Haaland K, Temkin N, Randahl G, Dikmen S. Recovery of simple motor skills after head injury. *J Clin Exp Neuropsychol.* 1994;16:448–456.
14. Ingersoll C, Armstrong C. The effects of closed-head injury on postural sway. *Med Sci Sports Exerc.* 1992;24:739–742.
15. Klonoff P, Costa L, Snow W. Predictors and indicators of quality of life in patients with closed-head injury. *J Clin Exp Neuropsychol.* 1986;8: 469–485.
16. Lehmann J, Boswell S, Price R, Burleigh A, deLateur B, Jaffe K, and Hertling D. Quantitative evaluation of sway as an indicator of functional balance in post-traumatic brain injury. *Arch Phys Med Rehabil.* 1990;71: 955–962.
17. Levin H. Position paper on mild brain injury. *Proceedings of the Mild Brain Injury in Sports Summit.* Dallas, TX: National Athletic Trainers' Association, Inc; 1994:53–61.
18. Mauritz K, Dichgans J, Hufschmidt A. Quantitative analysis of stance in late cortical cerebellar atrophy of the anterior lobe and other forms of cerebellar ataxia. *Brain.* 1979;102:461–482.
19. McIntosh T, Vink R. Biomechanical and pathophysiologic mechanisms in experimental mild to moderate traumatic brain injury. In: Hoff J, Anderson T, Cole T, eds. *Mild to Moderate Head Injury.* Boston, MA: Blackwell Scientific Publications; 1989:35–45.
20. Mitchell S, Lewis M. Tendon-jerk and muscle-jerk in disease and especially in posterior sclerosis. *Am J Med Sci.* 1886;92:363–372.
21. Nashner L. Adaptation of human movement to altered environments. *Trends Neurosci.* 1982;5:358–361.

22. Nashner L. Adapting reflexes controlling the human posture. *Explor Brain Res.* 1976;26:59–72.
23. Nashner L, Berthoz A. Visual contribution to rapid motor responses during postural control. *Brain Res.* 1978;150:403–407.
24. Nashner L, Black F, Wall C. Adaptation to altered support and visual conditions during stance: patients with vestibular deficits. *J Neurosci.* 1982;2:536–544.
25. National Athletic Trainers' Association Research & Education Foundation. Executive summary: mild brain injury summit roundtable. *Proceedings of the Mild Brain Injury in Sports Summit.* Dallas, TX: National Athletic Trainers' Association, Inc; 1994:2–5.
26. Newton R. Recovery of balance abilities in individuals with traumatic brain injuries. *Balance: Proceedings of the American Physical Therapy Association Forum.* Nashville, TN: APTA; Jun 13–15, 1989:69–72.
27. Norre M. Sensory interaction testing in platform posturography. *Laryngol Otol.* 1993;107:496–501.
28. Ommaya A, Ommaya A, Salazar A. A spectrum of mild brain injuries in sports. *Proceedings of the Mild Brain Injury in Sports Summit.* Dallas, TX: National Athletic Trainers' Association, Inc; 1994:72–80.
29. Saunders R, Harbaugh R. The second impact in catastrophic contact-sports head injury. *J Am Med Assoc.* 1984;252:538–539.
30. Shumway-Cook A, Horak F. Assessing the influence of sensory interaction on balance. *Phys Ther.* 1986;66:1548–1550.

In every game
there's a beginning,
a middle and an end.

So,
how do you keep the middle
from feeling like the end?

As a trainer you know what it takes to keep your
athletes performing at their peak.
From the first quarter to the last.
That's why there's Gatorade.
Because nothing puts back what your athletes lose better
than Gatorade® Thirst Quencher.
It's the optimal formula for a thirst quencher.
More than 25 years of scientific testing has proven it.
To hear why nothing can outperform Gatorade call
1-800-88-GATOR.

LIFE IS A SPORT DRINK IT UP

Gatorade Thirst Quencher

Salary Survey of Certified Athletic Trainers in Delaware, New Jersey, New York, and Pennsylvania

James Somerville, ATC; Michael Stanwood, ATC, CSCS

Objective: The objective of this study was to obtain salary information from certified athletic trainers in District Two of the National Athletic Trainers' Association (NATA) for use as a reference guide to assist entry-level and experienced ATCs interested in obtaining athletic training positions in Delaware, New Jersey, New York, and Pennsylvania.

Design and Setting: Mailed survey, sample of convenience. This study was conducted in the Sports Medicine Department of a children's hospital.

Subjects: A survey was sent to all 2,274 certified members of District Two. Of the surveys mailed, 970 (42.7%) were returned. Of the surveys returned, 725 (74.7%) were from full-time athletic trainers, 105 (10.8%) were from part-time athletic trainers, and 140 (14.4%) were unusable.

Measurements: A survey consisting of 15 questions related to salaries and demographics of the athletic trainers' employment settings.

Results: Forty-eight percent of the respondents were employed in the clinic or hospital setting, and almost 48% of those responding possessed a master's degree. The state with the highest response rate was Pennsylvania with 45% of the total. The highest rate of response according to experience was 27% from athletic trainers having 4 to 6 years of experience. According to practice setting, the lowest mean salary was \$32,928 ± \$10,098 at the college or university level, and the highest was \$59,778 ± \$48,803 at the professional sport level. According to education level, the lowest mean salary was \$30,132 ± \$9,584 (bachelor's degree), and the highest was \$48,070 ± \$12,973 (PT or ATC). The mean salary by state was lowest in Delaware (\$32,330 ± \$12,865) and highest in New Jersey (\$36,695 ± \$12,593). The highest mean salary by years of experience was \$57,308 ± \$30,723 (25 years or more).

Conclusions: Further comparative studies in this area need to be conducted to recognize current trends with the intent of establishing national or regional standards of salary compensation for certified athletic trainers.

Key Words: athletic training, salary, District Two, compensation

The athletic training profession continues to evolve and grow through new and different employment opportunities, increasing numbers of entry-level certified athletic trainers, and increasing knowledge. Because of the diversity in the field of athletic training, it is important to obtain information regarding salaries within the profession. It is evident that certified athletic trainers are interested in this issue.[1–8] Other salary studies have been conducted,[1,4–7] but only two[4,5] related to a specific district. No previous studies have provided salary information of ATCs in Delaware, New Jersey, New York, and Pennsylvania. The purpose of this study was to obtain recent salary data that can be used for future comparison with other salary studies, to provide reference material for ATCs currently practicing in or considering relocating to District Two, and to provide data to the NATA should they in the future establish professional salary standards for certified athletic trainers.

METHODS

A questionnaire was designed and sent to all 2,274 certified members listed in the 1994 NATA Membership Directory in District Two along with a self-addressed stamped envelope; a cover letter was also mailed to each member at the address listed in the directory. We requested reply within 6 weeks. Budgetary constraints prohibited a follow-up mailing.

James Somerville is athletic trainer and **Michael Stanwood** is coordinator in the Sports Medicine Department, Alfred I. duPont Institute Pediatric Hospital, Wilmington, DE.

The survey consisted of 15 questions and was designed to provide anonymity for each respondent. Survey topics included highest earned academic degree, practice setting, years of experience as a certified athletic trainer, state in which currently employed, annual salary, and whether a full-time or part-time position was held. Information regarding other certifications and credentials, nonathletic training responsibilities, and supplemental income was also obtained.

RESULTS

Of the 2,274 surveys mailed, 970 were returned (42.7%). There were 830 usable questionnaires, which gave us a 36.4% response rate. One hundred forty were not usable because 33 (3.4%) were pursuing higher education on a full-time basis, 30 (3.1%) are not currently employed as an athletic trainer, 19 (2%) no longer work in District Two, and 58 (6%) returned incomplete questionnaires. Of the 830 usable surveys returned, 725 (87.3%) were from full-time athletic trainers, and 105 (12.7%) were from part-time trainers. Several factors related to income and job description. Three hundred thirty-eight (46.6%) of full-time athletic trainers reported they had some form of supplemental income. It is unknown whether this is by choice or necessity. The survey also asked athletic trainers to state what other certifications outside of athletic training, if any, they possessed. Answers included, but were not limited to, emergency medical technician, licensed or registered physical therapist, registered nurse or bachelor of science in nursing, certified strength and conditioning specialist, certified teacher, massage therapist, and physical therapy assistant. First-aid and CPR certifications were not considered in this study. Of ATCs responding, 349 (48.1%) possess some other national or state certification. Full-time athletic trainers who reported having responsibilities outside of athletic training in their job descriptions numbered 384 (53%).

The response rate was broken down by practice setting, academic degree earned, state in which employed, and years of experience as an ATC. The largest response according to athletic employment setting was 372 (44.8%) from trainers working in the clinic or hospital setting. Regarding educational degree, 396 (47.7%) have master's degrees. The largest response rate by state was Pennsylvania with 375 (45.2%). Athletic trainers having 4 to 6 years of experience had the largest response rate in this category with 224 (27%).

The highest mean salary for full-time athletic trainers in District Two was for those in professional sports, earning \$59,778 (± \$48,803), while college or university athletic trainers had the lowest salary, \$32,928 (± \$10,098) (Table 1). According to educational degree, athletic trainers who also have a physical therapy degree earn the most, \$48,070 (± \$12,973), and athletic trainers with a bachelor's degree earn the least, \$30,132 (± \$9,584) (Table 2). New Jersey reports the highest-paid athletic trainers in District Two, earning \$36,695 (± \$12,593). The salary according to experience ranges from \$26,904 (± \$6,584) for athletic trainers with up to 3 years of experience, to \$57,308 (± \$30,723) for athletic trainers with 25 or more years of experience (Table 3). Of all ATCs in colleges, universities, and high schools, the teacher-athletic trainer has the highest salary, earning an average of \$40,695 (± \$10,443).

DISCUSSION

As more certified athletic trainers enter the work force, it is important to compile salary information to determine trends both now and in the future. Differences in salaries according to geographic location, practice setting, academic degree, and experience are areas that need to be explored. We found one study[4] that included these variables. Our survey included the professional and corporate settings as well.

In comparison with the survey done in District Four, the high school athletic trainer earned slightly more (\$36,410 ± \$10,064) in District Two than in District Four (\$35,696 ± n/a).[4] Similar results were reported in the clinical setting. District Two ATCs working in the clinic averaged \$33,910 (± \$14,623), while District Four clinical athletic trainers earned \$32,500 (± n/a).[4] The most substantial fluctuations were observed in the college setting. District Four reported an average salary of approximately \$25,000 (± n/a) for Division I college athletic trainers,[4] while District Two reported an average of \$31,942 (± \$8,548). Division II college athletic trainers earned a mean salary of \$30,000 (± n/a) in District Four compared with a mean of \$39,406 (± \$12,632) in District Two. Also, Division III ATCs made substantially less in District Four (\$22,667 ± n/a) than in District Two (\$31,270 ± \$8,829). Why is there such a large discrepancy between the two districts in salaries at the college settings? If it is due to geographic location, it would stand to reason that there would be similar discrepancies at the clinical settings.

Table 1. Salary According to Practice Setting (Full-Time Positions) (Mean ± SD)

Setting	Salary	n	%
Secondary or High School	\$36,410 ± \$10,064	171	23.6
College or University	\$32,928 ± \$10,098	197	27.2
Clinic or Hospital	\$33,910 ± \$14,623	343	47.3
Professional Sports	\$59,778 ± \$48,803	9	1.2
Corporate	\$44,780 ± \$28,379	5	.6

Table 2. Salary According to Education (Full-Time Positions) (Mean ± SD)

Degree	Salary	n	%
Bachelor's	\$30,132 ± \$9,584	285	39.3
Master's	\$34,883 ± \$14,983	351	48.4
Doctorate	\$47,656 ± \$6,982	9	1.2
PT and ATC	\$48,070 ± \$12,973	80	11.0

Table 3. Salary According to Experience (Full-Time Positions) (Mean ± SD)

Years Experience	Salary	n	%
0–3	\$26,904 ± \$6,584	182	25.1
4–6	\$30,183 ± \$7,643	207	28.5
7–9	\$35,720 ± \$10,602	109	15.0
10–12	\$40,525 ± \$13,081	84	11.6
13–15	\$42,155 ± \$13,563	73	10.1
16–18	\$47,016 ± \$23,945	32	4.4
19–21	\$54,730 ± \$22,112	20	2.8
22–24	\$49,983 ± \$9,827	6	.8
25+	\$57,308 ± \$30,723	12	1.6

The largest response to our questionnaire was from full-time ATCs working in the clinical setting (343, 47.3%). This was twice the number of responses received from athletic trainers employed in the high school setting (171, 23.6%). Moss found that there were four times more entry-level positions for ATCs in the clinical setting than in the high school setting.[5] If this is typical across the board, it would stand to reason that there are more athletic trainers employed in the clinical settings, thus, the higher response from clinic-based ATCs to our questionnaire. Also, more athletic trainers responded from the college setting (197, 27.2%) than from high schools (171, 23.6%). This is interesting since there are many more high schools than colleges. The high school setting seems to be the one in which to concentrate prospective employment efforts.

Our survey indicates a large influx of ATCs in the work force in recent years. We observed a high number (389, 53.7%) of athletic trainers with fewer than 6 years of experience responding. If this trend continues with no increase in employment opportunities, there will soon be a disproportionate ratio of ATCs for available jobs. This could pose a serious problem for those interested in entering the profession in the future.

We also found almost identical mean salaries for athletic trainers in the college setting at the Division I (\$31,942 ± \$8,548) and Division III (\$31,270 ± \$8,829) levels. The number of respondents (77, 10.6%) was identical. Considering that Division I athletics typically generate considerably more revenue than Division III athletics, it is surprising that ATCs do not have higher salaries at the Division I level. At the same time, athletic trainers working at the Division II level averaged \$39,406 (± \$12,632). It is uncertain why Division II athletic trainers' salaries are more than \$7,000 higher, on average, than Divisions I and III. This may be partially due to the lower response rate (33, 4.6%).

Future studies need to be conducted to determine ATC salary norms for the purpose of establishing a regional or national salary standard by the NATA. Comparisons between districts as well as comparisons with other allied health professions need to be made to establish a basis for such a standard. This cannot be done without obtaining the needed information. The NATA should support each district, not only by funding, but also administratively, to obtain needed data regarding salaries. The athletic training profession changes and evolves constantly and will continue to do so in the future. We need to plan ahead for these changes. In order to effectively plan for the future, we must determine where we are today.

REFERENCES

1. Gieck J, Lephart S, Saliba E. NATA certification: a 5 & 10 year follow-up. *Athl Train. JNATA* 1986;21:120–121,163.
2. Goetze P. Are we a profession or a trade? *NATA News.* Oct 1993;5:19.
3. Guccione AA, Jette AM. Regional differences in physical therapists' incomes. *Phys Ther.* 1984;64:1209–1213.
4. Lauenzi D, Sellers D. Salary and job description survey conducted at District Four annual meeting. *NATA News.* Jun 1991;3:11.
5. Moss C. 1992 entry-level athletic trainer salaries. *J Athl Train.* 1994;29: 205–207.
6. Paris D. A certified athletic therapists questionnaire: five-year update. *J Can Athl Ther Assoc.* Apr 1991;5:22–25.
7. Paris D. Year of the CAT: results from a questionnaire for certified athletic therapists. *J Can Athl Ther Assoc.* Fall 1987;1:6–7,9.
8. Weidner T. It's up to ATCs to obtain higher salaries. *NATA News.* Sep 1990;2:4.


ANKLE LOK®
America's most popular lace up Ankle Brace
SWEDE-O
FOR EVERY ANKLE
SWEDE-O-ARCH LOK®
Superior support even in the vulnerable plantar flexed position
STRAP LOK®
Bullet proof your ankles
Official Supplier
NATA
LIGHTNING LOK®
America's fastest lacing ankle brace
CALL TOLL FREE TODAY FOR INFORMATION: 1-800-525-9339

The Effectiveness of the Aquaflex Gel Pad in the Transmission of Acoustic Energy

Brian Klucinec, ATC

Objective: The purpose of this study was to assess the effectiveness of the Aquaflex Gel Pad in the transmission of acoustic energy.

Design and Setting: This was a comparative study that utilized descriptive statistics for result interpretation. The independent variables included ultrasound intensity, interposed materials, and trials. The dependent variable was peak-to-peak voltage output recorded via an oscilloscope. The study was conducted in a ventilated research laboratory.

Measurements: Three trials were conducted with six combinations of material interposed between a conducting (1 MHz) and a receiving sound head. The interposed materials were as follows: 1) ultrasound gel, 2) gel plus a gel pad, 3) gel plus a gel pad and pig tissue sample (0.90 cm of subcutaneous fat), 4) gel plus a gel pad and a pig tissue sample (1.8 cm of subcutaneous fat), 5) gel plus thin pig tissue sample, and 6) gel plus thick pig tissue sample. Each interposed material combination was tested at the intensities (W/cm^2) as follows: 0.10, 0.25, 0.50, 1.00, 1.50, and 2.50.

Results: The gel pad proved to be an efficient couplant in the delivery of high-frequency acoustic energy. Using ultrasound gel as the base line (100% transmissivity) it was concluded that the gel pad transmitted more acoustic energy at every intensity except at 0.1 W/cm^2. The gel pad used with the two thicknesses of subcutaneous fat gave comparable results. Gel used with the two thicknesses of subcutaneous fat yielded results that warrant further investigation.

Conclusions: I believe gel pads are a practical choice for clinical applications of ultrasound over uneven surfaces. The reusable gel pads offer the clinician a convenient and reliable method for delivering ultrasound energy to the patient. I believe it is preferable to use the gel pad with ultrasound gel directly applied to the patient and at the sound head-gel pad interface as opposed to using the traditional water bath immersion method.

Key Words: ultrasound, transmissivity, gel pad

There are many couplants commercially available for ultrasound transmission.[1] A couplant or coupling agent is a medium used to transfer sound waves.[12] The main function of the coupling agent is to provide high transmission with low absorption of ultrasound energy. Any ultrasound energy absorbed by the coupling agent is said to be attenuated.[1] Characteristics of coupling agents include viscosity, ease of use, salt content, cost, and the ability to exclude air.[9,13]

The exclusion of air is important due to the reflection of the sound waves that may occur at couplant-tissue interfaces.[13] The viscosity determines how much of the couplant will be needed per treatment. The ease of use of the couplant refers to the relative lubrication provided by the coupling agent.[12,13] A low salt content couplant minimizes salt buildup on the sound head over time, thus decreasing the potential of damage to the crystal housed in the transducer.[9] Lastly, cost of the couplant may be the determining factor for what is used in the clinic.[12,13]

Some coupling agents, such as topical gel, have been demonstrated to transmit sound energy efficiently.[1,6,11,12] Others, like water, are inefficient.[4,5] Recently, gel pads have been made commercially available. These pads function as a coupling agent by themselves or when used with a topical gel.[8] The purpose of the gel pad is to provide patient comfort and protection over bony protuberances or irregular surfaces.[8] Because topical gel has been proven to transmit more ultrasound energy than glycerin, mineral oil, or water,[1,4,5,6,11,12] the gel pad, theoretically, should exhibit the same quality as topical gel. This may not be the case. The purpose of this in vitro study was to determine the effectiveness of a commercial gel pad in delivering sound energy to pig tissue.

At the time of this study **Brian Klucinec** was an undergraduate at Slippery Rock University, Slippery Rock, PA 16057. Currently, Mr. Klucinec is a graduate student at the Krannert School of Physical Therapy, University of Indianapolis, 1400 East Hanna Avenue, Indianapolis, IN 46227. This article earned Mr. Klucinec recognition as first runner-up in the 18th Annual Student Writing Contest.

MATERIALS AND METHODS

Instrumentation

A 1-MHz Intelect 225P ultrasound unit (Chattanooga Corp., Chattanooga, TN), with a 5.0 cm^2 sound head and an effective radiating area (ERA) of 4.0 cm^2, was used to deliver acoustic energy at selected intensities. The unit was calibrated before the first trial. A detachable transducer having the same ERA was utilized to receive the signal sent by the 1-MHz unit by patching the coaxial cable into an oscilloscope via a bus net connector. For recording purposes, a 100 Ms/sec 450 Gould digital storage oscilloscope (Gould Inc., Ilford, United Kingdom) was used to record peak-to-peak values at various intensities. For accuracy and consistency, a two-dimensional level was used to fix all movable instruments.

Procedure

To perform the pilot trials and experiment, a platform apparatus (Fig 1) was constructed out of steel, aluminum, and plexiglass. The foundation consisted of a 50-lb aluminum

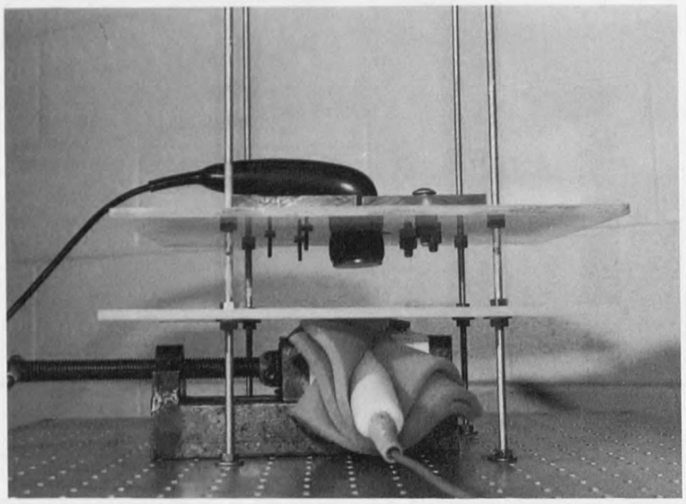


Fig 1. The constructed apparatus.

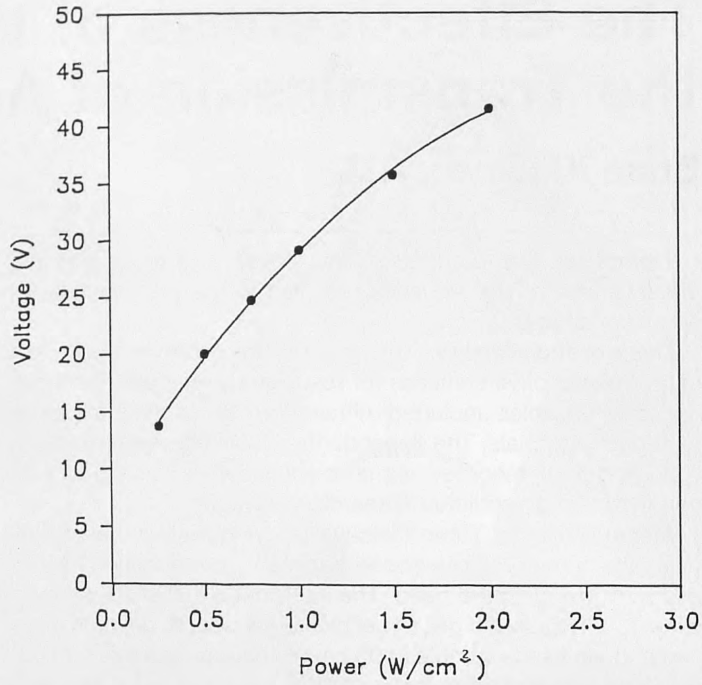


Fig 2. Mean voltage output of the three pilot trials at selected intensities.

block with 1/4-inch holes drilled into it at 1-inch intervals. Four 1/4-inch rods were fixed in these holes 7 inches apart and secured by nuts with washers. Two pieces of plexiglass were made to slide vertically along these rods creating two horizontal platforms. In the center of the plexiglass platforms, holes were drilled to house the transducer heads. The bottom piece of plexiglass was fixed and housed the receiving sound head. The top piece of plexiglass was movable and housed the transmitting transducer. The detachable sound head was fixed in a hand-tightened vise surrounded by foam to protect the transducer. The surface of the detachable sound head was then made level and flush with the bottom piece of plexiglass.

The transmitting transducer was placed in the hole drilled in the top piece of plexiglass allowing the ERA to be parallel to the ERA of the receiving sound head. The transmitting sound head was made parallel to the receiving sound head by viewing the ERA through a convex mirror and using a level. The transmitting sound head was then fixed to the top plate by creating a "harness" for the transducer neck. This harness was made from two pieces of thicker plexiglass. One piece was fixed with bolts while the other was allowed to move by slots to adjust for tightness. Fixation of the transmitting transducer created only one movable piece throughout the duration of the experiment.

Pilot trials were conducted to test the accuracy of the apparatus (Fig 2). The pilot trials were conducted with the use of an Aquaflex Ultrasound Gel Pad (Parker Laboratory, Orange, NJ) and Liqua Sonic Ultrasound Gel (Chester Laboratory, Erlanger, KY). Each trial was conducted by placing ultrasound gel at each interface to prevent reflection of the acoustic energy. The transmitting transducer was then lowered until it reached contact with the gel pad. The movable piece, supported by four nuts and washers, was made parallel to the bottom piece using a two-dimensional level. To record the data, the ultrasound unit was turned on, set at 100% continuous, then manually adjusted to the desired intensity. The peak-to-peak voltage was recorded immediately. Three pilot trials were completed. After each trial, the constructed apparatus was disassembled, cleaned, and reassembled.

During this project, ultrasound transmission was measured at six intensities with six different material combinations interposed between the sound head. The six materials were: 1) ultrasound gel, 2) gel plus a gel pad, 3) gel plus a gel pad and a pig tissue sample (0.90 cm of subcutaneous fat), 4) gel plus a gel pad and a pig tissue sample (1.8 cm of subcutaneous fat), 5) gel plus the thin pig tissue sample, and 6) gel plus the thick pig tissue sample.

Pig tissue was selected because the ratio of skin, fat, muscle, and bone is similar to that of humans.[7] The first tissue sample had the dimensions of 4 inches by 4.75 inches with 0.90 cm of subcutaneous fat. The second tissue sample had dimensions of 4 inches by 4.50 inches with 1.8 cm of subcutaneous fat. The tissue was obtained fresh, then frozen, and finally thawed before the testing. The tissue was thawed in lukewarm water approximately 20 hours in advance and then allowed to warm to room temperature. Room temperature was recorded by a digital thermoprobe at 72.5° F. Because the two tissue samples differed in the amount of hair on the skin, one sample was trimmed to be visibly similar to the other sample. This was done knowing that the tissue with more hair would have attenuated more acoustic energy.[2,3] Before beginning each trial, care was taken to cleanse the plexiglass, transducers, and tissue samples with tap water. This was done to free the instruments and tissue samples of debris that might have accumulated.

Three trials were conducted for each of the six interposed materials. Care was taken to place an adequate amount of ultrasound gel at each interface to prevent reflection. Care was also taken to eliminate any air trapped at each interface by firmly pressing down on the tissue and gel pad. For each material trial set up, the movable segment of the apparatus was lowered until contact was made with the tissue, gel pad, or gel. The segment was then made parallel to the fixed segment by

Table 1. Trial 1 Ultrasound Interposed Materials with Peak-to-Peak Voltages Read at Specified Intensity Levels (W/cm²)

	Intensities					
Interposed materials	0.10	0.25	0.50	1.00	1.50	2.50
Gel	1.66	7.33	10.20	16.00	20.20	25.30
Gel + pad	1.16	11.50	12.30	19.70	26.30	27.30
Gel + pad + thin tissue	1.16	2.66	8.33	17.70	12.20	20.00
Gel + pad + thick tissue	1.16	5.50	7.33	11.70	18.50	24.50
Gel + thin tissue	1.00	4.50	6.00	8.66	10.30	12.70
Gel + thick tissue	2.16	10.00	14.80	21.70	27.00	36.80

adjusting the nuts under the movable segment and checked with the two-dimensional level.

Ultrasound transmission was read at six selected intensities during each trial. Starting at the lowest intensity, the ultrasound unit was turned on and manually adjusted to the desired intensity. The peak-to-peak voltage of the sine wave was recorded immediately. The ultrasound unit was then shut off and the intensity turned down. Each interposed material was tested in the same sequence of intensities. The interposed material was not subjected to continuous ultrasound exposure because increasing thermal responses reduces the impedance of the tissue.[10]

After testing each material at each intensity, both transducers and surrounding ultrasound gel were examined for debris that might have interfered with the test. Between each trial, new ultrasound gel was placed at the interfaces to ensure an adequate interface.

RESULTS

Figure 2 represents the mean voltage output of pilot trials 1, 2, and 3 at specified intensity levels. The data recorded for each pilot trial were similar. The repeatability of peak-to-peak values for each pilot trial set the foundation for the following trials.

Peak-to-peak voltages for each interposed material at specified intensity levels during the three trials are presented in Tables 1, 2, and 3, respectively. The average peak-to-peak voltages from the three trials are presented in Table 4. The gel pad proved to be an efficient couplant in transmitting acoustic energy (Fig 3). Using ultrasound gel as a base line (100% transmissivity), as much as 27% more acoustic energy was transmitted through the gel pad. The gel pad transmitted more acoustic energy at every intensity except at 0.10 W/cm². The gel pad used with the two thicknesses of subcutaneous fat gave comparable results (Fig 4). This finding is in agreement with a recent report[2] that ultrasound does penetrate through subcutaneous fat.

The trials using ultrasound gel with the thin and thick tissues produced perplexing results. The peak-to-peak voltages of the ultrasound gel and the thick tissue sample were more than double compared with the ultrasound gel used with the thin sample (Fig 5).

DISCUSSION

The gel pad was an efficient transmitter of acoustic energy. The gel pad interposed with the two thicknesses of tissue produced similar results. The tissue samples differed only in the thickness of subcutaneous fat.

There was a discrepancy when the gel pad was removed and both thicknesses of tissue were subjected to just ultrasound gel as the conducting medium. The ultrasound gel used with the thick tissue produced more than twice the voltage output compared with the interposed material of gel and thin tissue. There may be several explanations for this finding. Pressure variations may have been a contributor to changes in transmissivity throughout the experiment.[12] In applying pressure to the tissue, a quantity of the ultrasound gel may have been dispersed, leaving only a thin film of gel. The thin layer of gel coupled with the thicker subcutaneous fat sample may have aided in the conduction of the acoustic energy, leading to increased transmission of acoustic energy and consequently increased voltage readings. However, the magnitude of difference in acoustic energy transmission between the two tissues plus ultrasound gel for all three trials suggests that pressure differences may not have been the cause. This study was limited to a 1-MHz ultrasound unit; other frequencies may yield different results. Lastly, the BNR (beam nonuniformity ratio) of the 1-MHz ultrasound unit was 3.5 to 4.0:1. The poor crystal quality may have caused the vast range in the voltage readings.

Table 2. Trial 2 Ultrasound Interposed Materials with Peak-to-Peak Voltages Read at Specified Intensity Levels (W/cm²)

	Intensities					
Interposed materials	0.10	0.25	0.50	1.00	1.50	2.50
Gel	1.83	8.33	11.80	16.70	20.00	25.80
Gel + pad	1.33	9.66	13.80	19.30	24.30	30.50
Gel + pad + thin tissue	1.16	3.66	7.00	14.00	15.50	21.20
Gel + pad + thick tissue	1.16	4.66	6.66	14.00	17.20	22.30
Gel + thin tissue	1.33	4.33	6.16	9.00	11.50	15.00
Gel + thick tissue	2.00	9.50	14.20	20.30	25.30	34.50

Table 3. Trial 3 Ultrasound Interposed Materials with Peak-to-Peak Voltages Read at Specified Intensity Levels (W/cm²)

	Intensities					
Interposed materials	0.10	0.25	0.50	1.00	1.50	2.50
Gel	2.00	9.00	12.80	18.00	22.00	28.00
Gel + pad	1.16	10.20	12.80	21.20	26.20	32.50
Gel + pad + thin tissue	1.16	4.33	6.66	13.00	16.50	21.00
Gel + pad + thick tissue	1.00	5.83	8.33	12.80	13.70	25.50
Gel + thin tissue	1.50	5.66	8.00	12.30	14.80	17.20
Gel + thick tissue	1.50	9.83	13.00	19.20	22.30	34.00

Table 4. Ultrasound Interposed Materials with Average Peak-to-Peak Voltages from Trials One, Two, and Three Read at Specified Intensity Levels (W/cm²)

	Intensities					
Interposed materials	0.10	0.25	0.50	1.00	1.50	2.50
Gel	1.83	8.22	11.60	16.90	20.73	26.37
Gel + pad	1.38	10.45	12.97	20.10	25.60	30.10
Gel + pad + thin tissue	1.16	3.55	7.33	14.90	14.73	20.73
Gel + pad + thick tissue	1.12	5.33	7.44	12.83	16.47	24.10
Gel + thin tissue	1.28	4.83	6.72	9.99	12.20	14.97
Gel + thick tissue	1.89	9.78	14.00	20.40	24.87	35.00

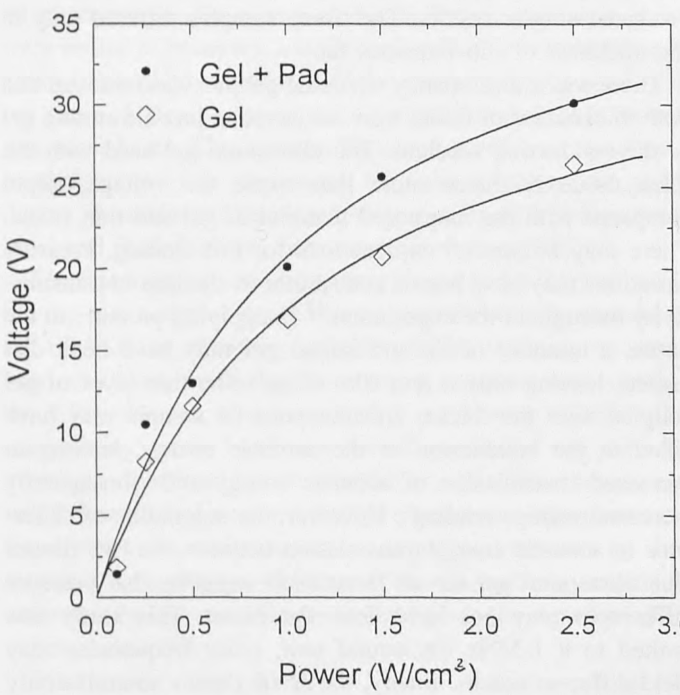


Fig 3. Comparison of gel and gel + pad conditions.

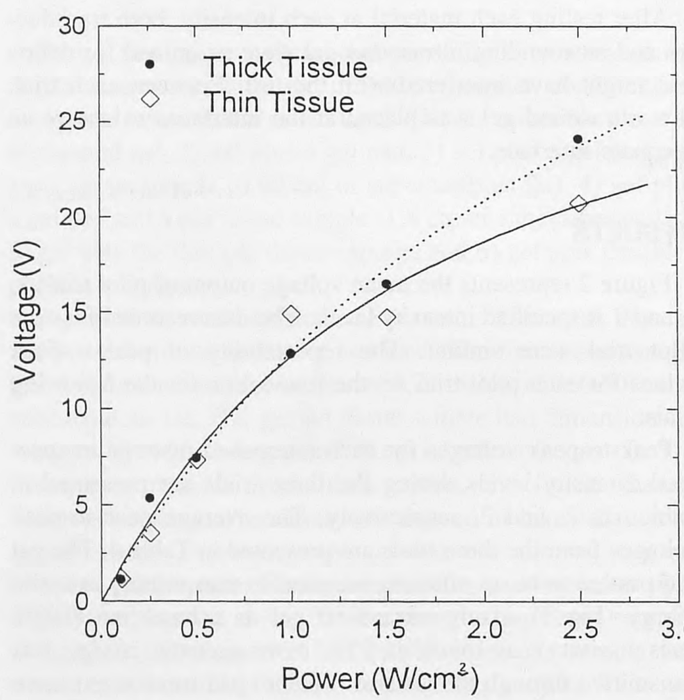


Fig 4. Comparison of gel + pad + thin tissue and gel + pad + thick tissue conditions.

I believe that gel pads are a practical choice for clinical applications of ultrasound over uneven surfaces. The causes of differing results when ultrasound gel was used with thin and thick tissues are not apparent and warrant further investigation. Until gel pads became commercially available, the traditional clinic method of ultrasound application to bony areas was done via water bath. Forrest and Rosen[4,5] have demonstrated that water baths are a relatively inefficient method of delivering high-frequency acoustic energy. Ultrasound application under water fails to increase the temperature of the target tissue to a therapeutic level. I believe gel pads are the couplant of choice for ultrasound treatments over bony prominences. My findings suggest that gel pads are an efficient couplant in the delivery of high-frequency acoustic energy.

The reusable gel pads offer the clinician a convenient and reliable method for delivering ultrasound energy to the patient. When treating soft tissue around bony prominences, it is preferable to use the gel pad with ultrasound gel directly applied to the patient and at the sound head-gel pad interface as opposed to using the traditional water bath immersion method.

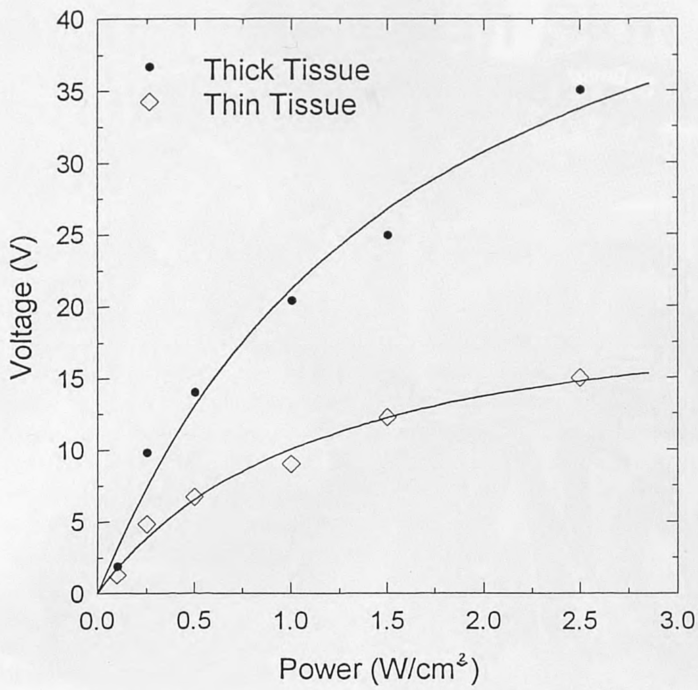


Fig 5. Comparison of gel + thin tissue and gel + thick tissue conditions.

ACKNOWLEDGMENTS

I thank Dr. Craig Denegar for his editorial assistance, patience, advice, direction, and inspiration; Dr. David Draper for his wise and valuable input; Dr. Rizwan Mahmood for his support, counsel, graphics, and research design assistance; Dr. Richard McCandless for his encouragement and support; the Slippery Rock University Technological Committee for their financial assistance; Parker Laboratories for Gel Pad donations; George McDowell for his photographic services; Scott Bruce for his editorial assistance; and my fellow student athletic trainers for providing me with their continuous support and encouragement.

REFERENCES

1. Docker MF, Foulkes DJ, Patrick MK. Ultrasound couplants for physiotherapy. *Physiotherapy.* 1982;68:124–125.
2. Draper D, Sunderland S. Examination of the law of Grotthus-Draper: does ultrasound penetrate subcutaneous fat in humans? *J Athl Train.* 1993;28:246–250.
3. Dyson M. Mechanisms involved in therapeutic ultrasound. *Physiotherapy.* 1987;73:116–120.
4. Forrest G, Rosen K. Ultrasound: effectiveness of treatments given under water. *Arch Phys Med Rehabil.* 1989;70:28–29.
5. Forrest G, Rosen K. Ultrasound treatments in degaussed water. *J Sport Rehabil.* 1992;1:284–289.
6. Griffen J. Transmissiveness of ultrasound through tap water, glycerin, and mineral oil. *Phys Ther.* 1980;60:1010–1016.
7. Lehmann JF, McMillan JA, Brunner GD, Blumberg JB. Comparative study of efficiency of short wave, microwave, and ultrasonic diathermy in heating hip joint. *Arch Phys Med Rehabil.* 1959;40:510–512.
8. Nault P. Applying ultrasound to irregular surfaces. *PT Magazine.* 1993;1:94.
9. Prentice WE. Therapeutic ultrasound. In: Prentice WE, ed. *Therapeutic Modalities in Sports Medicine.* St. Louis, MO:Mosby-Year Book Inc;1994:255–281.
10. Prentice WE, Donley PB. Shortwave and microwave diathermy. In: Prentice WE, ed. *Therapeutic Modalities in Sports Medicine.* St. Louis, MO:Mosby-Year Book Inc;1994:151–168.
11. Reid DC, Cummings GE. Efficiency of ultrasound coupling agents. *Physiotherapy.* 1977;63:255–257.
12. Warren GC, Koblanski JN, Sigelmann RA. Ultrasound coupling media: their relative transmissivity. *Arch Phys Med Rehabil.* 1976;57:218–222.
13. Williams R. Production and transmission of ultrasound. *Physiotherapy.* 1987;73:113–116.

Ankle and Thigh Skin Surface Temperature Changes With Repeated Ice Pack Application

Janice E. Palmer, MA, ATC; Kenneth L. Knight, PhD, ATC

Objective: Most of the research on cold applications has been performed on nonexercising supine subjects during a single cold pack application. Most athletic injuries occur during exercise, which increases skin temperature. Exercise before ice application will also increase ankle skin temperature during the rewarming phase. The purpose of this study was to examine the effects of activity on subsequent ice pack applications and rewarming using standard immediate care procedures.

Design and Setting: Three experimental conditions (20-, 30-, and 40-minute ice pack applications) were applied to 12 subjects in a repeated measures design. Subjects rode a bicycle ergometer for 15 minutes before ice application to the ankle and opposite thigh, and were active (walking with crutches, simulated showering and dressing) for 20 minutes following application. Subjects rested with the limb elevated for an additional 40 minutes. Ice packs were then reapplied for the appropriate time (20, 30, or 40 minutes) followed by 60 minutes of rest with the limb elevated.

Subjects: Twelve (8 males, 4 females) college-aged volunteers. Only subjects with good-to-high fitness levels were accepted for this study.

Measurements: Ankle skin, thigh skin, and atmospheric temperatures were measured every minute using an Isothermex (Columbus Instruments, Columbus, OH).

Results: Thigh temperature changes during the first ice application were greater during the 30- and 40-minute conditions than the 20-minute condition. Ankle and thigh temperature changes during the first ice application and rewarming, and for the entire trial were greater during the 40-minute condition than the 20- or 30-minute conditions. Throughout the first ice application and rewarming, and the entire trial, thigh temperature changes were greater during the 30-minute condition than the 20-minute condition.

Conclusions: During immediate care procedures following injury, ice packs should be reapplied immediately following showering, changing clothes, and returning home.

Key Words: ice application, cryotherapy, ankle and thigh, skin surface temperatures

Cryotherapy has become the most widely accepted modality for the immediate care of acute sport injuries.[3,4,12,13,21] Ice applications reduce the magnitude of secondary hypoxic injury by decreasing tissue temperature. This decrease reduces the rate of metabolism and the need for oxygen,[4] resulting in quicker healing, rehabilitation, and recovery.[15]

Skin and subcutaneous tissue temperatures decrease immediately with ice application.[2,5,6,11] Deep tissue temperature decreases at a slower rate than surface temperatures.[8,11,12] To maintain lowered skin temperatures, an application-reapplication protocol is followed, reducing the chances of secondary hypoxic injury. The majority of individuals disagree on their recommendations for time on and time off.[22] Knight[15] suggested an intermittent application protocol of 30-minutes on and 90-minutes off for the acute stage of injury to help maintain a lowered tissue temperature.

Most of our knowledge of the body's response to cold applications is the result of research on nonexercising supine subjects during a single cold pack application.[19,22,24,28] In nonexercising individuals, the second application of an ice pack lowers temperatures to a greater extent than the first and results in lower temperatures during rewarming.[24] Most athletic injuries occur during exercise, which increases skin temperatures.[9,18,25,26] Indeed, exercise before ice pack application will increase ankle skin temperature during the postapplication or rewarming.[19]

Protocols for most research in this area have required the subject to be supine.[19,22,24,28] In real life, an injured athlete will shower, change clothes, and return home after icing the injured part. It seems that this activity would increase the rate of rewarming, but this has not yet been examined. This study examined the effects of activity following ice pack application on tissue rewarming and the effect of the activity on subsequent ice pack applications and rewarming.

METHODS

The design of this experiment was a 2 × 3 factorial with repeated measures on both factors. Skin surface temperatures were measured in the ankle and opposite thigh while subjects underwent three conditions (20, 30, and 40 minutes of ice application and reapplication). On 3 separate testing days, at least 48 hours apart, subjects lay supine for 5 minutes, rode an exercise bike for 15 minutes, had ice packs applied for the specified time, simulated showering for 20 minutes, rested supine for 40 minutes, had the cold pack reapplied for the specified time, and rested without cold packs for 60 minutes. Treatment orders were established according to two balanced 3 × 3 Latin squares and subjects were randomly assigned to these orders.

Eight males (age = 23.6 ± 1.2 yr; ht = 70.6 ± 2.0 in; wt = 179.5 ± 29.5 lb) and 4 females (age = 22.0 ± 0.8 yr; ht =

Janice E. Palmer has just finished physiotherapy school at the University of Halifax in Halifax, Nova Scotia, Canada.
Kenneth L. Knight is now professor of physical education at Brigham Young University in Provo, Utah.

64.8 ± 1.3 in; wt = 147.7 ± 17.9 lb) participated. During an orientation session prior to testing, subjects gave informed consent and were screened for any contraindications to the treatments, including cold allergies and any previous heart conditions.

During testing, subjects were supine on a table with their ankles elevated 6 inches. During the preapplication period, six thermocouples (TX 31; Columbus Instruments, Columbus, OH) were taped in place with 1/2-inch × 1-inch Dermiclear (Johnson & Johnson, New Brunswick, NJ) so that the tip of the thermocouple remained exposed. The thermocouples on the ankle were positioned over the anterior talofibular ligament. The thermocouples on the anterior thigh were positioned 7 cm above and 7 cm below a point midway between the tibial tuberosity and the anterior superior iliac spine. All positions were marked with a felt tip pen so that the thermocouples were applied to the same position each day. The thermocouples were attached to a electronic temperature measuring device (Isothermex; Columbus Instruments, Columbus, OH) interfaced with a 386 computer.

Subjects performed a submaximal bicycle stress test.[1] From these results, maximal oxygen consumption (predicted maximum was VO_2 = 40.8 ± 8.4 L/min for males and VO_2 = 35.5 ± 4.4 L/min for females) and fitness level were predicted. Subjects were classified into fitness levels using oxygen uptake capacity (mL/kg × minute) predicted from heart rate and workload. All subjects scored in the good-to-high fitness level range.

Temperature recording began when the thermocouples were attached. Ankle, thigh, and atmospheric temperatures were measured every minute except during the second exercise period. The subjects performed a 15-minute ride on a bicycle ergometer (Fitron; Cybex, Ronkonkoma, NY) using a target heart rate range of 60% to 80% of their age-predicted maximum heart rate.[20]

A 20-, 30-, or 40-minute ice pack application followed the first exercise period. One ice pack was applied to the lateral aspect of the ankle and another to the anterior aspect of the opposite thigh. In both instances, they were centered over and covered the thermocouples and were secured with 6-inch elastic wraps. The ice packs were manually compressed every 5 minutes to minimize the thermal gradient.[28]

Following the first application, the ice pack and elastic wrap were removed for 20 minutes, during which subjects simulated showering and changing clothes. For 5 minutes each subject walked slowly on crutches using a partial weight-bearing four-point gait (100 m at 1.41 m/sec), followed by 5 minutes of balancing on one leg (while showering), then 5 minutes of minimal activity while standing (dressing), and finally 5 minutes of slow crutch walking. The elastic wraps were then reapplied to the ankle and thigh for 40 minutes.

A second ice pack was applied 60 minutes after removing the first. The second ice pack application was equal in duration of time to the first ice application. The second ice pack was then removed and the elastic wrap was immediately reapplied for 60 minutes.

Data were analyzed using SPSS-X on a Vax computer. A Multivariate ANOVA was significant; therefore, one-way ANOVAs and Duncan's tests were used for post-hoc analysis.

RESULTS

Skin temperature decreased immediately and rapidly after ice application and continued to decrease gradually for the duration of the application (Tables 1 and 2). The temperatures at time = 0 were different between the ankle and thigh ($F(1,11) = 32.3$, $p = .0005$) and between the three ice pack application conditions ($F(2,22) = 3.4$, $p = .05$). Due to this difference, temperature changes (from beginning to end of time period) were computed and used for subsequent analysis (Table 3). Temperature changes during exercise were not significantly different between conditions ($F(2,22) = 1.0$, $p = .38$).

The thigh temperature changes during the first ice application were greater during the 30- and 40-minute conditions than during the 20-minute condition ($F(2,22) = 11.9$, $p = .0005$, Duncan post hoc $p < .05$). Temperature changes were not different between conditions in the ankle during the first ice pack application ($F(2,22) = 3.0$, $p = .07$) or during the second ice pack application in the ankle ($F(2,22) = 1.6$, $p = .23$) or thigh ($F(2,22) = 1.5$, $p = .24$).

The temperature changes were not different between conditions during the first rewarming of the ankle ($F(2,2) = 2.8$, $p = .13$) or thigh ($F(2,22) = 1.2$, $p = .32$) nor during the second rewarming of the ankle ($F(2,22) = .7$, $p = .51$). Thigh

Table 1. Ankle Skin Temperature During Three Conditions of Ice Pack Application (n = 12, Mean ± SD, °C)

		Length of Application of Cold Pack		
Condition	Time	20 min	30 min	40 min
Exercise	−15	30.2 ± 1.0	30.7 ± 1.4	30.7 ± 1.0
Ice application	0	29.6 ± 1.2	30.1 ± 1.0	29.9 ± 1.6
	1	18.6 ± 2.2	18.7 ± 2.4	19.4 ± 3.0
	10	7.9 ± 1.9	9.3 ± 3.5	8.7 ± 2.8
	20	5.9 ± 2.0	5.5 ± 1.2	6.3 ± 1.8
	30		5.2 ± 1.4	5.2 ± 1.2
	40			4.4 ± 1.2
Activity				
First rewarming	21	26.4 ± 1.7	25.8 ± 1.7	24.5 ± 1.9
	30	27.4 ± 1.8	26.8 ± 1.9	24.9 ± 2.2
	40	28.2 ± 1.9	27.9 ± 1.9	25.7 ± 2.2
	50	28.9 ± 1.9	28.6 ± 2.0	26.5 ± 2.2
	60	29.2 ± 1.9	29.0 ± 1.9	26.9 ± 2.3
Ice application	1	17.1 ± 2.0	18.4 ± 3.0	16.8 ± 2.7
	10	7.2 ± 1.7	7.8 ± 2.9	7.0 ± 2.4
	20	5.3 ± 1.3	5.0 ± 1.5	4.5 ± 1.8
	30		4.8 ± 1.8	3.8 ± 1.3
	40			3.8 ± 1.3
Second rewarming	1	10.3 ± 1.0	9.4 ± 1.5	8.3 ± 1.3
	10	16.3 ± 1.8	15.6 ± 1.8	14.1 ± 1.0
	20	19.2 ± 2.4	18.5 ± 2.2	16.8 ± 1.2
	30	20.9 ± 2.5	20.3 ± 2.3	18.5 ± 1.4
	40	22.2 ± 2.6	21.7 ± 2.4	19.9 ± 1.7
	50	23.3 ± 2.8	22.8 ± 2.4	20.9 ± 1.8
	60	24.1 ± 2.8	23.7 ± 2.4	21.9 ± 1.8

Table 2. Thigh Skin Temperature During Three Conditions of Ice Pack Application (n = 12, Mean ± SD, °C)

		Length of Application of Cold Pack		
Condition	Time	20 min	30 min	40 min
Exercise	−15	32.0 ± 1.0	32.1 ± 0.6	32.1 ± 1.0
Ice application	0	31.6 ± 0.9	32.0 ± 0.9	32.0 ± 0.9
	10	6.6 ± 1.5	7.5 ± 2.5	6.8 ± 2.0
	20	4.8 ± 1.0	5.2 ± 1.4	4.8 ± 1.0
	30		4.2 ± 0.9	3.8 ± 0.7
	40			3.5 ± 0.6
Activity				
First rewarming	21	27.6 ± 1.9	26.8 ± 1.8	26.0 ± 2.4
	30	28.8 ± 1.8	27.8 ± 1.9	26.7 ± 2.2
	40	29.9 ± 1.6	28.7 ± 1.8	27.7 ± 1.9
	50	30.8 ± 1.5	29.6 ± 1.7	28.6 ± 1.8
	60	31.1 ± 1.3	30.2 ± 1.5	29.2 ± 1.6
Ice application	1	16.4 ± 2.1	17.4 ± 2.4	15.9 ± 3.2
	10	5.6 ± 0.9	6.6 ± 1.7	5.2 ± 1.5
	20	4.6 ± 1.0	5.1 ± 1.4	4.4 ± 1.2
	30		4.6 ± 1.2	3.8 ± 1.2
	40			3.5 ± 1.3
Second rewarming	1	10.2 ± 1.2	9.7 ± 1.3	8.9 ± 1.0
	10	20.4 ± 1.2	19.6 ± 1.8	18.4 ± 1.1
	20	23.5 ± 1.3	22.6 ± 1.7	21.6 ± 1.3
	30	25.5 ± 1.4	24.4 ± 1.7	23.4 ± 1.5
	40	27.1 ± 1.4	25.7 ± 1.7	24.7 ± 1.6
	50	28.2 ± 1.4	28.8 ± 1.6	25.8 ± 1.8
	60	29.0 ± 1.4	27.9 ± 1.5	26.7 ± 1.8

temperature changes during the second rewarming were significantly different ($F(2,22) = 4.5$, $p = .02$, Duncan post hoc $p < .05$), with a greater temperature change during the 20-minute ice pack application than during 30- and 40-minute conditions. The temperature changes during second ice pack application and second rewarming were not significantly different between conditions in the ankle ($F(2,22) = .3$, $p = .73$), or thigh ($F(2,22) = .4$, $p = .68$).

Both ankle and thigh temperature changes during first ice pack application and rewarming were different between conditions. In the ankle, the 40-minute condition was greater than the 20- or 30-minute conditions ($F(2,22) = 12.8$, $p = .0005$, Duncan post hoc $p < .05$). In the thigh, the 40-minute condition was greater than the 20- or 30-minute conditions, and the 30-minute condition was greater than the 20-minute condition ($F(2,22) = 28.9$, $p = .0005$, Duncan post hoc $p < .05$).

The ankle temperature changes for the entire trial were greater during the 40-minute condition than during the 20- or 30-minute conditions ($F(2,22) = 6.9$, $p = .005$, Duncan post hoc $p < .05$). The thigh temperature changes were greater during the 30- and 40-minute conditions than during the 20-minute condition, and the 40-minute condition was greater than the 30-minute condition ($F(2,22) = 19.3$, $p = .0005$, Duncan post hoc $p < .05$).

Atmospheric temperatures were different between conditions ($F(2,3633) = 2.2$, $p = .0005$) but were within an acceptable range (25.2°C, 25.1°C, 25.3°C).

DISCUSSION

The rapid decrease in the ankle and thigh skin temperatures during the first few minutes of, and the slow and steady decline for the duration of, the ice pack application was in agreement with others.[5,19,23,24,28] The ankle temperature changes during the first rewarming were greater than those previously recorded by Post,[24] but were within the same range at the end of the second rewarming. The simulated activity associated with showering, changing clothes, and returning home on crutches caused the body parts to warm more quickly than previously thought.

Our ankle temperatures following 30 minutes of ice application and subsequent rewarming were 2°C to 10°C greater than recorded in previous studies (29.0° ± 1.9°C now vs 19.8° ± 1.9°C to 27.5° ± 3.1°C previously).[19,22,24] It is possible that the heat of the shower may have intensified this rewarming. Ice reapplication protocols have not considered the effects of activity following ice application. A reapplication protocol of 30 minutes on and 90 minutes off[15] is suitable for supine individuals or an athlete once he/she has returned home, but if an athlete is showering or returning home, this protocol delays reapplication too long. Ice should be reapplied immediately after the athlete showers and/or returns home.

Decreases in ankle skin temperature changes were midway between those previously reported[19,22,24,28] (Table 4). The reason for these differences is not apparent. Mancuso et al,[19] whose temperatures were lower than ours, suggested that atmospheric temperature may have affected their skin temperatures. Post[24] disagreed because there was not a direct relationship between limb and atmospheric temperature. The differences may be due to differences in the temperature-measuring instruments: Isothermex in this study and a telethermometer (Model 44TD; Yellow Springs Instruments (YSI), Yellow Springs, OH) and temperature probes (YSI Model 402) in the previous study. Our thigh temperature changes during ice application were within the range as previously reported research from our lab using the Isothermex[14] device (Table 4).

Thigh temperature change during ice pack application is faster than change in the ankle or forearm, but slower than in the fingers. The fingers rewarm at a faster rate than the forearm and ankle.[16,17] Finger temperature returned to preimmersion temperature within 15 minutes of ice pack removal. Recovery periods of up to 7 hours have not been sufficient for temperatures to return to preapplication levels.[5] Rewarming of the ankle and forearm were reported to take in excess of 2 hours. Similar results have been reported in the lower leg.[23] Calf temperatures following immersion in 12.5°C to 15°C water for 30 minutes resulted in a temperature 3.6°C less than preimmersion after 180 minutes and about 2°C less after 6 to 7 hours.

Ankle temperature increases due to exercise before ice pack application were less than those found by Mancuso,[19] but similar to Edwards.[9] Mancuso[19] reported an increase of 2.1°C and 2.3°C in skin temperature during 15 and 30 minutes of treadmill running at 60% to 80% VO_2 maximum. Our subjects increased 0.7°C (ankle) and 0.2°C (thigh) during a 15-minute bicycle ride at 60% to 80% VO_2 maximum. Edwards[9] reported an increase of 1.0°C (at an atmospheric temperature of 28°C)

Table 3. Temperature Change During Selected Time Periods at the Ankle and Thigh (°C)

Condition	Length of Application of Cold Pack 20 min	30 min	40 min
Ankle			
Exercise	−.6 ± 1.5	−.6 ± 1.1	−.8 ± 1.2
First ice pack application	−23.7 ± 2.6	−25.0 ± 2.1	−25.5 ± 2.1
Second ice pack application	−23.9 ± 2.5	−24.2 ± 2.2	−23.2 ± 2.5
First rewarming	+23.3 ± 3.0	+23.8 ± 2.8	+22.5 ± 2.2
Second rewarming	+18.8 ± 3.0	+18.9 ± 2.0	+18.2 ± 1.9
First ice pack application and first rewarming	−.4 ± 1.7	−1.1 ± 1.8	−3.0 ± 1.7*
Second ice pack application and second rewarming	−5.0 ± 2.1	−5.3 ± 1.6	−5.0 ± 1.4
Entire trial	−5.4 ± 3.0	−6.4 ± 2.5	−8.0 ± 2.0*
Thigh			
Exercise	−.4 ± 1.0	−.1 ± 1.0	+.1 ± 1.0
First ice pack application	−26.8 ± 1.4	−27.8 ± 1.4	−28.5 ± 1.3†
Second ice pack application	−26.5 ± 1.2	−25.6 ± 1.5	−25.6 ± 1.9
First rewarming	+26.3 ± 1.4	+26.0 ± 1.3	+25.6 ± 1.5
Second rewarming	+24.4 ± 1.2	+23.2 ± 1.6	+23.2 ± 1.3§
First ice pack application and first rewarming	−.5 ± 1.3	−1.8 ± 1.4	−2.9 ± 1.7‡
Second ice pack application and second rewarming	−2.1 ± 1.0	−2.4 ± 0.9	−2.4 ± 1.3
Entire trial	−2.6 ± 1.6	−4.2 ± 1.3	−5.3 ± 1.8‡

Temperature increased during time period (+); temperature decreased during time period (−).
* 40- minute greater than 20- and 30-minute conditions ($p < .05$).
† 40- and 30-minute greater than 20-minute condition ($p < .05$).
‡ 40- and 30-minute greater than 20-minute condition, and 40-minute greater than 30-minute condition ($p < .05$).
§ 30- and 40-minute less than 20-minute condition ($p < .05$).

Table 4. Temperature Change in Various Sites During First Ice Application (°C)

	Measuring Device	Length of Ice Application 20 min	30 min	Atmospheric Temperature 40	45
Ankle					
Urban (28)	YSI	26.0	28.7		24.0
Mlynarczyk (22)	YSI	26.8	28.0	28.9	25.9
Mancuso (19)	YSI		21.9		24.8
Post (24)	YSI	22.1	23.1		24.0
		22.3	23.7		
Present Study	Isothermex	23.7	24.0	25.5	25.2
Thigh					
Knight					
DKZ (unpublished)	YSI	23.6	24.3	24.9	
DKA (unpublished)	Isothermex	26.2	26.8		
DKB (unpublished)	Isothermex	25.7	26.0	26.2	
Present Study	Isothermex	26.8	27.8	28.5	25.2

in ankle skin temperature during a 30-minute bicycle ride at 40% to 60% VO_2 maximum. This difference was probably due to a combination of two facts: bicycle riding is an exercise specific to the lower extremities, while treadmill running is more general and requires the use of the entire body.[27] Second, the duration of the ride was less. The increase in thigh temperature may have been different than the ankle because of better heat dissipation due to a larger surface area and increased vascularity of muscle.

Ankle and thigh temperature changes are greater after 40-minute ice applications than after 20-minute ice applications. Mlynarczyk[22] reported that ankle temperature changes were greater after a 20-minute condition than after a 45-minute condition. Thigh temperature following the first ice application, and both the ankle and thigh following the second ice application, showed a similar trend.

These data confirmed Post's[24] report that ankle temperatures were lower in all conditions during the second cycle of ice pack application and rewarming. Thigh temperature changes during second ice pack application, however, did not demonstrate this trend. Temperatures were lower at the end of rewarming. Cooling during the second ice application did not cause the temperature change during the second rewarming to be lower than the first rewarming, which is in agreement with Post.[24]

Subjects complained of pain a number of times throughout the treatment sessions, but they experienced the most pain during the 40-minute application. Two subjects claim to have suffered ill effects as a result of the treatment sessions. A week later they began experiencing a "pins-and-needles" sensation in the lateral aspect of the ankle and into the fourth and fifth toes with light touch. Nerve palsy is thought to be induced by cold application, tight elastic wraps, or a combination of the two.[7,10] One of the subjects had mentioned that the elastic wrap was very tight. She had participated in previous cold studies with no adverse effects. The possibility of a delayed effect of cold and/or elastic wraps has not been discussed and needs further investigation.

Repeated ice applications are a common and appropriate treatment for acute injuries. The critical factor appears to be the exercise following ice pack application. It appears that ice should be reapplied immediately after activity rather than being delayed. The body part that is to be iced determines the length of ice pack application. Further research is needed in the area of specific application protocols for specific body parts.

REFERENCES

1. Adams GM. *Exercise Physiology Laboratory Manual.* Dubuque, IA: William C Brown Publishers; 1990:43–53.
2. Bierman W, Friedlander M. The penetrative effect of cold. *Arch Phys Ther.* 1940;21:584–592.
3. Bing JH, Watts N. Effects of cooling on the triceps surae reflex. *Am J Phys Med.* 1962;42:240–251.
4. Borken N, Bierman W. Temperature changes produced by spraying with ethyl chloride. *Arch Phys Med Rehabil.* 1955;36:288–290.
5. Bugaj R. The cooling, analgesic, and rewarming effects of ice massage on localized skin. *Phys Ther.* 1975;55:11–19.
6. Cohn BT, Draeger RI, Jackson DW. The effects of cold therapy in the postoperative management of pain in patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med.* 1989;17:344–349.
7. Collins K, Storey M, Peterson K. Peroneal nerve palsy after cryotherapy. *Physician Sportsmed.* May 1986;14:105–108.
8. Cote DJ, Prentice WE, Hooker DN, Shields EW. Comparison of three treatment procedures for minimizing ankle sprain swelling. *Phys Ther.* 1988;68:1072–1076.
9. Edwards RJ, Harrison MH, Mills FJ. Blood volume and protein responses to skin cooling and rewarming during cycling exercises. *Eur J Appl Physiol.* 1983;50:195–206.
10. Green GA, Zachzewski JE, Jordan SE. Peroneal nerve palsy induced by cryotherapy. *Physician Sportsmed.* Sep 1989;17:63–70.
11. Hocutt JE. Cryotherapy. *Am Fam Physician.* Mar 1981;23:141–144.
12. Hocutt JE, Jaffe R, Rylander R, Beebe JK. Cryotherapy in ankle sprains. *Am J Sports Med.* 1982;10:316–319.
13. Johnson DJ, Moore S, Moore J, Oliver RA. Effects of cold submersion on intramuscular temperature of the gastrocnemius muscle. *Phys Ther.* 1979;59:1238–1242.
14. Knight KL. *Cryotherapy in Sports Injury Management.* Champaign, IL: Human Kinetics; 1995:59–75.
15. Knight KL. Ice for immediate care of injuries. *Physician Sportsmed.* Oct 1982;10:137.
16. Knight KL, Aquino J, Johannes SM, Urban CD. A re-examination of Lewis' cold induced vasodilation—in the finger and the ankle. *Athl Train, JNATA.* 1980;15:248–250.
17. Knight KL, Elam JF. Rewarming of the ankle, forearm, and finger after cryotherapy: further investigation of Lewis' cold induced vasodilation. *J Can Athl Ther Assoc.* 1981;8:17–18.
18. MacDougall JD, Reddan WG, Layten CR, Dempsey JA. Effects of metabolic hyperthermia on performance during heavy prolonged exercise. *J Appl Physiol.* 1974;36:538–544.
19. Mancuso DL. *Effects of Prior Activity on Skin Surface Temperature Response of the Ankle During and After a 30-Minute Ice Pack Application.* Terre Haute, IN: Indiana State University; 1986. Thesis.
20. McArdle WD, Katch FI, Katch VL. *Exercise Physiology: Energy, Nutrition, and Human Performance.* Philadelphia, PA: Lea and Febiger; 1986:356–360.
21. McMaster WC, Liddle S, Waugh TR. Laboratory evaluation of various cold therapy modalities. *Am J Sports Med.* 1978;6:291–295.
22. Mlynarczyk JM. *Temperature Changes in the Ankle During and After Ice Pack Application of 10, 20, 30, 45, and 60 Minutes.* Terre Haute, IN: Indiana State University; 1985. Thesis.
23. Petajon JH, Watts N. Effects of cooling on the triceps surae reflex. *Am J Phys Med.* 1962;41:240–251.
24. Post JB. *Ankle Skin Temperature Changes with Repeated Ice Pack Application.* Terre Haute, IN: Indiana State University; 1990. Thesis.
25. Saltin B, Gagge AP, Stolwijk JAJ. Body temperature and sweating during thermal transients caused by exercise. *J Appl Physiol.* 1970;28:138–327.
26. Stolwijk JAJ, Saltin B, Gagge AP. Physiological factors associated with sweating during exercise. *Aerospace Med.* 1968;39:1101–1105.
27. Roberts JA, Alspauc JW. Specificity of training effects resulting from programs of treadmill running and bicycle ergometer riding. *Med Sci Sports.* 1972;4:6–10.
28. Urban CD. *Insulating Effect of Elastic Wraps Used During the Application of Ice, Compression, and Elevation to the Lateral Aspect of the Ankle.* Terre Haute, IN: Indiana State University; 1980. Thesis.

Comparison of Stretching with Ice, Stretching with Heat, or Stretching Alone on Hamstring Flexibility

Gary R. Brodowicz, PhD, FACSM; Robert Welsh, MA; James Wallis, MS

Objective: To investigate the efficacy of stretching with ice for increasing hamstring flexibility.

Design and Setting: Supine hamstring flexibility was measured before and after subjects accomplished a 20-minute hamstring stretching routine. Two groups of eight subjects accomplished the routine using one of two modalities. A control group (n = 8) accomplished the routine without a modality. The measurements were compared.

Subjects: Twenty-four male collegiate baseball players.

Measurements: Heat or ice applied to the hamstring.

Results: We found differences in the responses among subject groups. Supine hamstring flexibility after stretching with ice was greater than both stretching with heat and stretching alone. Scores after stretching with heat and stretching alone were not different.

Conclusions: The results of our investigation suggest that the application of ice may provide enhanced short-term improvements in hamstring flexibility over heat or stretching alone. Further research is necessary to investigate the possible mechanisms for these improvements and to determine whether similar results can be obtained with other muscle groups.

Key words: cryotherapy, stretching, flexibility

Adequate flexibility is an important characteristic of physical fitness. Many athletic teams devote attention to the development or maintenance of flexibility, mainly through the use of various stretching exercises. There continues to be debate regarding the optimal technique(s) for stretching and flexibility training.

Numerous researchers have attempted to determine how temperature influences range of motion,[2,3,4,6,10,11,13,16,17] but it appears that there are no clear answers. The purpose of this study was to investigate the efficacy of cryostretching for increasing supine hamstring flexibility. We compared stretching with ice, stretching with heat, and stretching alone.

METHODS

Subjects

A convenience sample of 24 healthy male college baseball players (age = 20.7 ± 1.2 yr, ht = 73.0 ± 2.6 in, wt = 192.1 ± 16.4 lb) agreed to participate in the study. The University of Portland subcommittee on research involving human subjects granted approval for the study. All subjects gave voluntary written informed consent before participation. Subjects were involved in daily baseball training sessions and weight resistance exercise training 3 days per week. We verbally screened all subjects to ensure that none suffered from injuries or disabilities involving the hamstring muscle group.

Gary R. Brodowicz is an associate professor in the Department of Public Health Education at Portland State University, P.O. Box 751, Portland OR 97207. At the time of the study, **Robert Welsh** was a master's degree student at the University of Portland. **James Wallis** is assistant professor and head athletic trainer in the Department of Athletics at Portland State University, Portland, OR.

Equipment

A Leighton flexometer[9] (Fig 1) was used to assess hamstring flexibility for the pretest and posttest. We performed pilot tests using 12 subjects (18 to 41 years) to compare the Leighton flexometer with a standard goniometer in the measurement of supine hamstring flexibility. The measurements made with the Leighton flexometer appeared to be more consistent, and the flexometer was easier to use than a double-arm goniometer.

We applied standard hot packs (110°F to 115°F), secured with an elastic wrap, to the posterior thigh in subjects who stretched with heat. Subjects who stretched with ice used bags filled with crushed ice held in place over the hamstring muscle group with an elastic wrap. The area covered by the hot packs or crushed ice was approximately 10 inches by 19 inches and included the central portion of the hamstring muscle group.

Procedures

Each subject performed a supine hamstring flexibility pretest between 1:00 P.M. and 2:00 P.M. on the test day. We positioned each subject supine and securely strapped a Leighton flexometer to the lateral aspect of the right mid-calf (Fig 2). To stabilize the pelvis and contralateral leg, the test administrator secured the contralateral leg at the knee and secured both hips at the anterior superior iliac spine. After the flexometer was zeroed, the athlete was asked to raise his leg as far as possible without bending the knee. Subjects kept the ankle in a neutral position (90°) in an attempt to reduce the variability caused by dorsiflexion and plantar flexion. The test administrator did not assist the subject and gave only verbal encouragement, locking the flexometer at the terminal position of hip flexion. Three trials were administered, with a 20-second rest between trials. We tested the subject's left leg using the same protocol. The

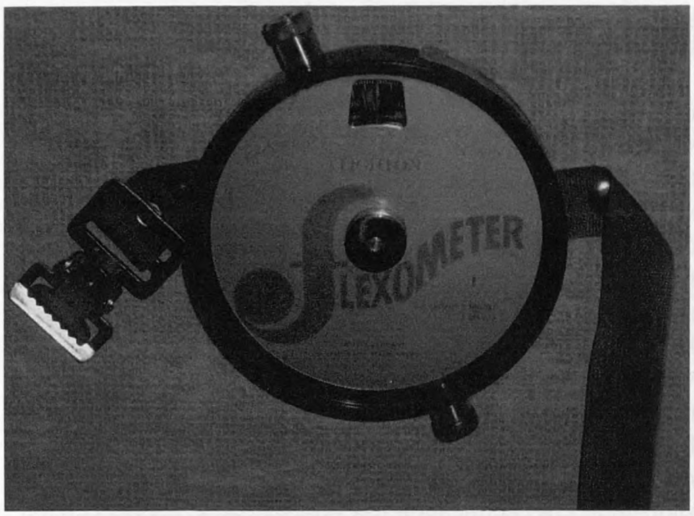


Fig 1. Leighton flexometer.

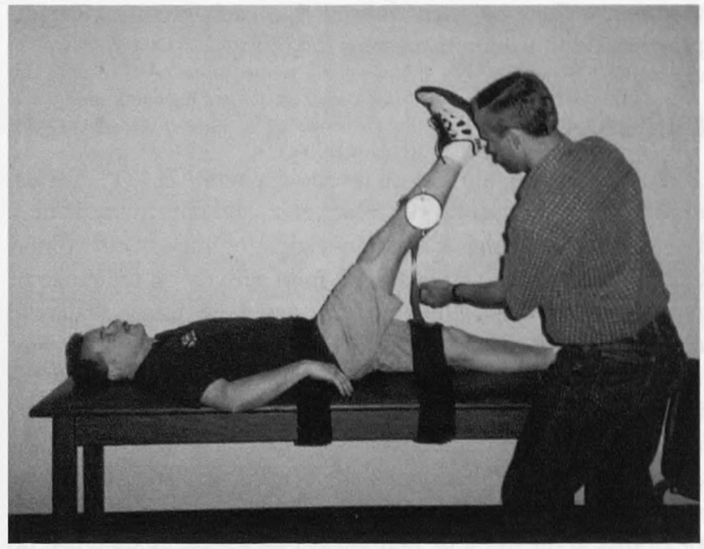


Fig 2. Subject performing supine hamstring flexibility test.

average of three trials was used as the supine hamstring flexibility score for each leg, with the sum of the scores for the two legs used as the dependent variable.

We randomly assigned subjects to treatment groups. The group that stretched with heat (n = 8) performed a 20-minute stretching routine with hot packs secured to the posterior thigh of each leg; the group that stretched with ice (n = 8) performed the same stretching procedures with ice bags secured to the posterior thigh of each leg; the group that only stretched (n = 8) performed the stretching routine without a modality. Stretching consisted of 2 single- and 2 double-leg static stretches (modified hurdler's stretch and sit-and-reach) held for 3 minutes each. Total stretching time was 20 minutes.

A posttest supine hamstring flexibility test was conducted by the same test administrator immediately after the experimental treatment in the same manner as the pretest.

Statistical Analysis

Simple descriptive statistics summarized the physical characteristics of each subject. The dependent variable (supine hamstring flexibility score) was the sum of the mean scores for the right and left leg. To examine effects on supine hamstring flexibility, we used a 2-way group-by-time repeated measures analysis of variance (ANOVA) with modality (stretch with heat, stretch with ice, and stretch only) as the grouping factor and trial (pretest, posttest) as the repeated measures factor. Tests of simple main effects were performed with ANOVA followed by Newman-Keuls multiple comparison procedure to identify different means. We used paired *t* tests to evaluate the differences between pretest and posttest means for each treatment group. Statistical significance was accepted at $p \leq .05$.

RESULTS

Group means for the pretest and posttest supine hamstring flexibility scores are presented in the Table. ANOVA indicated a main effect for modality ($F(2,21) = 3.77$; $p < .05$), trial ($F(1,21) = 63.14$; $p < .05$), and modality by trial interaction ($F(2,21) = 6.83$; $p < .05$). Tests of simple main effects (1-way ANOVAs performed on pretest group means and on posttest group means) demonstrated no difference between the pretest scores for the three groups ($F(2,21) = 1.54$; $p = .24$). Posttest means were found to be different ($F(2,21) = 6.66$; $p < .05$). The Newman-Keuls multiple comparison procedure revealed that the mean for the group that stretched with ice was greater than the means for both the group that stretched with heat and the group that only stretched. There was no difference between the means for the group that stretched with heat and the group that only stretched.

The treatment-by-trial interaction indicated that there were differences between the groups in their responses to the various

Pretest and Posttest Supine Hamstring Flexibility Scores

	Pretest*			Posttest*		
Group	Right	Left	Sum	Right	Left	Sum
Stretch + heat	84.6 (7.7)	87.4 (8.2)	172.0 (14.4)	88.8 (5.7)	90.9 (3.9)	179.6 (8.3)
Stretch + ice	86.5 (5.6)	90.5 (6.9)	177.0 (9.2)	95.1 (8.3)	99.8 (7.6)	194.9† (11.6)
Stretch only	83.9 (8.0)	81.5 (8.1)	165.4 (15.4)	85.9 (8.7)	86.4 (8.1)	172.3 (16.6)

* Given in degrees and standard error of the mean.
† Greater than stretch + heat and stretch only ($p < .05$).

treatments. Paired *t* tests showed that each group made improvements in supine hamstring flexibility.

DISCUSSION

Our results are contrary to those of others.[3,5,11,14,16] Differences in protocols, subjects, treatments, and data analysis may be partly responsible. A study investigating the effects of mild activity, heat, cold, and heat with mild activity on the range of motion at the wrist, elbow, ankle, and knee found that cold application (immersion in 10°C water for 10 minutes) was inferior to all other treatments, with the exception of the knee.[16] The investigation of different joints hampers comparisons with the present study.

Another study investigated the effects of static stretching, sauna warm-up, cold applications, and exercise warm-up on flexibility at the hip joint and found that ice application had no effect on straight leg flexion in 70 male students.[5] The duration of cold application (2.5 minutes) may have limited any hypothesized beneficial effects of the treatment.

Superficial heat followed by a 1-minute stretch and superficial cold followed by a 1-minute stretch were compared with stretching alone using 12 males and 12 females aged 18 to 39 as subjects.[17] A significant increase in hamstring length was noted regardless of the treatment used, with no significant differences detected between treatments. This experiment was different from ours in that thermal treatments were followed by stretching; our subjects performed stretching with heat or ice. Also, the stretching consisted of a single 1-minute stretch whereas our subjects performed several 3-minute stretches.

Flexion, abduction, and external rotation in the right hip were measured in a study that compared the combination of heat and stretching with heat alone and stretching alone.[6] Heat followed by stretching increased hip flexion range of motion immediately after and 30 minutes after the treatment, but the increase was not significantly greater than stretching alone. Heat alone did not increase range of motion at the hip joint. This study again differed from ours in that the stretch was performed after the 20-minute heat treatment and the passive stretch was held for only 7 seconds.

A study similar to ours found that both cryotherapy (ice) and thermotherapy (hydrocollators) improved immediate hip range of motion (measured with a goniometer) but detected no difference between the treatments.[11] The methodology of our study differed in several respects. We chose to measure hamstring flexibility with a Leighton flexometer instead of a goniometer. We also selected as our dependent variable the sum of the flexion scores (mean of 3 trials) for both legs. Our study design included a control group (stretch only) that allowed us to investigate the efficacy of temperature manipulations during a stretching protocol. It is unknown to what extent the use of athletes as subjects contributed to the difference in conclusions. The primary difference in our study is that we chose to examine the combined effect of static stretching and temperature manipulations on range of motion. An important limitation of our study is that the small convenience sample (n = 8 per group) limited our ability to detect any statistically significant difference between the means of the group that stretched with ice and the group that stretched with heat.

One study that investigated the effect of brief cold application on passive hip flexion was performed on 40 college-age volunteers.[12] Fluori-Methane spray (Gebauer Co., Cleveland, OH) (6 applications of 5 seconds each) in combination with stretching increased passive hip flexion 8.78°, but it was concluded that there was no significant improvement in passive hip flexion. Unlike our investigation, the total duration of cold application was only about 30 seconds, limiting any meaningful comparison to our results.

What are possible mechanisms for the cold-induced facilitation of flexibility in this study? A diminished proprioceptive feedback after stretching with ice may somehow act to increase range of motion. A review of several studies revealed that short-term cold application has little affect on proprioception.[8]

Another plausible mechanism relates to the effects of cooling on the stretch reflex. One study demonstrated that cooling a stretched muscle caused a depression of the stretch reflex.[7] In theory, this effect could have allowed our subjects to stretch further during the leg flexion test. The activation of the stretch reflex in our subjects was minimized because of the slow, controlled stretch performed during the stretching protocol and the leg flexion test.

The beneficial effects of cold application during stretching may be related to effects on muscle spasm or pain sensation.[1] The use of ice and low-load prolonged stretch may be useful for increasing the range of motion where inflammation or painful factors contribute to reduced function in patient populations.[10] Our study included only healthy athletes who were free from any known injuries or disabilities to the hamstrings, so it is unlikely that leg flexion was limited by abnormal pain or spasm. On the other hand, when ice treatment is combined with static stretching, the athlete may find it easier to endure the mild discomfort commonly felt at the terminal position of the stretch. One study reviewed evidence suggesting that stretching combined with cold application for the purpose of increasing range of motion should be used only in certain situations.[15] These include 1) when it is desired to tear connective tissue, 2) instances where intense pain warrants the use of cold-induced analgesia, and 3) muscle spasticity.[15] We interpret our results as supporting the use of ice during stretching, but we advise that caution be used in its practical application. We agree that after cooling it would be prudent to warm up properly to minimize stress-induced muscle tears.[8]

In conclusion, the results of this investigation suggest that the application of ice while stretching may provide enhanced short-term improvements in flexibility over heat or stretching alone. Further research must be performed to uncover the mechanism(s) involved.

REFERENCES

1. Benson TB, Copp EP. The effects of therapeutic forms of heat and ice on the pain threshold of the normal shoulder. *Rheumatol Rehabil* 1974;13:101–104.

2. Chambers R. Clinical uses of cryotherapy. *Phys Ther.* 1969;49:245–249.
3. Cornelius W, Jackson A. The effects of cryotherapy and PNF on hip extensor flexibility. *Athl Train, JNATA.* 1984;19:183–199.
4. Cornelius W, Khosrow E, Watson J, Hill D. The effects of cold application and modified PNF stretching techniques on hip joint flexibility in college males. *Res Q Exerc Sport.* 1992;63:311–314.
5. Frey HJ. *A comparative study of the effects of static stretching, sauna warm-up, cold applications, exercise warm-up, on extent flexibility, and dynamic flexibility of the hip joint.* Salt Lake City, Utah: University of Utah; 1970. Thesis.
6. Henricson A, Fredriksson K, Persson I, Pereira R, Rostedt Y, Westlin N. The effect of heat and stretching on the range of hip motion. *J Orthop Sports Phys Ther.* 1984;6:110–115.
7. Horvath SM, Hollander JL. Intra-articular temperature as a measure of joint reaction. *J Clin Invest.* 1949;28:469–473.
8. Knight KL. *Cryotherapy in Sport Injury Management.* Champaign, IL: Human Kinetics; 1995:173.
9. Leighton JR. The Leighton flexometer and flexibility tests. *J Assoc Phys Mental Rehabil.* 1966;20:86–93.
10. Lentell G, Hetherington T, Eagan J, Morgan M. The use of thermal agents to influence the effectiveness of a low-load prolonged stretch. *J Orthop Sports Phys Ther.* 1992;16:200–207.
11. Minton J. A comparison of thermotherapy and cryotherapy in enhancing supine extended-leg, hip flexion. *J Athl Train.* 1993;28:172–176.
12. Newton R. Effects of vapocoolants on passive hip flexion in healthy subjects. *Phys Ther.* 1985;65:1034–1036.
13. Price R, Lehman J. Influence of muscle cooling on the viscoelastic response of the human ankle to sinusoidal displacements. *Arch Phys Med Rehabil.* 1990;71:745–748.
14. Rosenberg BS, Cornelius WL, Jackson AW. The effects of cryotherapy and PNF stretching techniques on hip extensor flexibility in elderly females. *J Phys Educ Sport Sci.* 1990;2:31–36.
15. Sapega AA, Quedenfeld TC, Moyer RA, Butler RA. Biophysical factors in range-of-motion exercise. *Physician Sportsmed.* 1981;9:57–64.
16. Sechrist WC, Stull GA. Effects of mild activity, heat applications, and cold applications on range of joint movement. *Am Corr Ther J.* 1969;23:120–123.
17. Taylor B, Waring C, Brashear T. The effects of therapeutic application of heat or cold followed by static stretch on hamstring muscle length. *J Orthop Sports Phys Ther.* 1995;21:283–286.

The Effects of Prophylactic Brace Construction Materials on the Reactive Responses of the MCL During Repetitive Impacts

Patrick E. Patterson, PhD, PE; Jay Eason, MS

Objective: The purpose of the present study was to investigate the effect of different construction materials on the ability of a prophylactic brace to reduce the stresses sustained by a surrogate medial collateral ligament (MCL) under low-energy repetitive impact conditions.

Design and Setting: A surrogate leg was fixed at both the hip and foot with the knee in full extension. A prophylactic brace was attached to the surrogate leg and the system struck by an impactor weighing either 6.68 kg or 16.9 kg.

Subjects: A single brace design (Am Pro Knee Guard) was used. Three different materials (nylon, aluminum, graphite) were used in constructing the brace uprights.

Measurements: Tension in the MCL was measured under all conditions of brace material and impactor weight. In addition, the impact impulse response of the system was evaluated.

Results: The graphite and aluminum uprights showed significant reductions in both MCL peak tension magnitude (from 12 to 21% improvement) and in the impulse response of the MCL (from 36 to 47% improvement) when compared to the no-brace condition.

Conclusions: The present study indicates that the choice of brace upright material does have a significant effect on the transmission and absorption of low-level repetitive impact forces at the MCL and should be an important consideration in the design of better knee braces.

Key Words: knee braces, MCL protection, brace materials

The value of prophylactic bracing as a means of preventing or reducing knee injury in athletes has created significant controversy over the years. Studies of the possible protective effects for noninjured athletes have shown mixed results. Longitudinal studies evaluating the actual use of braces over the course of multiple football seasons have generated findings ranging from indications that braces effectively reduce,[8,14] have no effect on,[9,18] or even increase,[7,15] the occurrence of injuries. Some studies have found a significant reduction in the total number of injuries occurring, but not in their severity.[16] Other studies did not find a reduction in the total number of injuries occurring, but instead found a reduction in the injury severity as evidenced by performing 70% fewer surgeries on those injuries.[17] Biomechanical testing of cadaver and surrogate legs has been no less mixed, with results ranging from the determination that the braces are effective,[5] have limited effectiveness,[2,3] or are ineffective[1,13] in providing protection to the medial collateral ligament (MCL).

No clear consensus has been reached regarding the value of bracing the knees of noninjured athletes. A possible explanation for the wide variety of results found in the literature, including the anecdotal reductions, might be the magnitude of the typical impacts found in sport. Most impacts that occur during a sporting event are well below the level of severity that will cause permanent damage to the MCL. However, the cumulative effects of these lesser impacts could set the stage for future major injury. Researchers have found that many athletes sustaining major knee injuries had ligamentous laxity caused by previous knee injuries,[4] indicating that chronic exposure to less than severe levels of impact must be considered as a possible contributing factor in sustaining catastrophic injuries.

To determine whether the choice of material used in the manufacture of the brace uprights would be a significant factor in reducing both the peak tension magnitude sustained by, and the reactive impulse provided by, the MCL during repetitive low-energy impacts, we struck a surrogate leg protected by braces with uprights made from three different materials. It was anticipated that use of stiffer construction materials in the brace uprights would significantly reduce both the peak tension and reactive impulse provided by the MCL.

Patrick E. Patterson is an associate professor in the Department of Industrial and Manufacturing Systems Engineering and the Biomedical Engineering Program, Iowa State University, Ames, IA 50011. At the time of the study, **Jay Eason** was a graduate student in the Biomedical Engineering Program at Iowa State University.

METHODS

Since the objective of the present study was to test the effect of material stiffness on a brace's ability to protect the MCL, a single brace style was used to eliminate any differences due to brace configuration. Uprights made of three different materials were tested with the results compared to a control condition in which no brace was used.

The Test Apparatus

The supporting frame for the surrogate leg and impactor pendulum was constructed with the leg held in a fixed position by pins located through the hip and ankle (Fig 1). These pins were inserted into bearing sleeves isolated from framework vibrations by the use of rubber bushings.

The pendulum pivoted on an axle inserted into the bearing sleeves at the height of the hip pin and located to impact directly on the surrogate knee joint at the bottommost point of its swing. The impactor surface was a football helmet rigidly attached to the pendulum.

The surrogate leg bones were made from square aluminum tubing with a wall thickness of 0.32 cm, selected to limit torsional motion on impact. Aluminum was chosen because it has strength, stiffness, and bending characteristics similar to bone.[11] The leg's size and shape were based on the characteristics of the average male: tibia and femur lengths of 35.1 cm and 45.7 cm, respectively, and thigh and calf circumferences of 59.5 cm and 37.5 cm, respectively.[12] The leg's tissue was built up from layers of gel and foam to match the bulk and consistency of normal tissue.

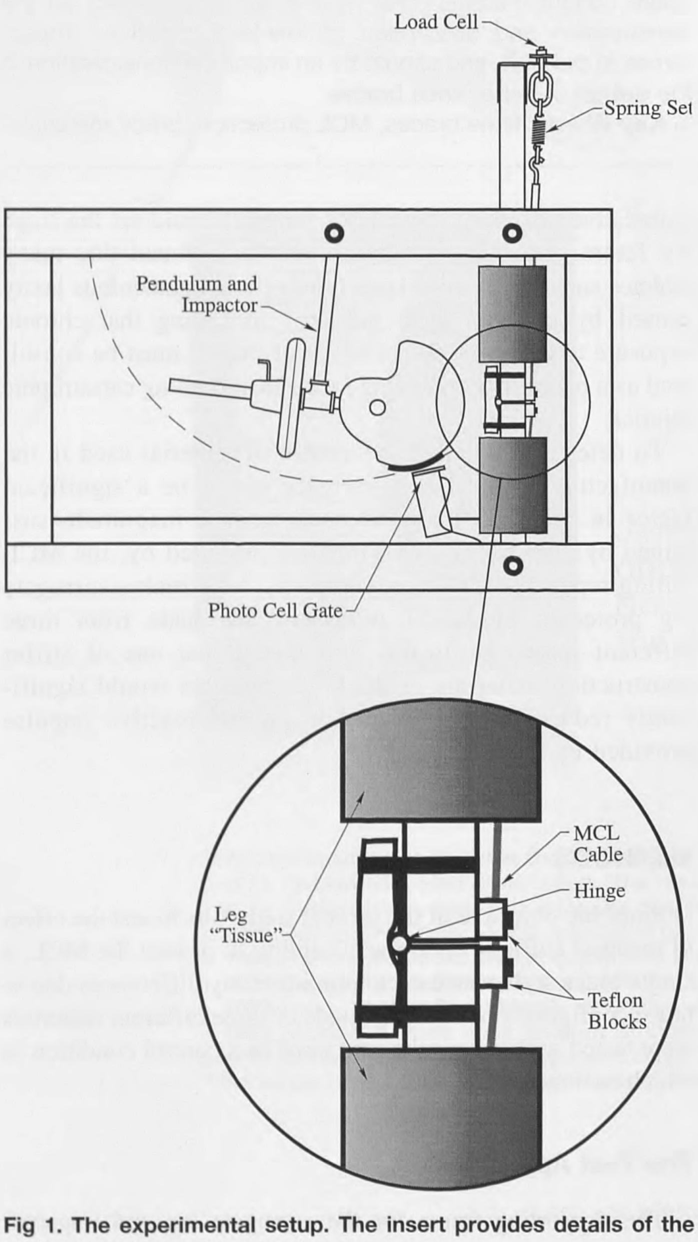


Fig 1. The experimental setup. The insert provides details of the knee joint without the knee brace.

The pendulum impacted on the lateral surface of the knee causing it to open on the medial side, an action resisted by the surrogate MCL. The MCL was modeled by a 0.95-cm stranded steel cable with a working load rating of 444.5 kg, a value similar to that used in similar surrogate studies.[11] The proximal end of the cable was clamped to a bar attached to a set of six springs having a spring constant of 470 N/cm. These springs transmitted forces via a steel U-bolt and flat plate to a quartz load cell (Fig 1).

The brace used in this research was the Am Pro Knee Guard (Athletic Training Specialists, Ames, IA), a uniaxial preventive brace having bilateral uprights fabricated from nylon. Cuffs, formed from a combination of polypropylene and polyethylene, are held onto the leg by bands of neoprene with VELCRO® attachments (see Randall, Miller and Schurr[14] for photograph). The uprights were removed and duplicated in both 6061-T6 aluminum and graphite fiber. The static bending stiffness for each of the materials was 8 N/cm for nylon, 230 N/cm for aluminum, and 264 N/cm for graphite.

Procedure

The leg was fixed at both the hip and foot with the knee fully extended for all impact conditions, simulating a worst case knee impact situation. Brace-leg coupling was performed as recommended by the brace manufacturer and checked before each trial.

Two different loads were placed on the pendulum, representing low-impact (6.68 kg) and high-impact (16.9 kg) conditions. These load values were selected based upon the results of a pilot study. The study determined the maximum impact value that the leg-brace combination could oppose without allowing the surrogate MCL to elongate more than 12.6%, a value beyond which an actual ligament would typically be torn.[3] The high-impact condition was arbitrarily set at 75% of this value.

The pendulum was manually raised until it contacted a notched marker and then released to begin the collection loop of the data acquisition program. A photocell gate, fixed to the frame of the apparatus in the path of the pendulum, was connected to a Keithley A/D converter (Keithley Metra Byte Corporation, Taunton, MA) and constantly monitored by the program. Data collection was started before impact, when the photocell was tripped by the impactor. The impactor struck directly on the lateral aspect of the knee joint (Fig 1) and was not allowed to rebound. This sequence was repeated 100 times for each material.

Data Analysis

To analyze the data statistically, we performed independent *t* tests comparing the four conditions of cable (MCL) tension for each of the two pendulum loads. The four conditions represented data from the control (impacts on the leg with no brace), the Am Pro brace as manufactured (nylon uprights), the Am Pro modified with aluminum uprights (aluminum), and the Am Pro modified with graphite uprights (graphite). Data are summarized as mean ± SD, with differences considered to be significant at $p < 0.01$.

Additional comparisons evaluated the reduction in reactive impulse at the MCL compared to a nonbraced knee. During an impact the momentum of the striking object must be reduced to zero (dissipated) before the struck body's structures are damaged. A momentum value by itself does not provide information regarding how it changes value (from a maximum value to, hopefully, zero). An impulse value was used to provide this information. An impulse is a time history of a force as it relates to the change in momentum over a specific interval; that is, $F_a\Delta t = m\Delta v$, where F_a is the average force acting during a time interval (Δt) to cause a change in momentum ($m\Delta v$).

An infinite number of time and force combinations are possible that will change momentum to a required value. For example, 100 N applied over a 1-second interval provides the same capability for reducing an object's momentum as does 50 N applied over 2 seconds, 100 Ns. The difference between these impulses is the effect each has on a structure; high force over a short time interval indicates a quicker stop with potentially damaging effects, while the same impulse delivered by use of a low force over a longer period acts to soften the blow.

Of particular interest is the impulse that must be resisted by the MCL during this time interval. The impact momentum delivered to the knee must be reduced to a low level before the internal structures, such as the MCL, are loaded beyond their capacity. The brace-leg coupling characteristics, which affect how successfully the system transmits forces to the soft tissues, dictate the proportion of the total resistance (ie, residual needs provided in the form of tension and reactive impulse) that must be provided by the MCL to preserve structural integrity. A load uniformity ratio, defined as the ratio of peak tension to average tension, was used as an indicator of the energy absorption characteristics of the brace-leg combinations. A higher ratio indicates a sharper rise and fall of tension in the ligament due to high deceleration response characteristics (large F_a, small Δt) of the brace-leg combination. A plot of the force in the MCL over time was used to further aid interpretation of the impulse.

RESULTS

The impact of loads striking a surrogate knee under conditions of low constant velocity indicated that the material selected for constructing the uprights in a knee brace does make a significant difference in MCL protection. Since the aluminum and graphite configurations were much stiffer than the nylon, it was anticipated that they would provide greater MCL protection than either the control or the original configuration.

Peak Tension

Tension measurements in the MCL were taken under both low- and high-impact conditions. Aluminum and graphite uprights reduced MCL tension from 12% to 21% compared to the no-brace condition. All comparisons with the control were significant [$t(198)$, $p < .01$], except for the nylon versus no-brace comparison in the low-impact condition. The means and standard deviations of the MCL tension data are shown in the Table.

Reactive Impulse

The time history of the tension in the MCL, as it attempted to reduce the residual momentum of the impactor, was also averaged for each brace material in the two impact conditions. This reactive impulse was used to compare how well each brace-material-leg combination dissipated the impact forces. Aluminum and graphite uprights reduced the reactive impulse of the MCL from 36% to 47% compared to the no-brace condition. This was in contrast to the uprights made from nylon. Not only were the peak and average tension greater in the nylon upright condition, but also the time over which the force was applied was greater, further increasing the impulse (Fig 2). Significant differences from the control were found for all reactive impulse comparisons [$t(198)$, $p < .01$] (Table).

DISCUSSION

Our results show that upright material selection does have a significant effect on the transmission and absorption of low-

Comparisons of Means (Standard Deviations): Peak Tension, Impulse, Load Uniformity Ratio (LUR), and Impact Safety Factor (ISF)

Brace Material	Peak Tension (N)	Impulse (Ns)	LUR	ISF
No Brace				
Low*	427.4 (3.2)	51.5 (0.68)	3.9 (0.01)	—
High	1314.7 (22.6)	264.8 (0.04)	2.4 (0.02)	—
Nylon				
Low	439.4 (2.5)	48.6 (0.48)	3.9 (0.01)	0.1†
High	1443.6 (13.9)	281.9 (2.25)	2.4 (0.02)	−8.9
Aluminum				
Low	339.6 (2.6)	27.7 (0.29)	5.6 (0.02)	18.2
High	1099.7 (33.1)	170.6 (4.29)	2.8 (0.03)	16.7
Graphite				
Low	362.1 (1.2)	28.8 (0.08)	5.6 (0.02)	17.2
High	1174.2 (17.6)	153.3 (2.26)	3.1 (0.02)	10.5

* Low- and high-impact conditions.
† Stated as a percentage (%). Positive values indicate an improvement over the no-brace condition.
All possible comparisons were significant ($p < 0.01$) except for the plastic versus no-brace comparisons in the low-impact condition.

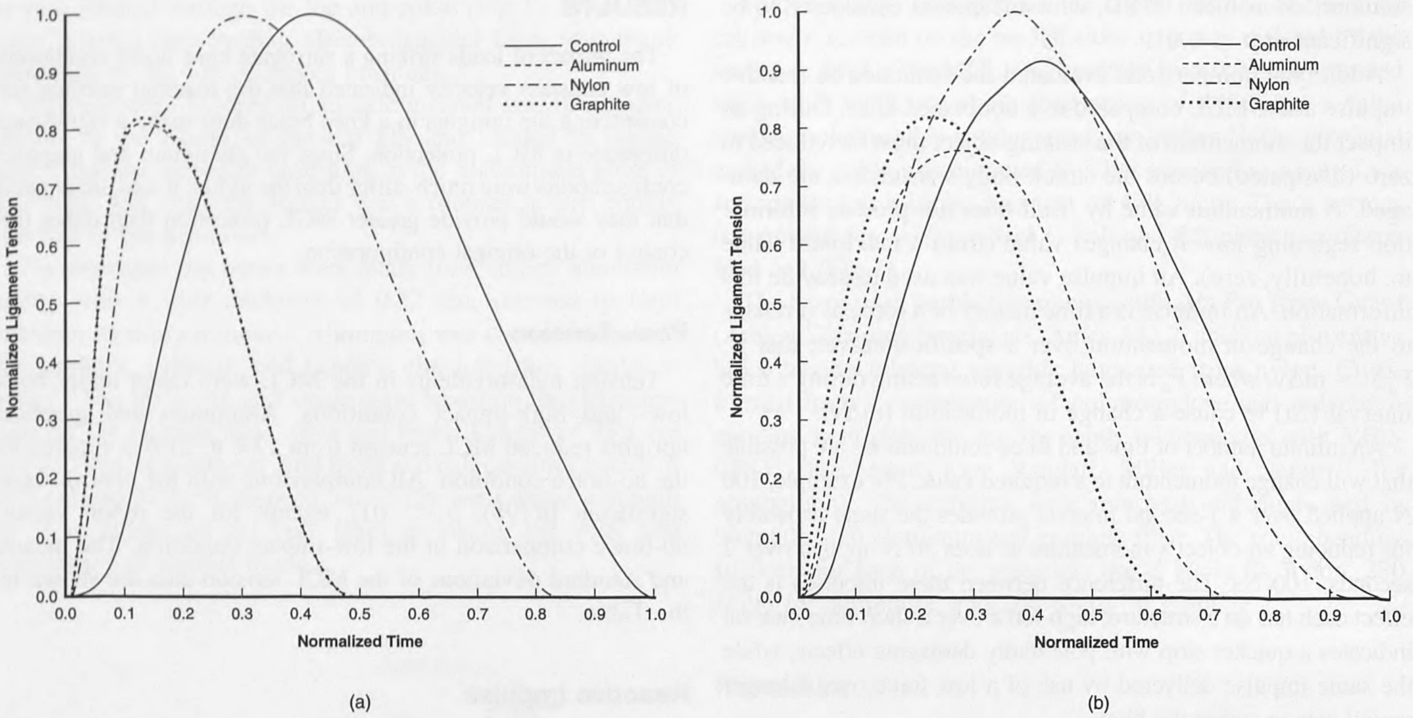


Fig 2. Averaged impulse shapes for each condition: (a) low impact; (b) high impact.

level, repetitive impact forces at the knee. Stiffer materials, which better resisted bending, provided more protection to the MCL in this test situation. That is, the MCL was required to provide a smaller proportion of the total resistance to an impact when protected by a brace made of stiffer materials.

We found that the graphite and aluminum brace-leg units provided additional protection to the MCL in the form of improved impact absorption. This finding could account for the wide variety of results found in the literature, including the anecdotal injury reductions seen in several studies.[8,14] Most impacts that occur during a sporting event are well below the level of severity needed to damage the MCL permanently. However, the cumulative effects of these lesser impacts could lead to laxity of the ligament and a propensity for future major injury.[4] Our findings imply that braces may be well suited for reducing the effects of minor impacts such that the involved structures are less likely to sustain microtraumas that could, over time, result in the sustaining of a more severe injury.

Unexpectedly, the nylon material performed no better than wearing no brace at all and, in the high-impact condition, not only provided no reduction in peak tension from the control case but actually demonstrated values higher than those found in the no-brace condition. Similar counterintuitive results have been reported previously in a study of anterior cruciate ligament forces during bracing[1] and in a survey of injury rates.[7]

The impulse results indicated that the stiffer materials provided a greater degree of protection than either the original nylon brace material or no brace at all. For the low-impact condition all braces demonstrated a reduction in the average impulse at the MCL compared to the no-brace condition. Similar results were found in the high-impact condition, except for the original nylon material, which again performed more poorly than no brace at all. Interestingly, while the tensions seen at the MCL were greater in magnitude in the high-impact case, as expected, the load uniformity ratio actually improved when compared to the low-impact case. This indicates a more uniform distribution of the forces over time for the high-impact condition.

We suggest that the design of the Am Pro Knee Guard, and prophylactic braces in general, accounted for the surprising nylon upright results. The brace design provided only a small space between the joint and the hinge (joint line clearance). In this situation only the most rigid of materials could prevent knee joint contact, even in our low-impact conditions. The resulting joint line contact concentrates forces on the knee that should be distributed along the brace to the soft tissues. This contact actually increases the damaging forces because a three-point bending effect is created by the brace-leg combination.[6,13] However, we noted that even during this nonoptimum joint line contact only the nylon material was unable to provide additional protection to the MCL. Since the nylon bent more easily in response to an impact, little transference of the impact forces to the coupled soft tissues could take place before the contact between the brace upright and the surrogate knee occurred.

This study focused on the reactive impulse needed by the MCL to reduce impactor momentum after the brace-leg contributions, by considering the time history of the impact. France, Paulos, Jayaraman, and Rosenberg[6] assessed the impact response of a braced knee by testing several commercially available braces and defined an Impact Safety Factor (ISF), which was based on a ratio of the peak tensions of the braced to unbraced knee divided by their respective momentum values. A minimum ISF of 1.50, equal to a 30% reduction in MCL load, was arbitrarily proposed as a standard level of safety. They concluded that the tested braces were biomechanically inadequate. However, they felt that with refinements in brace material properties and mechanical design, preventive knee bracing could be made effective in preventing injury. The values of ISF for the conditions of the present study varied from 0.9 (plastic, high impact) to 1.2 (aluminum and graphite, high impact, and aluminum, low impact), providing a maximum load reduction of only 18% at the MCL, well below the recommended level of 30%. However, if the impulsive nature of the impacts is accounted for, much greater protection is provided than is indicated by the ISF method (Table, Fig 2) for this range of impacts.

Since the combination of factors surrounding any impact to a knee (energy content of the blow, its location, surface type, angle of impact, strength, fatigue, etc) cannot be controlled in the real world, it is most difficult to assess epidemiologic and anecdotal data. The higher incidence for braced athletes reported in some studies[7,15] may be the result of exposures to high-energy impacts outside the expected range of protection provided by a brace. Future research will investigate brace-leg units by use of increased impact velocities, a variety of impact locations, a variety of leg volumes, and the consideration of muscle fatigue. While upright material rigidity provides significantly better protection to the MCL than no brace at all, additional design characteristics must evolve to provide both increased structural rigidity and force transference capability if protection from more severe acute injuries is desired. However, the results of the present research demonstrated a marked reduction in force and impulse transference to the MCL for both the graphite and aluminum materials during low-energy impacts, indicating that there exists a range of impact values for which a brace may provide much needed protection. By combining with our results information from studies indicating that a good brace fit does not necessarily provide the best force reduction characteristics,[10] it may be possible to design protective braces in which the brace-leg coupling configuration is less form fitting and less movement restrictive than today's generation of braces.

Our research implies that today's braces can contribute much needed protection to the MCL under certain circumstances, provided appropriate materials are used in their construction. However, more research is needed before a definitive assessment can be made regarding their effectiveness in a wide variety of circumstances.

REFERENCES

1. Baker BE, Van Hanswyk E, Bogosian S, Werner FW, Murphy D. A biomechanical study of the static stabilizing effect of knee braces on medial stability. *Am J Sports Med.* 1987;15:566–570.
2. Baker BE, Van Hanswyk E, Bogosian S, Werner FW, Murphy D. The effect of knee braces on lateral impact loading of the knee. *Am J Sports Med.* 1989;17:182–186.
3. Brown TD, Brand RA. *Final Report: Mechanical Performance of the Am Pro Knee Brace.* Iowa City, IA:University of Iowa; 1986.
4. Ekstrand J, Gillquist J. The frequency of muscle tightness and injuries in soccer players. *Am J Sports Med.* 1982;10:75–78.
5. Erickson A, Yasuda K, Beynnon B, Johnson R, Pope M. A dynamic evaluation of the effectiveness of prophylactic knee braces. *Trans Orthop Res Soc.* 1991;16:186.
6. France PE, Paulos LE, Jayaraman G, Rosenberg TD. The biomechanics of lateral knee bracing. Part II. Impact response of the braced knee. *Am J Sports Med.* 1987;15:430–438.
7. Grace TG, Skipper BJ, Newberry JC, Nelson MA, Sweester ER, Rothman ML. Prophylactic knee braces and injury to the lower extremity. *J Bone Joint Surg (Am).* 1988;70:422–427.
8. Hansen BL, Ward JC, Diehl RC. The preventive use of the Anderson knee stabler in football. *Physician Sportsmed.* 1985;13:75–81.
9. Hewson GF, Mendini RA, Wang JB. Prophylactic knee bracing in college football. *Am J Sports Med.* 1986;14:262–266.
10. Lunsford TR, Lunsford BR, Greenfield J, Ross SE. Response of eight knee orthoses to valgus, varus and axial rotation loads. *J Prosthet Orthot.* 1990;2:274–288.
11. Mason JT, Cawley PW, Mason BR. Method of determining stress effects in components of the human knee and anthropomorphic leg device therefore. US patent 4,850,877. 1989.
12. McConville JT, Laubach LL. Anthropometry. In: Webb and Associates, eds. *Anthropometric Source Book, Volume 1: Anthropometry for Designers.* NASA Reference Publication 1024. Washington, DC: U.S. Government Printing Office, 1978:III1–III106.
13. Paulos LE, France PE, Rosenberg TD, Jayaraman G, Abbott PJ, Jaen J. The biomechanics of lateral knee bracing. Part I: Response of the valgus restraints to loading. *Am J Sports Med.* 1987;15:419–429.
14. Randall R, Miller H, Schurr D. The use of prophylactic knee orthoses at Iowa State University. *Orthot Prosthet.* 1984;37:54–57.
15. Rovere GD, Haupt HA, Yates CS. Prophylactic knee bracing in college football. *Am J Sports Med.* 1987;15:111–116.
16. Sitler M, Ryan J, Hopkinson W, Wheeler J, Santomier J, Kolb R, Polley D. The efficacy of a prophylactic knee brace to reduce injuries in football. *Am J Sports Med.* 1990;18:310–315.
17. Taft TN, Hunter S, Fundurbeck CH. Preventive lateral knee bracing in football. Presented at the American Orthopaedic Society for Sports Medicine. Nashville, TN; July 1, 1985.
18. Zemper ED. A two-year prospective study of prophylactic knee braces in a national sample of college football players. *Sports Train Med Rehab.* 1990;1:287–296.

Effect of Closed Chain Exercise on Quadriceps Femoris Peak Torque and Functional Performance

John R. Wawrzyniak, MA, PT, ATC, CSCS;
James E. Tracy, MS, PT, ATC, CSCS; Peter V. Catizone, PT, ATC;
Rich R. Storrow, PT

Objective: To determine the effect of a 6-week leg press training program on quadriceps femoris peak torque and lower extremity functional performance.

Design and Setting: A 2 × 3 factorial design. A private university-based outpatient physical therapy clinic was used for testing. The university strength and conditioning center was used for training sessions.

Subjects: A volunteer sample of thirty nonathletic, college-age females participated. All thirty subjects completed the study.

Measurements: Subjects were randomly assigned to either a control group (G_{con}) or an exercise group that performed isotonic unilateral leg presses through either 0 to 60° (G_{60}) or 0 to 90° (G_{90}) of knee flexion. Subjects trained 3 days/wk for 6 weeks using the DAPRE technique. Pre and post isokinetic testing of the quadriceps femoris at 60°/sec and hop tests for distance and time were measured.

Results: Both training groups showed significant pre-post increases ($p < .05$) for: concentric peak torque, eccentric peak torque, and hop test for distance. G_{60} showed a significant decrease in hop test for time values. Significant increases ($p < .05$) in eccentric peak torque was seen between training groups and the control group, concentric peak torque was significantly greater only in G_{90} as compared to G_{con}. No significant differences were observed between G_{60} and G_{90} for any of the measured variables. There were no differences between the three groups for any of the functional hop test measurements.

Conclusions: Unilateral leg press exercise performed through 0 to 90° of knee flexion increases concentric and eccentric peak torque while training from 0 to 60° improves eccentric torque. No changes in functional performance as measured by hop tests were seen in any groups. Transference between closed kinetic chain (CKC) exercise and open kinetic chain testing was supported, but not between CKC and functional performance testing.

Key Words: closed kinetic chain exercise, leg press, functional testing, isokinetic testing

The leg press is a commonly used closed kinetic chain (CKC) exercise included early in many rehabilitation programs designed to increase quadriceps femoris strength and simulate normal functional activity.[2,7,14,18,22,24] Wilk and Andrews[24] recommend that leg presses be performed actively from 0 to 60° of knee flexion to minimize anterior tibial shear force following anterior cruciate ligament (ACL) reconstruction. Many functional sports and nonsport-related activities require knee flexion through a range of at least 0 to 90°; therefore, strengthening of the knee musculature within this range, at the appropriate time in the rehabilitation program, is essential if normal function within this range is expected. To date, no studies have compared strength and functional changes after a leg press training program, performed through specific ranges of motion (ROM).

Only a few studies[7,20,26] have attempted to compare isokinetic or functional changes following a CKC exercise protocol. The effects of lateral step-up exercise on quadriceps femoris strength and lower extremity performance have been investigated in two recent studies.[20,26] Results from these studies show no significant increases in isokinetic torque of the quadriceps femoris with either a 6-week progressive step-up program without resistance[20] or a 4-week daily adjusted progressive resistance exercise (DAPRE) protocol.[26] Worrell et al[26] did, however, find significant improvements in the following CKC functional tests: hop test for time, hop test for distance, leg press, and maximal step-up repetitions with body weight plus 25%. A study by Fowkes-Godeck[7] reported that CKC hip sled exercise training produced isokinetic strength gains in the quadriceps femoris greater than or equal to gains by subjects who trained using open chain exercise at all speeds tested.

Although several studies have supported the use of CKC exercise in reducing anterior shear forces at the knee[2,9,10,14,17,18,21–24,27] and patellofemoral forces,[5,14,16] only a recent study by Cordova et al[4] compared quantitative changes in isokinetic and functional testing following an isotonic leg press training protocol. Their results showed significant in-

John R. Wawrzyniak is a staff physical therapist at Penn State University, The Hershey Medical Center in Hershey, PA and was an undergraduate physical therapy student at East Carolina University at the time of this study.
James E. Tracy is an associate clinical professor of physical therapy at East Carolina University in Greenville, NC.
Peter V. Catizone is a staff physical therapist at the Malden Hospital in Malden, MA and was an undergraduate physical therapy student at East Carolina University at the time of this study.
Rich R. Storrow is a staff physical therapist at Rehab Services, Lakemore, OH and was an undergraduate physical therapy student at East Carolina University at the time of this study.

creases in both isotonic and isokinetic strength after a leg press training program but did not find these strength increases to correlate positively with increases in one-legged-jump reaction force. Further quantification of strength and functional performance following leg press exercise through specific ranges of motion would allow athletic trainers and/or clinicians to better substantiate their use of CKC exercises, such as the leg press, and more clearly define which exercises are most effective in achieving a patient's specific goals.

The purpose of this study was to determine the effect of unilateral isotonic leg press training performed from 0 to 60° and 0 to 90° of knee flexion on quadriceps femoris peak eccentric and concentric torque as well as functional performance in hop tests for distance and time. It was hypothesized that subjects in either training group would significantly increase quadriceps femoris eccentric and concentric peak torque and performance in the hop tests versus the control group. Furthermore, it was also hypothesized that the group exercising from 0 to 90° of knee flexion, because they were working through a ROM similar to that being tested isokinetically, would produce the greatest increases in concentric and eccentric peak torque.

METHODS

A 2 × 3 factorial design was used in this study with time (pretest/posttest) being one independent variable and training group (control, 0 to 60° of knee flexion and 0 to 90° of knee flexion) the second independent variable. The following four dependent variables were analyzed: 1) concentric, and 2) eccentric, peak torque of the quadriceps femoris muscle at 60°/sec, 3) hop test for distance, and 4) hop test for time.

Subjects

Thirty healthy college-aged females volunteered to participate in this study (Table 1). Subjects did not engage in any aerobic or weight training program during the 6 months prior to this study and had no history of knee pathology or surgery in either leg. Before subjects gave informed consent, they were familiarized with the purpose and procedures of the study.

Instrumentation

Concentric and eccentric peak torque of the quadriceps femoris muscle was measured using a Biodex dynamometer (Biodex Corporation, Shirley, NY). The Biodex was calibrated prior to each testing session according to the manufacturer's guidelines.[1]

A standard hack squat leg press machine (Nordic Fitness Products, Raleigh, NC) was used, which allowed the addition of external weight for each training session. A standard window lock and numerical scale was attached to the rail of the leg press. The numerical value of the window lock position that corresponded to the desired degree of knee flexion (either 60° or 90°) was recorded for each subject. A Monark cycle ergometer (Monark-Crescent, Varberg, Sweden) was used during the warm-up phase prior to each exercise and testing session.

Table 1. Description of Subjects (means ± SD)

Group	Age (yrs)	Height (cm)	Weight (kg)
G_{Con} (n = 10)	21.80 ± 2.97	163.58 ± 7.20	60.24 ± 8.96
G_{60} (n = 10)	21.70 ± 2.67	167.39 ± 5.55	59.65 ± 7.65
G_{90} (n = 10)	21.90 ± 2.38	167.89 ± 9.31	64.41 ± 12.34

Testing Procedures

One week prior to pretesting, all subjects completed an orthopedic medical history form followed by an orthopedic screening of the knee, which included ROM, strength (manual muscle testing), and ligamentous stability testing. Subjects were randomly assigned to one of three groups. Within each group a treatment leg was randomly chosen using a balanced design to assure that each group contained an equal number of right and left legs. This random assignment of treatment legs was done to better represent the random occurrence of knee injuries typically seen in rehabilitation, thus obtaining groups that represented a typical patient population.

One week prior to testing, subjects participated in an orientation session in which they were instructed in the correct techniques involved with concentric and eccentric isokinetic testing of the knee extensors on the Biodex at 60°/sec and functional hop tests for distance and time. Subjects were allowed to practice each test until they were comfortable with that test.

All subjects were tested one week before and one week after a 6-week training protocol using a counterbalanced design for the four dependent variables: 1) hop test for distance, 2) hop test for time, 3) concentric isokinetic testing, and 4) eccentric isokinetic testing. Prior to each testing and training session we monitored each subject in warm-up exercises that consisted of riding a bicycle ergometer for 5 minutes at a resistance of 2.0 Kpds at 50 RPM (100 watts), followed by stretching the quadriceps femoris, hamstring, hip adductors, and gastrocnemius muscle groups. Three of the investigators assumed the same role for all measurements of the functional and isokinetic testing.

Hop Tests

Each subject performed a maximal single-leg hop test for distance, which was measured by recording the distance from the starting position to the landing position of the heel of the tested leg.[26] Two warm-up hops were allowed. After a 2-minute rest period, three hops were performed, and the average score was recorded to the nearest millimeter.

Hop test for time measurements were made by recording the time it took subjects to cover a distance of 20 ft with consecutive single-leg hops. Each subject was instructed to assume a crouched position on one leg while one researcher stood next to the finish line with a stopwatch. Timing began when the subject sprang from the starting position and ended when the subject crossed the finish line.[24] Subjects were allowed two submaximal warm-up hops covering the 20-ft distance. Following a 1-minute rest period, each subject performed three maximal hops. The three trials were averaged and recorded to the nearest 1/100 of a second.

Isokinetic Testing

Subjects were positioned on the Biodex dynamometer with the height and seat position adjusted to align the dynamometer's axis of rotation with the anatomic axis of the knee joint. The shin pad was positioned 2.5 cm proximal to the medial malleolus. The thigh and waist restraints were adjusted until snug, and we instructed the subjects to position their hands on opposite shoulders to stabilize the trunk. Gravity was corrected according to the manufacturer's recommendation.[1]

Isokinetic concentric and eccentric quadriceps femoris peak torque of the trained leg was measured at 60°/sec. Each subject was instructed to perform three submaximal (50%) and two maximal warm-up repetitions of concentric followed by eccentric contractions with 3 minutes rest between the two sets of contractions. Following a 5-minute rest period, each subject performed two separate isokinetic tests: 1) five maximal repetitions of concentric knee extension (using quadriceps femoris) from 90° of knee flexion to 10° of knee flexion and, 2) five repetitions of maximal eccentric knee extension (using quadriceps femoris) from 10° of knee flexion to 90° of knee flexion. A 5-minute rest period was allowed between concentric and eccentric contractions, and order of testing was assigned based on a counterbalanced design. The maximal concentric and eccentric peak torque occurring during the five repetitions was recorded for data analysis. Subjects were verbally encouraged during the testing sessions to induce maximal contractions.

Training Protocol

Subjects were randomly assigned to one of three equal groups: a) G_{con}, which performed no exercise, b) G_{60}, which performed leg press exercise from 0 to 60° of knee flexion, and c) G_{90}, which performed leg press exercise from 0 to 90° of knee flexion. Subjects in the training groups performed unilateral isotonic leg press exercise (Fig 1), three times a week for 6 weeks. The exercise protocol used in this study was designed to provide maximal overload in a controlled manner to the quadriceps femoris muscle, using exercise equipment commonly found in the clinic or training room.

Each subject's knee ROM was measured during the leg press with a goniometer prior to the first exercise session. A window lock was positioned to provide a block (Fig 2) and limit knee flexion ROM depending on the group assignment. This value was recorded on each subject's data sheet to ensure reliability between training sessions. Each subject's foot placement on the weight sled platform was standardized by marking the platform with tape for each session with the feet in 20° of abduction.

Subjects were instructed in specific warm-up exercises on the leg press machine, which included 2 sets of 10 repetitions of double-leg and 1 set of 10 repetitions of single-leg press exercise with 55 pounds (weight sled with no external

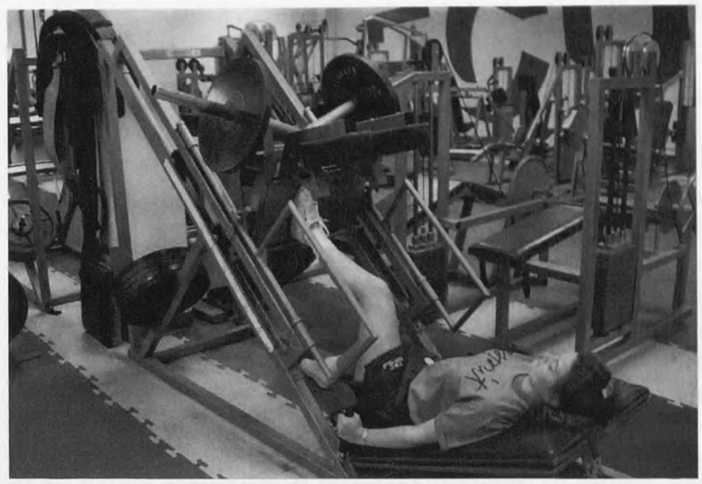


Fig 1. Subject positioning on the hip sled apparatus during exercise training sessions.

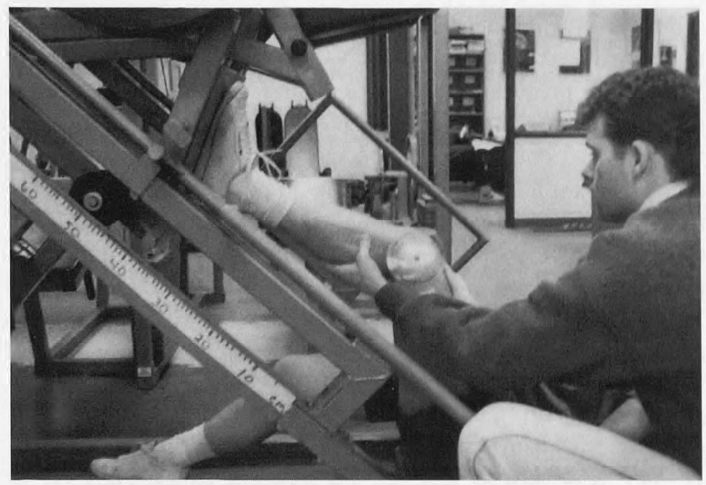


Fig 2. Knee flexion range of motion measurement for leg press exercise.

weight) performed through the ROM of their designated training group. This served to refamiliarize subjects with the ROM required for their particular training group. We used the daily adjusted progressive resistive exercise (DAPRE) technique, consisting of four sets of single-leg press exercise.[13] This resistance program is designed to provide maximum overload for each training session. The DAPRE protocol provided adjusted working weights for each set and session based on the number of repetitions performed during the third and fourth sets, respectively. Original working weight for each subject was estimated from the results of a 10-repetition maximum test performed prior to the first exercise session. Subjects performed 10 repetitions at half this working weight, followed by six repetitions at three-fourths working weight, a maximum number of repetitions at full working weight, and a fourth set at an adjusted weight depending on the number of repetitions the subject was able to perform in the third set. If subjects were able to complete seven repetitions or more, an adjustment to the working weight was made for the next training session.[13]

Statistical Analysis

A multivariate analysis of variance (MANOVA) was used to determine if differences exist across training condition and time on the linear combination of four variables using the Wilk's lambda criterion. This was done to determine if an overall significance occurred among the three groups. Univariate F-tests were performed on each separate dependent variable. Following a significant omnibus test, the Tukey multiple comparison procedure was used to locate specific group differences. Significance was determined at the $p < .05$ level. Hop test for distance interclass correlation coefficient (ICC) for the three pretest trials for all 30 subjects was .85 with a standard error of measurement (s_e) of 5.68 cm. Hop test for time ICC for the three pretest trials for all subjects was .93 with a s_e of .075 seconds.[6]

RESULTS

Means and standard deviations for quadriceps femoris peak concentric and eccentric torque values and functional hop tests values are presented in Tables 2 and 3, respectively. Both training groups showed significant increases in quadriceps femoris peak concentric and eccentric torque and performance in the hop test for distance from pre- to posttesting. Hop test for time values significantly decreased in G_{60} from pre- to posttesting. MANOVA testing revealed significant pre- and posttest differences among the groups ($F(8,48) = 2.83$, $p = .012$).

Univariate analysis for each dependent variable (Table 4) revealed significant differences in peak concentric torque values ($F(2,27) = 6.52$, $p = .005$) and peak eccentric torque ($F(2,27) = 9.90$, $p = .001$). No significant difference among the three groups was seen in hop test for time values ($F(2,27) = .712$, $p = .50$) or hop test for distance values ($F(2,27) = 3.03$, $p = .065$). Tukey post hoc testing demonstrated greater concentric peak torque and eccentric peak torque values for G_{90} compared to G_{con}. The G_{60} group showed a significantly greater eccentric peak torque value as compared to G_{con}. No significant differences were seen between the G_{60} and G_{90} training groups for any of the dependent variables.

DISCUSSION

CKC exercises have, in the last few years, replaced open kinetic chain exercise as the treatment of choice for strengthening the lower extremity following surgery.[2,8,9,21,22,24,27] There are a number of advantages related to the performance of CKC exercise, including co-contraction of the hamstrings and quadriceps femoris,[2,9,28] increased joint stability through greater joint congruency,[2] increased tibio-femoral joint loading,[27] and functional lower extremity movement using eccentric and concentric contractions at the hip, knee, and ankle.[26] Stresses placed on the limb are also similar to normal weight bearing, thus increasing proprioception and prevention of bone and muscle atrophy.[3] The use of CKC exercise early in the rehabilitation program reduces patellofemoral forces,[5,14,16] promotes quadriceps strengthening,[14,17,21,22,24] prevents loss of knee flexion range of motion,[22,24] and increases proprioceptive input.[9,14,16]

The results of our study indicate that an aggressive 6-week DAPRE leg press protocol performed from 0 to 90° of knee flexion significantly improved isokinetic concentric and eccentric peak torque, while leg press performed from 0 to 60° significantly improved only isokinetic eccentric peak torque. These results support transference of muscle strength gains between CKC exercise and open chain testing, but not between CKC and functional performance testing. These results differ from those reported by Worrell et al,[26] who reported significant improvement in five functional tests after a 4-week lateral step-up protocol, but no significant improvement in isokinetic concentric knee extension peak torque. Reynolds et al[20] also reported no significant improvement in concentric or eccentric knee extension peak torque at 60°/sec after a 4-week lateral step-up protocol and suggested that open chain assessment of muscle strength may not adequately assess strength changes incurred via CKC exercise. Fowkes-Godek[7] reported significant quadriceps strength gains following 8 weeks of hip sled training during open and CKC testing, but no specific functional test comparisons were made.

Our methods differed from other CKC training studies in that both knee ROM and resistance were controlled throughout

Table 2. Quadriceps Femoris Peak Torque Values at 60°/sec (means ± SD)

	Pretest	Posttest
G_{Con}		
Concentric (ft-lbs)	127.85 ± 21.77	129.40 ± 24.18
Eccentric (ft-lbs)	160.18 ± 28.06	166.14 ± 36.87
G_{60}		
Concentric	131.59 ± 19.26	141.34 ± 22.40*
Eccentric	169.61 ± 20.51	201.40 ± 20.07*
G_{90}		
Concentric	136.72 ± 29.49	152.36 ± 22.55*
Eccentric	178.63 ± 36.64	211.71 ± 29.80*

* Significant pre-post test increases $p < .005$

Table 3. Functional Hop Test (Distance and Time) Value (means ± SD)

	Pretest	Posttest
G_{Con}		
Hop test distance (cm)	150.39 ± 17.28	152.43 ± 16.94
Hop test time (sec)	2.33 ± 0.36	2.30 ± 0.38
G_{60}		
Hop test distance (cm)	159.69 ± 15.41	166.15 ± 13.67*
Hop test time (sec)	2.11 ± 0.19	2.02 ± 0.19*
G_{90}		
Hop test distance (cm)	159.64 ± 15.91	167.63 ± 16.84*
Hop test time (sec)	2.19 ± 0.29	2.11 ± 0.28

* Significant pre-post test changes $p < .005$

Table 4. Between Group Differences for Dependent Variables*

	G_{con}	G_{60}	G_{90}
Concentric peak torque	a	a,b	b
Eccentric peak torque	a	b	b
Hop test distance	a	a	a
Hop test time	a	a	a

* Groups with same letter are not significantly different $p < .05$

the study. The lack of significant isokinetic strength increases reported by Worrell and Reynolds may be attributed to a short training period of only 4 weeks,[26] insufficient quadriceps overload during the 6 weeks of training,[20] variations in the degree of knee flexion between subjects, and failure to exercise through the ROM tested isokinetically.[20,26] Kannus[11] has suggested that exercises should be performed through the range where peak torque in the quadriceps femoris occurs.

The improvements in quadriceps femoris peak torque we found are likely attributed to an increase in neural adaptation,[25] resulting in increased motor unit recruitment and possibly muscle hypertrophy.[16] We hypothesize that, as knee flexion increases, greater demand is placed on the quadriceps femoris to extend the knee during the "press" or concentric phase of the movement. The G_{90} group exercising from 0 to 90° of knee flexion would therefore have greater demand placed on the quadriceps mechanism, while the G_{60} group may place greater demand on the hip extensors to push the weight. Electromyographic analysis[12] of the quadriceps during the leg press exercise indicates that peak EMG activity occurs between 93° and 113° of knee flexion. Although our exercise groups did not train past 90° of knee flexion, it is reasonable to assume that the G_{90} group would experience greater quadriceps activity as compared to the G_{60} group because they closely approached this range. This hypothesis is supported by our results, which showed a significant improvement for G_{90} in both quadriceps concentric and eccentric peak torque as compared to G_{con}. The specificity principle[15] could also contribute to an increase in isokinetic peak torque values seen in the G_{90} group since this group's training closely approximated the ROM used during the isokinetic testing.

We believe that proper execution of leg press exercise and the ability to stop at a specific point in the ROM emphasize eccentric quadriceps contraction and proprioceptive control. Eccentric quadriceps peak torque in both the G_{60} and G_{90} groups improved significantly compared to the G_{con}. This is due to the fact that training groups will improve versus a control group that does no training. The finding that no significant differences were found between training groups for eccentric strength changes can be theorized to occur because maximal values of eccentric torque during isokinetic testing are usually observed early in the ROM. Both groups would have trained through this ROM, using eccentric control to lower the weight sled to the ROM stop. Because G_{60} performed this exercise through less knee flexion ROM, they were able to tolerate a greater working weight as compared to G_{90}. Although the distance traveled by the weight was less, the increased load provided a greater mechanical advantage of the quadriceps musculature and less patellofemoral reaction force and resulted in a significant increase in quadriceps peak torque from pre- to posttesting.

Several authors[2,9,21,22,24] have described the importance of CKC training to more accurately simulate athletic activity and prepare athletes for return to sports after injury. Although, statistically, no significance was seen in univariate analysis of the functional hops between groups, the pre-post test mean differences in the hop test for distance followed a pattern of improvement similar to that found with isokinetic testing. The G_{90} and G_{60} showed mean hop distances that were greater than the control group. Increased variability within subjects along with measurement error could have accounted for the tests' not being statistically significant. These results differed from Worrell et al,[26] who demonstrated increases in both the hop test for distance and time after a progressive lateral step-up protocol. Increased proprioceptive input with lateral step-up exercise may have accounted for these differences.

Athletic trainers and clinicians continue to develop rehabilitation protocols that allow athletes to return to functional activities as quickly as possible. The athletic trainer needs to consider the effect each exercise will have on maximizing strength in atrophied muscles, the forces acting on joints, and tension created in surgically repaired structures such as the ACL. Earlier conservative protocols designed to protect the repaired or injured structures during rehabilitation often resulted in significant disuse atrophy of the quadriceps femoris and a slow return to competitive athletics.[19] More recently, CKC exercises, such as the leg press and minisquats, have been advocated to strengthen muscles early in the rehabilitation (7 to 14 days)[2,5,22] of patients with lower extremity pathology. Several authors advocate limiting the ROM to 0 to 30°[23] or 0 to 60°[24] of knee flexion to prevent strain on the ACL graft. Protection of the graft is obviously important early in the rehabilitation process of the ACL, but leg press exercise can also be incorporated into the rehabilitation and training of nonsurgical patients. At some point, even with the ACL patient, the athletic trainer must progress the exercise program to match the functional needs of the patient.

The results of our study indicate that exercising in a controlled ROM of either 0 to 60° or 0 to 90° of knee flexion provides sufficient overload to result in significant quadriceps femoris strength gains. The results also indicate that isotonic leg press training may not have a specific functional training effect as evidenced by the lack of significant improvements in functional tests after the training program.[4] Additional research is needed to investigate the changes in functional testing following leg press exercise.

CONCLUSIONS

Six weeks of leg press exercise performed 3 d/wk with the DAPRE protocol from 0 to 90° of knee flexion significantly improved concentric and eccentric quadriceps femoris peak torque. Leg press training from 0 to 60° degrees of knee flexion produced an increase in a quadriceps eccentric peak torque. No significant differences were found between the two training groups for any of the measured variables. There was no significant difference in hop test for time or distance values among the three groups. These results support transference between CKC exercise and open chain testing, but not between CKC and functional performance testing. The athletic trainer may therefore consider larger ranges of motion to increase concentric versus eccentric muscle strength in a leg press exercise program but should not expect increases in peak torque to correlate with increases in functional performance. Clinicians could also develop protocols using specific ROMs of leg press depending on the specific functional needs of the patient.

ACKNOWLEDGMENTS

The authors thank Jeff Conners, CSCS and Tom Howley, CSCS strength coaches at East Carolina University for their support and cooperation with this study. We also thank NATA District III for funding this project.

REFERENCES

1. Biodex. System calibration. In: *Clinical Data Station Operations Manual.* Shirley, NY: Biodex Corporation, Inc; 1988.
2. Blair D, Wills RP. Rapid rehabilitation following anterior cruciate reconstruction. *Athl Train, JNATA.* 1991;26:32–43.
3. Bynum EB, Barrack RL, Alexander AH. Open versus closed chain kinetic exercises after anterior cruciate ligament reconstruction. *Am J Sports Med.* 1995;23:401–406.
4. Cordova ML, Ingersoll CD, Kovaleski JE, Knight KL. A comparison of isokinetic and isotonic predictions of a functional task. *J Athl Train.* 1995;30:319–322.
5. DeCarlo MS, Shelbourne KD, McCarroll JR, Rettig AC. Traditional versus accelerated rehabilitation following ACL reconstruction: a one-year follow-up. *J Orthop Sports Phys Ther.* 1992;15:309–316.
6. Fleiss JL. *The Design and Analysis of Clinical Experiments.* New York, NY: John Wiley & Sons; 1986:8–14.
7. Fowkes-Godek S. Two methods of strength and endurance training for knee rehabilitation: a comparative study. *J Athl Train.* 1994;29:157–158. Abstract.
8. Frndak PA, Berasi CC. Rehabilitation concerns following anterior cruciate ligament reconstruction. *Sports Med.* 1991;12:338–346.
9. Fu FH, Woo SL, Irrgang JJ. Current concepts for rehabilitation following anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther.* 1992;15:270–278.
10. Henning CE, Lynch MA, Glick KR. An in vivo strain gauge study on elongation of the anterior cruciate ligament. *Am J Sports Med.* 1985;13:22–26.
11. Kannus, P. Relationship between peak torque and angle-specific torques in an isokinetic contraction of normal and laterally unstable knees. *J Orthop Sports Phys Ther.* 1991;13:89–94.
12. Kleiner DM, Drudge TK, Richard MD. An electromyographic comparison of popular open and closed kinetic chain knee rehabilitation exercises. *J Athl Train.* 1994;29:156–157. Abstract.
13. Knight KL. Knee rehabilitation by the daily adjustable progressive resistive exercise technique. *Am J Sports Med.* 1979;7:336–337.
14. Lutz GE, Stuart MJ, Sim FH, Scott SG. Rehabilitative techniques for athletes after reconstruction of the anterior cruciate ligament. *Mayo Clinic Proceedings.* 1990;65:1322–1329.
15. McArdle WD, Katch FI, Katch VL. *Exercise Physiology: Energy, Nutrition and Human Performance.* 3rd ed. Malvern, PA: Lea & Febiger; 1991;425–426.
16. Moritani T, DeVires HA. Neural factors versus hypertrophy in time course of muscle strength. *Am J Phys Med.* 1979;58:115–130.
17. Ohkoshi Y, Yasuda K, Kaneda K, Wada T, Yamanaka M. Biomechanical analysis of rehabilitation in the standing position. *Am J Sports Med.* 1991;19:605–611.
18. Palmitier RA, An KN, Scott SG, Choa EY. Kinetic chain exercise in knee rehabilitation. *Sports Med.* 1991;11:402–413.
19. Paulos LE, Noyes FR, Grood ES, Butler DL. Knee rehabilitation after anterior cruciate ligament reconstruction and repair. *Am J Sports Med.* 1981;9:140–149.
20. Reynolds NL, Worrell TW, Perrin DH. Effect of lateral step-up exercise protocol on quadriceps isokinetic peak torque values and thigh girth. *J Orthop Sports Phys Ther.* 1992;15:151–155.
21. Shelbourne DK, Klootwyk TE, DeCarlo MS. Update on accelerated rehabilitation after anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther.* 1992;15:303–308.
22. Shelbourne DK, Nitz P. Accelerated rehabilitation after anterior cruciate reconstruction. *Am J Sports Med.* 1990;18:292–298.
23. Voight M, Bell S, Rhoades D. Instrumented testing of anterior tibial translation in open versus closed kinetic chain activity. *Phys Ther.* 1989;71:S98.
24. Wilk KE, Andrews JR. Current concepts in the treatment of anterior cruciate ligament disruption. *J Orthop Sports Phys Ther.* 1992;15:279–293.
25. Wilk KE, Romaniello WT, Soscia SM, Arrigo CA, Andrews JR. The relationship between subjective knee scores, isokinetic testing, and functional testing in the ACL-reconstructed knee. *J Orthop Sports Phys Ther.* 1994;20:60–73.
26. Worrell TW, Borchet B, Erner K, Fritz J, Leerar P. Effect of a lateral step-up protocol on quadriceps and lower extremity performance. *J Orthop Sports Phys Ther.* 1993;18:646–653.
27. Yack JH, Collins CE, Whieldon TJ. Comparison of closed and open kinetic chain exercise in the anterior cruciate ligament deficient knee. *Am J Sports Med.* 1993;21:49–54.
28. Yasumitsu O, Kazunori Y, Kiyoshi K, Tatsuhiko W, Masatomo Y. Biomechanical analysis of rehabilitation in the standing position. *Am J Sports Med.* 1991;19:605–611.

Jaybird & Mais, inc.
ATHLETIC TRAINERS PRODUCTS
JAYBIRD ONE
PREMIUM ATHLETIC TAPE
"Stick with us, we're on a roll"
Jaybird & Mais, inc.
ATHLETIC TRAINERS PRODUCTS
MADE IN U.S.A.
• Premium 100% Cotton Athletic Tapes
• Lightweight Elastic Stretch Tape
• Heavyweight Stretch Tape
• Adhesive Foams and Moleskins
• Shoulder Pad Tape
• Non-Woven Adhesive Tape
#1 Jaybird One • #45 Supreme • #4025 Med-Pak • #20 Trainers • #25 Pro-White
PLEASE STORE COOL AND DRY
"Stick with us, we're on a roll"
Jaylastic
Athletic Stretch Tape
Jaybird & Mais, inc.
ATHLETIC TRAINERS PRODUCTS
Made in USA
• NATA Supplier Member
• 100% Guaranteed
• Factory Fresh Products
• Personal Customer Service
For your nearest Jaybird & Mais Distributor call:
(508) 686-8659
#4500 Jaylastic® • #5000 Jaylastic® Plus II • #4500-B Black Jaylastic®
Jaybird & Mais, inc.
DISPOSABLE INSTANT COLD PACK
Jaybird
TRAINERS
ADHESIVE FOAM
Jaybird & Mais, inc.
Jaybird
TRAINERS
MOLESKIN
ADHESIVE BACKING
Jaybird & Mais, inc.
Made in USA
Jayshield • Adhesive Foam • Moleskin • Shoulder Pad Tape • Foam Underwrap
Jaybird & Mais, inc.
Tel (508) 686-8659 • Fax (508) 686-1141
E-mail address: jnm@tiac.net
360 Merrimack Street • Lawrence, MA 01843

Reliability of Ground Reaction Forces During a Vertical Jump: Implications for Functional Strength Assessment

Mitchell L. Cordova, MA, ATC; Charles W. Armstrong, PhD

Objective: To determine the reliability of ground reaction force during a vertical jump.

Design and Setting: Two test sessions 48 hours apart in which subjects performed five maximal vertical jumps with their right lower extremity on a force platform without arm movement. Applied Biomechanics Laboratory at the University of Toledo.

Subjects: Nineteen healthy males (n = 12) and females (n = 7), with an average age of 21.3 years and 23.2 years, respectively, from the University of Toledo participated in this study. The average height for males and females was 70.0 and 66.6 inches, respectively. The average weight for males was 170.5 lbs., while the average weight for females was 132.4 lbs.

Measurements: Reliability of the peak vertical ground reaction force and vertical impulse was assessed using the formula for intraclass correlation coefficient (2,1) (ICC [2,1]).

Results: Measurement of peak vertical ground reaction force was demonstrated to be very reliable (ICC [2,1] r_{xx} = .94; SEM = .003% BW), whereas the reliability estimate for vertical impulse was not very reliable (ICC [2,1] r_{xx} = .22; SEM = .24% BW seconds). Furthermore, no significant relationship was found between peak vertical ground reaction force and vertical impulse. (BW = body weight; SEM = standard error of measurement).

Conclusions: We conclude that peak force measured during a one-legged vertical jump is reliable and may provide an alternate method of evaluation of lower extremity functional strength.

Key Words: ground reaction forces, vertical jump, functional strength assessment, closed kinetic chain

A common issue in rehabilitation involves the determination of an individual's readiness for return to normal levels of activity. This is particularly problematic in dealing with athletes, since their normal level of activity may involve musculoskeletal stress that far exceeds that of a nonathletic population. Often subsequent injury occurs when athletes are returned to competition too early, which may result from inaccuracies in the assessment of their functional abilities. To resolve this problem, clinicians have recently begun to emphasize the use of functional testing following rehabilitation.[14,15,20,25] In contrast to more traditional methods of assessment that focus on isolated joint testing, functional testing involves the evaluation of complete skills necessary for complex sport activities. It is felt that such assessment may be more relevant to the ability of athletes to perform these skills in the context of their specific sport.[3,14,15,17,19] As such, functional testing may provide a better estimate of the athlete's true readiness for return to activity.

Much of the present research regarding lower extremity assessment has focused on quantifying functional agility,[14,15,20,25] while little data exists on the topic of functional strength.[5,16] In some studies,[16,23] the expression "functional strength" has been associated with lower extremity strength training, yet it has not been clearly delineated. Although assessing functional strength is important following rehabilitation, it is necessary to first develop a construct for defining functional strength. Conceivably, a logical definition of functional strength is "the force produced by the lower extremity in a movement specific to sport," where most sport activities involve the lower extremity positioned in a closed kinetic chain.[3,17] However, both functional agility and functional strength assessment are important for the total rehabilitation of athletes when considering their return to competition.

Since many sports involve jumping movements or similar activities dependent on the generation of lower extremity power,[10,18] the vertical jump appears to provide a useful means of estimating lower extremity functional strength. Vertical jump performance is a well-documented measure of human power.[2,11,21] Peak force produced during a one-legged vertical jump correlates highly with peak power and vertical jump height attained.[4,6] Generation of peak force results from the net muscle moments created by the knee and hip extensors and ankle plantarflexors during propulsion. Another variable useful in evaluating lower extremity strength is vertical impulse. Vertical impulse represents the product of force and time during the propulsion phase of the jump. Essentially, vertical impulse is an accelerating force where a change in momentum occurs on the body.[13]

Directly measuring peak vertical ground reaction force and vertical impulse during the propulsion phase of a one-legged vertical jump may provide a valid means for quantifying estimates of lower extremity functional strength. However, as with all evaluation techniques and protocols, functional testing is very much dependent on the reliability of the test.[24] Unfortunately, no data exist concerning the reliability of peak vertical ground reaction force and vertical impulse produced

Mitchell L. Cordova is a graduate assistant and doctoral student in biomechanics in the Department of Health Promotion and Human Performance at The University of Toledo.

Charles W. Armstrong is a professor in the Department of Health Promotion and Human Performance and director of the Applied Biomechanics Laboratory at The University of Toledo.

during a functional task. Since the one-legged vertical jump appears to be a relevant test of functional strength, and analyzing ground reaction forces from the test provides insight into lower extremity force production, assessing the reliability of peak vertical ground reaction force and vertical impulse emerges as necessary. Thus, the purposes of this investigation were: 1) to determine the test-retest reliability of peak vertical ground reaction force and vertical impulse created during a one-legged vertical jump; and 2) to determine the relationship between peak vertical ground reaction force and vertical impulse produced during a one-legged vertical jump.

METHODS

Nineteen healthy student volunteers participated in the study. Subject characteristics are presented in Table 1. The investigator ensured that each subject read and signed an informed consent form approved by the University of Toledo's Human Subjects Research Review Committee. Participants reported no previous lower extremity injury, orthopaedic abnormalities, vestibular problems, or vision problems. All were familiarized with the purpose of the study and testing procedures.

One-Legged Vertical Jump Protocol

All participants performed the one-legged vertical jump protocol using the right lower extremity. Subjects reported to the laboratory on three separate occasions. The first meeting consisted of an orientation session in which the investigator instructed the subjects on the proper technique of the jump and the subjects performed multiple trials until they felt comfortable with the established jump protocol. They were then required to come in the next day for the first test session. At the beginning of the first test session subjects placed their right foot on the middle of the force plate, with their contralateral knee flexed at 90° to prevent the left foot from touching the force platform. They began each jump from an upright position. The protocol allowed for countermovement, although arm movement during the jump was restricted by having subjects cross their arms against their chests.[5] Arm swing used during the vertical jump has been shown to increase peak force compared to jumps performed without arm movement;[11,21] thus, we wanted to evaluate force production consequent to lower extremity strength only. We instructed the subjects not to go past 90° of knee flexion with the right extremity during this countermovement. Once the subject was set on the force platform, the investigator gave the command "go," which initiated the subject's jump. Each subject had 5 seconds to complete the jump. Subjects rested 1 minute between trials and were encouraged to jump maximally on each trial. The second series of testing occurred 48 hours later under the same testing procedures.

Table 1. Description of Subject Characteristics (Mean ± SD)

	Age (yr)	Height (in)	Weight (lb)
Males (n = 12)	21.3 ± 4.6	70.0 ± 2.3	170.5 ± 28.7
Females (n = 7)	23.2 ± 5.3	66.6 ± 4.3	132.4 ± 25.9

Data Collection

Subjects performed one-legged vertical jumps on a force platform (AMTI, model OR5-1; Newton, MA). The force platform was interfaced through a 12-bit analog-to-digital converter (Data Translations Inc, model DT2,801; Marlborough, MA) to a PC Brand 386 microcomputer. The raw force data were sampled at 200 Hz and digitally filtered with a second-order, low-pass Butterworth digital filter with the cut-off frequency set at 6 Hz. The program sampled the vertical ground reaction force data for each trial for a 5-second period. Customized software was used to perform an ensemble average of the 5 test trials for each subject from session 1 and session 2. The average peak vertical ground reaction force and vertical impulse for each subject from session 1 and session 2 were used for analysis.

Statistical Analysis

To estimate the reliability of peak vertical ground reaction force and vertical impulse the intraclass correlation coefficient (2,1) (ICC [2,1]) as described by Shrout and Fleiss[22] was used. The ICC (2,1) was chosen as the reliability estimate since it provides an estimate that includes the variability of measurements taken by any investigator on any subject.[22] The ICC (2,1) is represented by the following equation:[22] ICC (2,1) = (BMS−EMS)/{BMS + (k−1)EMS + [k(JMS-EMS)/n]}, where BMS = between mean square, EMS = residual mean square, JMS = between judges mean square, k = the number of sets of scores, and n = the number of persons observed. Mean square terms were acquired using the univariate F-statistic within the reliability statistics using SPSS for Windows v6.1 software (SPSS Inc, Chicago, IL). The standard error of measurement (SEM) was calculated as described by Gullickson.[9] It evaluates the difference between a subject's true score and observed score for a given test. A Pearson-product moment correlation was calculated between average peak vertical ground reaction force and average vertical impulse to determine the relationship between these two kinetic parameters. The level of significance was set a priori at $p < .05$.

RESULTS

In Table 2 the means and standard deviations are shown, as well as the reliability data for peak vertical ground reaction force and vertical impulse for each test session. The coefficient of stability estimate calculated for peak vertical ground reaction force was considered high ($r_{xx} = .94$), whereas for vertical impulse, a low reliability estimate ($r_{xx} = .22$) was discovered. No significant correlation ($p > .05$) was found between peak vertical ground reaction force and vertical impulse for test 1 ($r_{xy} = -.21$) and test 2 ($r_{xy} = -.28$). These values can be seen in Table 3.

Table 2. Descriptive Statistics (Mean ± SD) and Reliability Information for Ground Reaction Force Parameters for Test 1 and Test 2

Variable	Test 1	Test 2	ICC*	SEM†
PVGRF (%BW)‡	1.90 ± .23	1.92 ± .26	.94	.003
Min	1.62	1.60		
Max	2.51	2.45		
VI (%BW sec)§	1.30 ± .50	.91 ± .22	.22	.24
Min	.77	.10		
Max	2.30	1.16		

* ICC, intraclass correlation coefficient.
† SEM, standard error of measurement.
‡ PVGRF, peak vertical ground reaction force; BW, body weight.
§ VI, vertical impulse.

Table 3. Correlation Coefficients of Peak Vertical Ground Reaction Force and Vertical Impulse for Test Session 1 to Test Session 2

	$PVGRF_1$†	$PVGRF_2$
VI_1‡	−.21*	−.19*
VI_2	−.28*	−.27

† PVGRF, peak vertical ground reaction force.
‡ VI, vertical impulse.
* These correlations are not significant ($p > .05$).

DISCUSSION

In the most applied sense, the main objective of the vertical jump is to achieve maximum vertical height. To obtain maximum vertical height, the body's center of gravity needs to be as high above the ground as possible, with the greatest vertical velocity at the instant of take-off.[6,11] Sequential segmental rotations act to move the body's center of gravity, vertically, in a rectilinear path.[13] These segmental rotations result in external forces, or ground reaction forces, that are created as the jumper pushes against the ground to overcome inertia in accelerating the body upward. Due to Newton's second law, vertical displacement of the body's center of gravity can be influenced by manipulating the components of the vertical ground reaction force. Thus, evaluation of these components provides insight into the strategy that the individual has employed to maximize vertical jump height.

No previous literature was found reporting reliability estimates for peak vertical ground reaction force and vertical impulse produced during a one-legged vertical jump. The high test-retest reliability of the peak vertical ground reaction force obtained in this study (r_{xx} = .94) indicates that this measurement is stable over time. These results are consistent with those from a similar study[11] involving a two-legged vertical jump in which the reliability of peak vertical ground reaction force was reported to be .97. The high coefficient of stability for peak vertical ground reaction force found in this study indicates that maximal force produced by the leg extensor and ankle plantarflexor muscles during the jump is reproducible.

Quantifying the peak force generated during the vertical jump has important clinical implications: it may be an accurate and appropriate measure of one's ability to generate lower extremity power. It also allows the clinician to assess an athlete's lower extremity strength during a functional movement. This is significant because it considers the muscular force produced by the lower extremity in a weight-bearing closed kinetic chain environment. Furthermore, since peak force produced during a one-legged jump yields consistent results, the relative contribution of the noninvolved limb can be controlled. Additionally, a significant and high relationship has been demonstrated between peak vertical force produced and jump height achieved.[4,6] This suggests that peak vertical ground reaction force is a good indicator of lower extremity muscle strength and strongly predicts functional performance. Furthermore, peak force measured during a one-legged vertical jump appears to be more functional and sport-specific than traditional open kinetic chain testing procedures.

It may be argued that we should have measured pure vertical jump height from a simple jump and reach test. The problem with this measurement is that arm movement significantly increases peak force production, and, ultimately, greater jump height is attained during the jump.[21] As a result, arm movement masks the segmental torque production created by the lower extremity musculature during the jump-and-reach test. However, if vertical jump height achieved is of interest to the clinician, it can be calculated more accurately, from the kinetic and temporal variables produced by the force-time curves, by analyzing the ground reaction forces.[6]

The relationship between impulse and momentum is quite interesting when considering vertical jump performance. The impulse-momentum relationship exists because the product of the applied force and time (impulse) determines the change of momentum an object possesses. Momentum is simply the product of a given mass and its velocity.[13] If a change in momentum is to occur, an impulse must be applied. With respect to the force-time curve, impulse is characterized as the area under the curve. This area can easily be determined by multiplying the magnitude of force by the duration of time occurring at each point throughout the curve. Because vertical impulse is a function of force and time, it represents the interaction between force generated and time during the jump.[7] A change in vertical impulse is therefore dependent on changes in either force or time.

Since the purpose of pushing-type activities is to cause an increase in the velocity of a body or object, the time in which the applied force is acting should be maximized.[13] In terms of vertical jump activity, a compromise between the development of maximal force and maximal time of force production needs to exist. Vertical jump performance can suffer if the subject fails to maximize leg extension acceleration or propulsion time in generating the impulse during the jump. Basically, providing more time for the force to accelerate the body during the jump enables more time for the applied force to create a greater take-off velocity.[13] Dowling and Vamos[6] evaluated the importance of vertical velocity produced at take-off and its contribution to vertical height attained. They found that subjects who acquired the greatest jump height achieved the greatest vertical velocity at take-off, which resulted from a greater vertical impulse. Knowledge of the vertical impulse in relation to peak force production is critical for the sports therapist in evaluating an athlete's functional strength because it can then be known if a deficit exists in either the force or time of force production.

Although maximum force development is critical, the time in which the individual generates the force must be considered.

In this study, there was poor test-retest reliability for vertical impulse, unlike the results reported by Harman et al.[11] As previously indicated, their subjects performed two-legged jumps, which may be associated with enhanced balance and motor control during the jump. This may have positively affected the consistency of the involved movement patterns, which would be reflected in the reliability scores. In the present study, we found measurement of peak vertical ground reaction force to be highly reliable. As a result, it appears that time was the factor being manipulated, thus leading to the poor reliability for vertical impulse. In other words, subjects were able to produce consistent peak force output of the leg extensor musculature; however, the duration of this force changed. Perhaps, the poor reliability estimate found for vertical impulse was due to the unique neuromuscular strategies involved in performing a one-legged vertical jump.[8] In a simulation study[1] evaluating the effects of muscle strengthening on vertical jump height, it was found that increasing muscle strength while ignoring control mechanisms of the jump led to a decrease in jump height. In considering one-legged vertical jump performance, balance may be an important neural component to train. These strategies may be better explained and further explored with electromyography.

In examining the correlation coefficients between peak vertical ground reaction and vertical impulse in test 1 and between peak vertical ground reaction force and vertical impulse in test 2 (Table 3), a nonsignificant relationship was found. This result can be explained by the fact that the measurement of vertical impulse proved to be very unreliable. Additionally, the moderate sample size used in the study may have contributed to poor statistical power and thus a nonsignificant relationship. Based on the magnitude of the correlation coefficients found between peak vertical ground reaction force and vertical impulse in test 1 (-.21) and between peak vertical ground reaction force and vertical impulse in test 2 (-.28), sample sizes of 92 and 47, respectively, would have yielded a significant relationship with the probability set at .05 for a two-tailed test.[12] It should be remembered that sample size affects not the magnitude of the relationship but rather the accuracy of the relationship.[12] Further research should be done to explore the relationship of these variables in attempting to evaluate lower extremity functional strength using this protocol.

In conclusion, measurement of peak vertical ground reaction force during a one-legged vertical jump is reliable and allows the clinician to evaluate lower extremity strength during a sport-specific movement. Force platform dynamometry provides an alternative and accurate way to evaluate lower extremity force in estimating closed kinetic chain strength. Additional research needs to be done using the above-mentioned protocol to establish the sensitivity and validity of measurements comparing force production in injured and noninjured extremities.

REFERENCES

1. Bobbert MF, Van Soest AJ. Effects of muscle strengthening on vertical jump height: a simulation study. *Med Sci Sports Exerc.* 1994;8:1012–1020.
2. Bosco C, Luhtanen P, Komi PV. A simple method for measurement of mechanical power in jumping. *Eur J Appl Physiol.* 1983;50:273–282.
3. Bunton EE, Pitney WA, Kane AW, Cappaert TA. The role of limb torque, muscle action and proprioception during closed kinetic chain rehabilitation of the lower extremity. *J Athl Train.* 1993;28:10–20.
4. Busko K. An attempt at the evaluation of the lower extremities' power during a vertical jump on a dynamometric platform. *Biol Sport.* 1988;5:219–225.
5. Cordova ML, Ingersoll CD, Kovaleski JE, Knight KL. A comparison of isokinetic and isotonic predictions of a functional task. *J Athl Train.* 1995;30:319–322.
6. Dowling JJ, Vamos L. Identification of kinetic and temporal factors related to vertical jump performance. *J Appl Biomech.* 1993;9:95–110.
7. Gagnon M, Robertson GE, Norman RW. Kinetics. In: Dainty DA, Norman RW, eds. *Standardized Biomechanical Testing in Sport.* Champaign, IL: Human Kinetics; 1987:45–46.
8. Gauffin H, Tropp H. Altered movement and muscular-activation patterns during the one-legged jump in patients with an old anterior cruciate ligament rupture. *Am J Sports Med.* 1992;20:182–192.
9. Gullickson H. *Theory of Mental Tests.* New York, NY: John Wiley; 1950:117.
10. Harman EA, Rosenstein MT, Frykman PN, Rosenstein RM, Kraemer WJ. Estimation of human power output from vertical jump. *J Appl Sport Sci Res.* 1991;3:116–120.
11. Harman EA, Rosenstein MT, Frykman PN, Rosenstein RM. The effects of arms and countermovement on vertical jumping. *Med Sci Sports Exerc.* 1990;22:825–833.
12. Hinkle DE, Wiersma W, Jurs SG. *Applied Statistics for the Behavioral Sciences.* 3rd ed. Boston, MA: Houghton Mifflin; 1994:117–118, 625.
13. Kreighbaum E, Barthels KM. *Biomechanics: A Qualitative Approach for Studying Human Movement.* 3rd ed. New York, NY: Macmillan; 1990:352–358.
14. Lephart SM, Perrin DH, Fu FH, Gieck JH, McCue FC, Irrgang JJ. Relationship between selected physical characteristics and functional capacity in the anterior cruciate ligament-insufficient athlete. *J Orthop Sports Phys Ther.* 1992;16:174–181.
15. Noyes FR, Barber SD, Mangine RE. Abnormal limb symmetry determined by function hop tests after anterior cruciate ligament rupture. *Am J Sports Med.* 1991;19:513–518.
16. Olson KD. *Strength, Speed, and Power Gains With Isokinetic Training Versus Isotonic Training With the DAPRE Technique.* Terre Haute, IN: Indiana State University; 1992. Thesis.
17. Palmitier RA, An KN, Scott SG, Chao EY. Kinetic chain exercises in knee rehabilitation. *Sports Med.* 1991;11:402–413.
18. Payne AH, Slater WJ, Telford T. Use of a force platform in the study of athletic activities. In: Martin TP, ed. *Biomechanics of Sport.* Brockport, NY: State University of New York College; 1975:185–205.
19. Prentice WE. Closed kinetic chain exercise. In: Prentice WE, ed. *Rehabilitation Techniques in Sports Medicine.* 2nd ed. St. Louis, MO: Mosby; 1994:97–110.
20. Risberg MA, Eckland AE. Assessment of functional tests after anterior cruciate ligament surgery. *J Orthop Sports Phys Ther.* 1994;19:212–217.
21. Shetty AB, Etnyre BR. Contribution of arm movement to the force components of a maximal vertical jump. *J Orthop Sports Phys Ther.* 1989;11:198–201.
22. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. *Psychol Bull.* 1979;86:420–428.
23. Smith MJ, Melton P. Isokinetic versus isotonic variable resistance training. *Am J Sports Med.* 1981;9:275–279.
24. Thomas JR, Nelson JK. *Research Methods in Physical Activity.* 2nd ed. Champaign, IL: Human Kinetics; 1990:343.
25. Worrell TW, Booher LD, Hench KM. Closed kinetic chain assessment following inversion ankle sprain. *J Sport Rehabil.* 1994;3:197–203.

Evaluation of Sports-Related Temporomandibular Dysfunctions

Matthew E. Sailors, MEd, PT, ATC

Objective: To analyze the steps used in evaluation of sports-related temporomandibular dysfunctions and make recommendations for treatment and referral based upon the evaluation findings.

Data Sources: This review searched Cinahl (1982 to 1995) and Medline (1986 to 1995). Key words searched included "sports related temporomandibular dysfunction," "temporomandibular dysfunction," and "temporomandibular joint."

Data Synthesis: This paper provides an introduction to the anatomy and biomechanics of the temporomandibular joint (TMJ) as well as causes of temporomandibular disorders in athletes. An analysis of the evaluative steps used for the temporomandibular joint is also given. Findings that suggest specific temporomandibular dysfunctions are discussed.

Conclusions/Recommendations: Recommendations about when dental consultation is most appropriate or if conservative treatment is indicated are included. Hopefully, this will provide the sports medicine practitioner with a better understanding of the joint and its dysfunctions, as well as eliminate some unnecessary and costly dental referrals for our athletes.

Key Words: Temporomandibular dysfunctions, sports injuries, evaluation

Organized sports activities are responsible for many traumatic and nontraumatic injuries. Injuries to the head and neck regions are relatively common, especially in those sports classified as collision or contact sports, such as football, rugby, wrestling, and soccer,[2] where the head is often used as a striking object in the game. One injury that can occur is temporomandibular dysfunction (TMD), currently the most common orofacial disorder seen by health care workers today.[7] TMDs encompass a group of pathologies arising from the masticatory musculoskeletal system that lead to preauricular pain, temporomandibular joint (TMJ) dysfunction, pain in the muscles of mastication, limitations or deviations in mandibular range of motion, noises during mastication or mandibular function, or a combination of the above.[3,7,11,14–16]

In the past, TMDs have often mistakenly been associated with chronic pain patients and patients with psychological overlay, with counseling advocated as a main form of treatment despite the presence of strong clinical evidence of orthopedic dysfunction and inflammation.[8,10,15,18] This has been counterproductive for many TMD patients because only a small percentage develop chronic pain.[15] A second factor influencing the successful return to sport of athletes with TMD is that dentists are currently the primary professionals involved in TMD evaluation and treatment. While dentists have the most experience in dealing with TMDs and should serve as the primary referral source for these patients, some dentists may lack the training that the orthopedic sports medicine practitioner has in musculoskeletal evaluations and treatment procedures for soft tissue inflammatory conditions.[10]

Considering the above information, the purposes of this paper are to review the anatomy and biomechanics of the temporomandibular region, to review the causes of TMD, and to provide an analysis of the common evaluation procedures and tests used for diagnosing TMD. Hopefully, this will benefit the sports medicine practitioner in evaluating TMD and in recognizing when dental consultation is best indicated.

ANATOMY AND BIOMECHANICS OF THE TEMPOROMANDIBULAR REGION

The temporomandibular complex focuses around the TMJ. The TMJ is a true synovial joint[10,19] and comprises the mandibular condyle, an internal fibrocartilaginous disc, and the glenoid fossa of the temporal bone of the cranium (see Fig 1).[10,17,19,20] Movement of the TMJ is primarily dependent upon gravity and the muscles of mastication (temporalis, masseter, medial, and lateral pterygoid)[10,11,17] although rapid opening of the mouth or opening against resistance requires the use of the digastric, suprahyoid, infrahyoid, and mylohyoid muscles.[9,17]

Opening the mouth is achieved through the two combined motions, rolling and translation, of the mandibular condyle. Rolling occurs with relaxation of the muscles of mastication which allows the mandibular condyle to roll upon the fibrocartilaginous disc until midrange of opening is achieved.[10,11,19,20] During this anterior rolling of the mandible there is a relative posterior rotation of the disc on the condyle.[10,11,19,20] At this point, further opening is performed by the contraction of the lateral pterygoid muscle, which causes the condyle and disc to translate forward.[10,11,20] Condylar translation is limited to about 15 mm at maximal opening, with the disc translating only half of that distance.[10] Closing the mouth is controlled by the muscles of mastication and reverses the mechanical actions described above.[10,11,17,19]

The mandibular condyle fits onto the disc and is shaped to allow rolling and translation to occur easily. The mandibular condyle's capsular support is loose, and the chief ligamentous restraint is provided by the temporomandibular ligament, which resists lateral motion of the mandible.[19]

Matthew E. Sailors is an assistant professor in the Physical Therapy Department at the University of South Dakota, 414 East Clark Street, Vermillion, SD 57069.

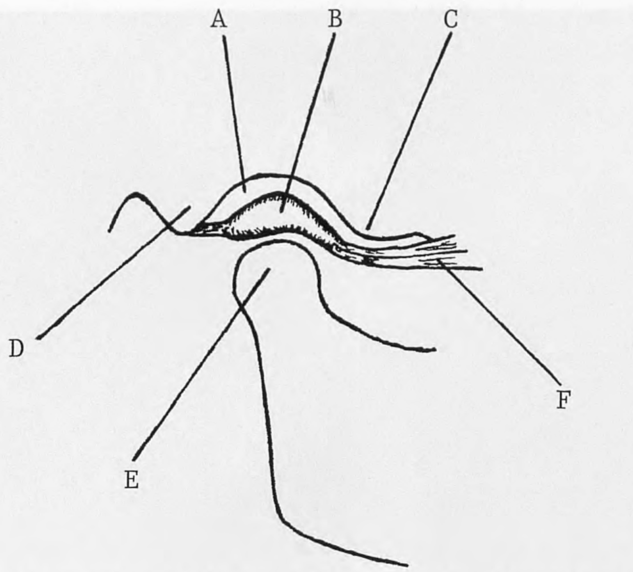


Fig 1. Lateral view of the mandible and cranium illustrating A) glenoid fossa, B) disc, C) articular tubercle, D) posterior glenoid spine, E) mandibular condyle, and F) lateral pterygoid muscle.

The fibrocartilaginous disc divides the joint space into upper and lower cavities[10,19] and permits translation to occur. The disc is attached to the lateral pterygoid muscle and the posterior and lateral collateral ligaments and is more firmly attached to the mandible than it is to the cranium. With translation, the disc will slide with the mandible until it is blocked by the articular tubercle of the temporal bone.[17,20] The disc, however, can become displaced in conditions of internal derangement,[1,5,8–10,18] which results in altered joint mechanics and progressive signs and symptoms of TMD. It should be noted that the disc is considered the one structure in the TMJ region that is least adaptable to stresses placed upon it.[18] This is because the other structures (muscles, ligaments, and capsule) have the capability of adaptation through hypertrophy, thickening, or repair to stress placed upon them.[18]

In the adult population, the disc lacks nerve endings and, therefore, is not a source of pain. There are nerve endings in the retrodiscal tissues and the temporomandibular capsule, though, and the alteration in condylar mechanics that occurs with derangement of the disc leads to pressure on these structures, which results in pain.[8] The evaluation procedures for diagnosing disc derangement will be covered later in this article.

CAUSES OF TMD

In the athletic population there are multiple causes of TMD.[4] First and foremost is trauma to the mandible itself.[4,5,10,13] Many sports, such as boxing, soccer, and rugby, do not require the use of headgear, and some sports that use headgear, such as wrestling, hockey, football, and baseball, often use headgear that does not adequately protect the temporomandibular region. In addition, some noncontact sports, such as water skiing and snow skiing,[2] or track and field events, such as the shotput,[20] produce situations that may place the temporomandibular region at risk. Unfortunately, the competitive spirit in athletes sometimes leads to a loss of composure on the playing field, resulting in fighting that can easily traumatize the TMJ.[22]

Direct blows to the mandible can lead to anterior dislocation,[17] inflammatory responses in the muscles of mastication,[10] ligamentous laxity,[9] and TMJ derangements.[4] In examining a group of 779 patients with TMD, Bakland and Boyne[4] found that 42% of these persons were able to associate a traumatic incident with the onset of symptoms and that just over 5% of these injuries were sports related or the result of physical blows to the mandible,[4] suggesting that TMD is certainly a potential sports injury, even though trauma accounts for only a modest percentage of cases in the general population.[11] Fortunately, it has been shown that TMD resulting from trauma is no more difficult to treat than, and has as good a prognosis as, TMD resulting from other causes.[13] Treatment for traumatic conditions usually consists of thermal and electrical modalities for inflammation and relief of the pain-spasm cycle followed by gentle stretching and strengthening exercises. Waide et al[20] present some excellent illustrations for TMD exercises and should be referred to for this portion of the treatment program.

A second predisposing factor of TMD in the sports population is stress.[4,8,10,11,13,18] Competitive athletes, whether at the recreational, high school, collegiate, or professional level, are constantly under stresses to better their own performances, maintain starting roles, maintain eligibility, and assist team performances, not to mention experiencing the stresses of everyday life. Typically, in the athletic population, stress is a secondary factor in the cause of TMD.[4] Usually the athlete has had a previous traumatic episode that he or she does not associate with the current TMD, which has been magnified by stress.[4] "Coping" has been identified as a strategy for handling stress or dealing with injury.[18] Most successful athletes have developed their own methods of coping with stress, but counseling in stress management can be very beneficial, especially for younger athletes, in curing as well as preventing stress-related TMD.[4,18]

Stress and trauma affect the temporomandibular region in a similar manner. Trauma causes muscle guarding due to the pain-spasm cycle, which increases the pull of the lateral pterygoid muscle on the disc, resulting in a stretching of the posterior and lateral collateral ligaments,[18] whereas stress causes overactivity of the muscles of mastication, which results in a clenching or gnashing of the mandible (bruxism), creating a similar problem.[8,11,13,18]

Another cause of TMD is structural anomaly, which may present in the forms of malocclusion, enlarged mandibular condyles, decreased joint space, or missing teeth.[8,11,16,18] In the past, sports such as ice hockey have appeared to view missing teeth as a symbol of experience and physical play, with little regard for the long-term effects on mandibular function. Current knowledge, however, suggests that abnormal tooth alignment or tooth loss can lead to long-term changes in mandibular function and mechanics that may predispose the athlete to TMD.[4] The use of a simple mouthguard will minimize tooth loss in sports and thereby serve to decrease the number of TMDs seen in athletes.[4,12]

EVALUATION AND DIAGNOSIS OF PROBLEMS IN THE TEMPOROMANDIBULAR REGION

The TMJ, being a synovial joint, should be evaluated along the same lines as other synovial joints. This should include a thorough history, postural inspection, palpation, range of motion, muscle testing, and referral for special testing as indicated.[3,7,10,11,14–16] In addition, the TMJ region often requires mediate auscultation (use of a stethoscope to listen for TMJ noise during motion) in determining joint noises.[7,11,16] In cases of severe trauma, if a fracture is suspected, or if the teeth are damaged, immediate referral should always be made regardless of the presence of a TMD.

As with all joint evaluations, the first step in evaluating the TMJ is a thorough history. Questions asked in the history are the same as those used in standard orthopedic exams (ie, chief complaint, mechanism of injury, date of onset, past medical history, what increases and decreases symptoms, pain ranking and intensity, etc). In addition, the athlete should be questioned about recent and past dental history since dental procedures can lead to development of TMD due to the prolonged, exaggerated opening of the mouth.[10,14–16]

If the history leads to suspicion of a TMD, there are several common signs and symptoms that a TMD will manifest. Most patients will complain of a jaw ache, earache, and/or headache with possible dizziness.[3,5,10,14–16] Other signs and symptoms include facial pain, decreased mandibular range of motion, and crepitus, clicking, popping, or grating in the TMJ with mandibular movements.[3,5,10,14–16] In some cases of internal disc derangement, the mandible may actually become locked or stuck at a fixed position or have an excessive loss of motion.[5,10,21] It should be noted that complaints of temporomandibular joint noise by themselves are not considered pathognomic for TMD,[7,11] since it has been estimated that as much as 44% of the general population has some clicking or noise in the TMJ region.[1,16]

The next step in the evaluation is to examine general facial appearance and posture. This involves assessment of several regions.[10] Facial symmetry should be quickly examined visually. Hypertrophy of the masseter muscle, which is commonly seen in those individuals participating in heavy weight-training programs, should be assessed. The masseter is easily seen by having the athlete clench the jaw closed very tightly.[6] There should be equal size bilaterally.

Postural assessment for forward head and rounded shoulders is performed by having the athlete stand next to a plumb line. Using a lateral view, the external auditory meatus should line up with the lateral tip of the acromion, and the acromion should line up with the greater trochanter of the femur (see Fig 2). A common mistake in assessing forward head posture is to simply line the ear up to the acromion. If the shoulders are rounded forward due to pectoralis muscle tightness, this will result in a false-negative finding. Other problems to be aware of are scoliosis and cervical torticollis, which affect the length-tension relationships of the muscles attaching to both sides of the mandible, thereby creating an uneven pull to one side.[10] The final step in the visual postural assessment is examination of teeth occlusion. If the teeth are maloccluded, or lined up improperly, this will lead to internal disc derangement and requires appropriate dental referral for reshaping or grinding of the teeth or the use of a dental appliance for correction.[10]

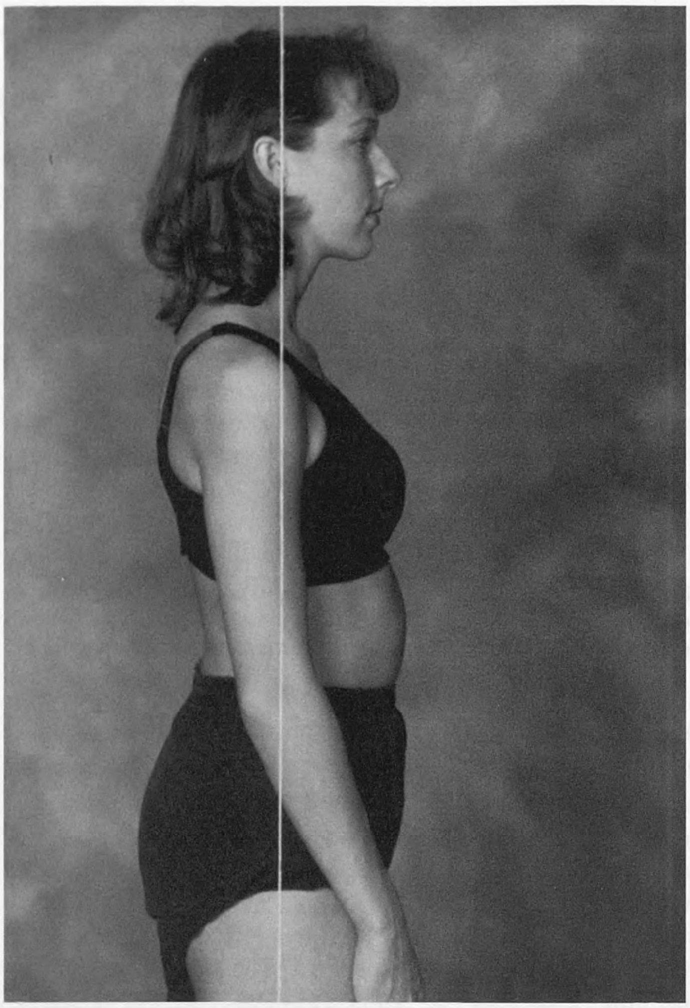


Fig 2. Plumb line assessment of posture from the lateral view.

Palpation of the TMJ region is quick and simple to perform; however, the examiner should wear examination gloves for most of this procedure. The external skin surface and superficial muscles of mastication can be palpated with the bare hand for increase in temperature and muscle tone. Palpation of the masseter muscle uses the same technique described above. The athlete clenches the jaw to assist in locating the muscle bellies, and these are palpated during both contraction and relaxation. The temporalis muscle should be palpated over its origin and muscle belly, from just above the eye to above the zygomatic arch, back to the posterior auricular area.[10,17] As before, if the athlete clenches the jaw during palpation, the muscle is very easy to locate. These muscles should not normally be painful to palpate so pain is considered a positive finding for TMD.[9,15] Other muscle groups to palpate are the hyoid muscles and the sternocleidomastoid muscles, since these are occasionally painful with dysfunctions of the temporomandibular region.

The lateral aspect of the temporomandibular joint space is palpated just anterior to the ear, and the chief findings of inflammation or trauma to the joint are swelling, increased temperature, or pain with palpation. To perform this, have the athlete open and close the mouth several times while palpating bilaterally. The mandibular condyles on both sides should move smoothly and equally. If the examiner feels one side rotate before the other or shift laterally while the mandible is moving, this may indicate a TMD. Next, while wearing examination gloves, the posterior aspect of the TMJ capsule can be palpated. Standing in front of the athlete with the little fingers inside the athlete's ears, the examiner presses very gently anteriorally (see Fig 3). The examiner has the athlete open and close the mouth several times, assessing for pain and palpating for equal motion bilaterally. Pain upon closing is indicative of posterior capsulitis and usually requires a dental referral since this condition is often caused by a mandibular condyle positioned too far posteriorally. Occlusal treatment, such as grinding or reshaping of the teeth, may be necessary to reposition the condyle more anteriorally.[10]

Range-of-motion testing involves a visual component and a goniometric component. TMJ motion allows three planes or directions of motion that should be examined: opening and closing, lateral excursion, and mandibular protrusion. Opening of the mouth varies in degree of motion available based on the physical size of the individual being evaluated; therefore, a general guideline to use for mandibular opening is to see if the athlete can place two knuckles or fingers in the open mouth (see Fig 4). If the athlete cannot place two knuckles in the mouth, this is a positive finding for hypomobility.[5,10,20] If the athlete can place three or more knuckles in the mouth, this is a positive finding for hypermobility.[5,10,20] Opening can also be measured by marking on a tongue depressor the distance between the maxillary and mandibular teeth and then measuring that distance in millimeters if a more objective measurement is desired.

Opening and closing of the mouth during its range of motion should be examined very carefully visually. Often, lateral deviations will occur during opening and closing in TMD patients, which can indicate some specific disorders.[10] For example, with opening, a deviation occurring early in the motion opposite the side of involvement is usually caused by muscle spasms. However, a deviation at midrange of motion will be due to a muscle imbalance. Finally, a deviation to the involved side at the end range of opening is most often due to posterior capsulitis.[9] The athletic trainer is well prepared to treat these conditions. However, if the athletic trainer is unsure of the diagnosis, a dental referral should be made.

Fig 3. Palpation of the posterior temporomandibular joint space.

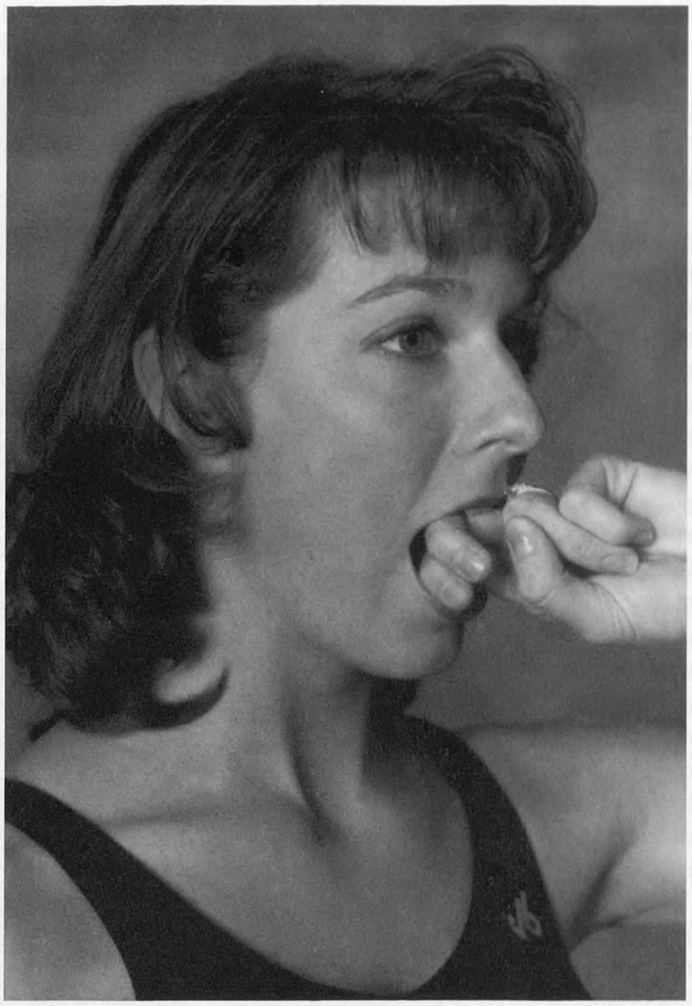


Fig 4. General mobility testing of mandibular opening with two fingers at the proximal interphalangeal joints.

Lateral excursion of the mandible involves a bilateral comparison of the motion and again compares the maxillary and mandibular teeth as landmarks. A side-to-side difference and/or pain with the motion are positive findings for a TMD.[10]

Protrusion, or jutting of the jaw forward, again uses the teeth as landmarks, and an objective measurement in millimeters should be taken. As stated earlier, due to size differences, there are no reliable norms across age and sex groups established for TMJ motions as there are for the knee or shoulder, for example. Therefore, the measurements are used only for later comparison to see if progress is being made with treatment. As a guideline, though, normal opening has been described as 40 to 60 mm,[5,19] lateral excursion at 7 to 12 mm,[5,19] and protrusion at 6 to 9 mm.[19]

Manual muscle testing of the TMJ region is confined to testing resisted opening and resisted closing[6,10] as lateral deviation and protrusion are tested with active motion during the range of motion evaluation. To perform the muscle test for the masticatory muscles, have the athlete open the mouth 1 to 2 cm; apply a stabilizing hand to the forehead and a resistance force to the chin as the athlete attempts to close the mouth. To resist opening of the mouth, have the athlete open the mouth 1 to 2 centimeters, apply a stabilizing force to the occiput, and apply a resistance force under the chin as the athlete attempts opening. Pain and/or weakness with the tests are positive findings for TMD.[10] As with all muscle tests, a gradual onset of force should be used so the athlete can resist the motion appropriately.[6,10]

The final step in the clinical evaluation for TMD involves mediate auscultation.[7,9] This is most beneficial in assessing the presence of osteoarthritis of the TMJ, which will present with grinding or crepitus at the end range of motion[10] and can also aid in diagnosing internal disc derangements. Disc derangements are divided into two categories: reducing derangements and nonreducing derangements.[1,5,8,10,21] A reducing derangement is often referred to as a reciprocal click, where the athlete will have a click at 15 to 20 mm opening the mouth and then a second click at 10 to 15 mm of closing of the mouth.[8,10] This is due to an anteriorly displaced disc, and the later in opening that the click occurs, the more anterior the disc is.[10] A nonreducing disc derangement is similar to a serious meniscal tear in the knee. The disc will get in the way of the mandibular condyle and prevent normal translation from occurring. This results in mandibular opening being limited to 15 to 20 mm of motion. A lateral deviation to the affected side will occur with opening, and there will be a decrease in lateral excursion toward the affected side.[5,8,10,21] Any athlete with a suspected disc derangement should be referred to the dentist for further evaluation.

The technique for auscultation of the TMJ is very simple. Place a stethoscope over the lateral aspect of the joint and ask the athlete to open and close the mouth several times; listen for joint noise. As stated previously, if the only positive finding to this point is joint noise, then a TMD has not been confirmed.[7,11] Joint noise should serve only as a confirmation of TMD after the examiner has discovered range-of-motion loss and pain with palpation, since these two tests have been shown to be 95% sensitive in diagnosing TMD when used together.[14]

Imaging techniques, such as radiographs, computerized tomography scans, and magnetic resonance imaging, are commonly used by dentists and physicians to view the TMJ region. Radiographs are taken in a panoramic view and in open- and closed-mouth positions.[11,15,16,20] Radiographs are indicated if osteoarthritis is suspected but are not very beneficial in diagnosing disc derangements.[9,16] CT scans and MRI are considered the most accurate imaging methods for TMD,[16] but, unfortunately, these methods are more costly, time consuming, and not readily available to most sports medicine facilities. It should also be noted that in the case of mandibular condyle malpositioning as the cause of TMD, all imaging methods are viewed with skepticism since it has been shown that condylar positioning is highly variable in both symptomatic and asymptomatic subjects and, therefore, should not be used as a sole diagnostic criterion for TMD.[16]

CONCLUSION

With the training that sports medicine practitioners have in evaluation and treatment of inflammation, muscle imbalance, and postural problems, the athletic trainer should play an integral part in the management of sports-related TMD. However, if unsure of the athlete's diagnosis or if faced with conditions such as fractures, dislocations, internal disc derangements, or malocclusion, appropriate dental or team physician referral should be made.

ACKNOWLEDGMENTS

I thank Heather Ahrendt, SPT, for modeling for the photographs used in this article and Glen Malchow for his photography work.

REFERENCES

1. Anderson GC, Schiffman EL, Schellhas KP, Fricton JR. Clinical vs arthrographic diagnosis of TMJ internal derangement. *J Dent Res.* 1989;68:826–829.
2. Arnheim DD. *Modern Principles of Athletic Training*. 7th ed. St. Louis, MO: Times Mirror/Mosby College Publishing; 1989:11–22.
3. Atkinson TA, Vossler S, Hart DL. The evaluation of facial, head, neck, and temporomandibular joint pain patients. *J Orthop Sports Phys Ther.* 1982;3:193–199.
4. Bakland LK, Boyne PJ. Trauma to the oral cavity. *Clin Sports Med.* 1989;8:39–41.
5. Braun BL. Treatment of an acute anterior disk displacement in the temporomandibular joint. *Phys Ther.* 1987;67:1234–1236.
6. Daniels L, Worthingham C. *Muscle Testing Techniques of Manual Examination.* 5th ed. Philadelphia, PA: WB Saunders Co; 1986:162–164.
7. Dworkin SF, Huggins KH, LeResche L, Von Korff M, Howard J, Truelove E, Sommers E. Epidemiology of signs and symptoms in temporomandibular disorders: clinical signs in cases and controls. *J Am Dent Assoc.* 1990;120:273–281.
8. Eversole LR, Machado L. Temporomandibular joint internal derangements and associated neuromuscular disorders. *J Am Dent Assoc.* 1985;110:69–79.
9. Friedman MH, Weisberg J. Joint play movements of the temporomandibular joint: clinical considerations. *Arch Phys Med Rehabil.* 1984;65:413–417.
10. Friedman MH, Weisberg J. Application of orthopedic principles in evaluation of the temporomandibular joint. *Phys Ther.* 1982;62:597–603.
11. Guralnick W, Kaban LB, Merrill RG. Temporomandibular joint afflictions. *N Engl J Med.* 1978;299:123–129.
12. Kulund DN. *The Injured Athlete*. 2nd ed. Philadelphia, PA: JB Lippincott Co; 1988:285–286.
13. LeResche L, Truelove EL, Dworkin SF. Temporomandibular disorders: a survey of dentists' knowledge and beliefs. *J Am Dent Assoc.* 1993;124:90–106.
14. Lobbezoo-Scholte AM, Steenks MH, Faber JAJ, Bosman F. Diagnostic value of orthopedic tests in patients with temporomandibular disorders. *J Dent Res.* 1993;72:1443–1453.
15. McNeill C, Mohl ND, Rugh JD, Tanaka TT. Temporomandibular disorders: diagnosis, management, education, and research. *J Am Dent Assoc.* 1990;120:253–263.
16. Mohl ND, Dixon DC. Current status of diagnostic procedures for temporomandibular disorders. *J Am Dent Assoc.* 1994;125:56–64.
17. Moore KL. *Clinically Oriented Anatomy*. 2nd ed. Baltimore, MD: Williams & Wilkins; 1985:916–921.
18. Parker MW. A dynamic model of etiology in temporomandibular disorders. *J Am Dent Assoc.* 1990;120:283–290.
19. Perry JF. The temporomandibular joint. In: Norkin CC, Levangie PK, eds. *Joint Structure and Function*. 2nd ed. Philadelphia, PA: FA Davis Co; 1992:193–206.
20. Waide FL, Bade DM, Lovasko J, Montana J. Clinical management of a patient following temporomandibular joint arthroscopy. *Phys Ther.* 1992;72:355–364.
21. Weisberg J, Friedman MH. Displaced disc preventing mandibular condyle translation: mobilization technique. *J Orthop Sports Phys Ther.* 1981;3:62–66.
22. Williams JGP. *A Colour Atlas of Injury in Sport.* London: Wolfe Medical Publications, Ltd; 1980:36.

Avulsion of the Inferior Canaliculus in a Collegiate Wrestler: A Case Study

Kenneth L. Cameron, MA, ATC, CSCS; Robert D. Kersey, PhD, ATC, CSCS; Jack Ransone, PhD, ATC

Objective: The purpose of this case study is to aid sports health care personnel in understanding the accurate identification and treatment of traumatic sports injuries involving structures of the lacrimal system.

Background: A 21-year-old, 118-pound wrestler sustained an avulsion of the inferior canaliculus of the right eye during a match. The injury resulted when the athlete was struck on the right cheek by the opponent's head, producing an inferior and lateral force. Following the initial control of hemorrhage, the athlete was permitted to complete the match. Upon initial evaluation, it was determined that the medial aspect of the lower right lid had been avulsed. The injury was approximately 1 cm in length. The athlete completed the match before being referred to the hospital for further evaluation.

Differential Diagnosis: Avulsion of the medial one-sixth of the lower right eyelid, involving damage to the inferior canaliculus and complete avulsion of the inferior medial canthal tendon.

Treatment: Surgical intervention was indicated in order to restore the lacrimal drainage system and to ensure patency of the inferior canaliculus. A bicanalicular silicon intubation procedure was utilized by the physician. Initial postoperative treatment included the application of topical antibiotics for seven days. The athlete was permitted to return to full participation within 1 week with the use of a wrestling face mask. The superficial sutures were removed 14 days following surgery and at that time the athlete was cleared for unrestricted activity. The silicon-reinforced medial canthal tendon suture was removed 6 weeks following surgical repair. The bicanalicular silicon stent was removed 6 months following initial injury and surgical intervention. No complications were noted throughout the 6-month postoperative stage or at the time of a follow-up interview 2 years postinjury.

Uniqueness: This is a relatively uncommon injury to encounter in athletics and one that has not been well addressed in the existing sports medicine literature.

Conclusions: When injury to the medial aspect of the eye occurs, recognition of the potential for lacrimal system involvement is essential. Therefore, the athletic trainer should be familiar with the anatomy of the lacrimal system and the potential for such injuries.

Key Words: lacrimal system, canthal tendon, laceration

The extreme nature of athletics may lead to a variety of facial injuries. Some areas of the face are more susceptible to injury than others.[13] Injury to the medial canthal area of the eye is relatively uncommon.[7] This area is protected by the nose and the superior orbital rim. However, when such an injury occurs, it may involve the severing of the canaliculi. It is critical that canalicular lacerations are correctly evaluated and repaired. Failure to recognize lacerations of the medial eyelid, with involvement to the lacrimal drainage system, may result in a disruption of this system. Complications from a nonfunctional lacrimal system include epiphora, excessive discharge, irritation, and the possibility for infection.[7]

FUNCTIONAL ANATOMY OF THE LACRIMAL SYSTEM

Knowledge of the functional anatomy of the lacrimal system is essential for the successful evaluation and treatment of injuries to this complex. The main function of the lacrimal apparatus is the secretion and drainage of tear fluid.[12] The secretion of tear fluid is important for the lubrication of the eye and also acts to provide the basic refractive mechanism of the eye. Ineffective function of the tearing mechanism may result in global cracking, infection, or impaired optical capacity of the eye. The major components that make up the lacrimal system can be seen in Figure 1.[4]

The lacrimal gland is located superior and immediately lateral to the orbit and is responsible for the secretion of tear fluid. Tear fluid is made up of water, mucus, and oil.[12] As one blinks, a layer of tear fluid is spread over the globe of the eye. This layer of tear fluid can last up to 30 seconds before it starts to lose its integrity and dissipate. As the orbit dries, the fifth cranial nerve triggers a blink reflex, which redistributes a new layer of tear fluid and eliminates any superfluous fluid.[4] Excessive tear fluid enters the lacrimal drainage system through the superior and inferior punctum. These tiny holes (1 mm in diameter) are located in the medial border of the upper and lower eyelid, approximately 6 mm from the medial canthus.[12] Upon entering the punctum, tear fluid flows through the superior and inferior canaliculi, which are approximately 8 to 10 mm in length, until the two canaliculi meet at the common canaliculus.

Rosenmüller's valve, located immediately lateral to the lacrimal sac, prevents the reflux of tear fluid from the lacrimal sac back into the canaliculi.[12] Medial to Rosenmüller's valve, the lacrimal sac is responsible for collection of tear fluid and aiding in lacrimal pump function. When tear fluid is collected in the lacrimal sac, it is emptied through the nasolacrimal duct and into the nose. The lacrimal pump is the mechanism by

Kenneth L. Cameron is an athletic trainer in the Department of Physical Education at the United States Military Academy, West Point, NY. **Robert D. Kersey** and **Jack Ransone** are associate professors in the Department of Human Performance at San Jose State University, San Jose, CA.

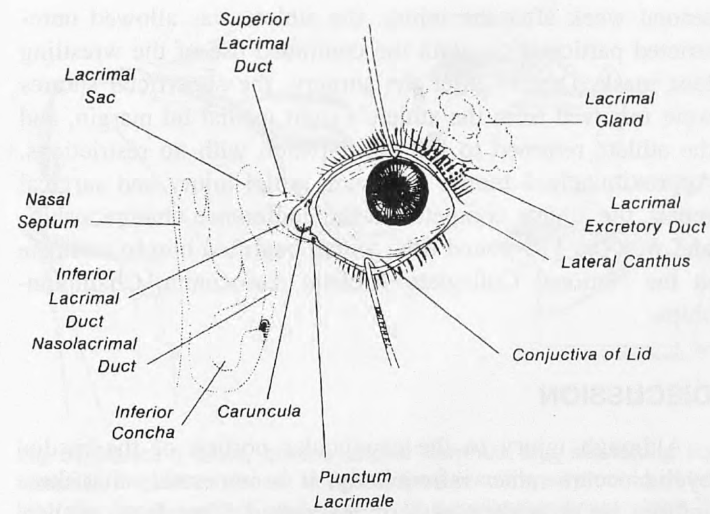


Fig 1. Left eye and lacrimal apparatus[4] (published courtesy of Williams & Wilkins).

which tear fluid is removed from the eye. Fluid accumulates in the medial aspect of the eye, known as the lacrimal lake, due to the pooling of tear fluid. According to Wolff,[12] when the eye closes, the lacrimal sac expands, causing suction throughout the canaliculi. This suction draws tear fluid in through the punctum, from the lacrimal lake. When the eye opens, the lacrimal sac collapses, forcing tear fluid out through the nasolacrimal duct and into the nose.[12]

The medial canthal tendon may be damaged when the medial portion of the upper or lower eyelid is injured.[10] The medial canthal tendon (Fig 2)[4] is composed of both a superior and an inferior portion. The function of the medial canthal tendon is to support the eyelid and to maintain the proper position of the punctum in the lacrimal lake. Therefore, when torn, the medial canthal tendon must be repaired to restore proper punctal positioning for normal tear drainage.[10]

CASE REPORT

During a 118-pound collegiate wrestling match, a wrestler dropped and lowered his head to block the takedown attempt of his opponent. The athlete was struck on the right cheek by the

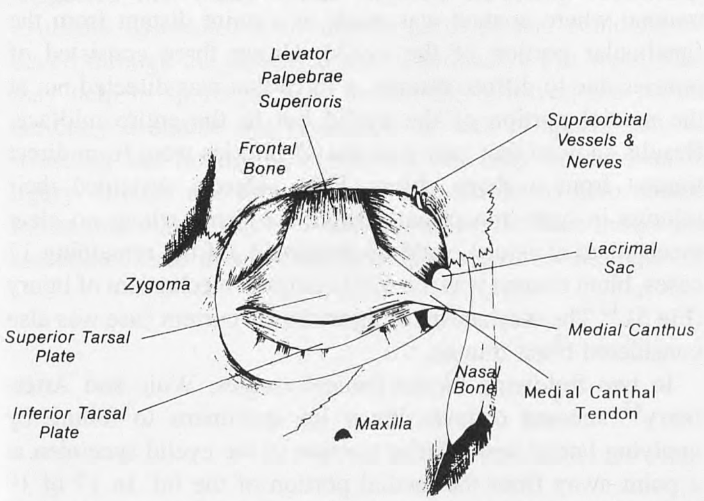


Fig 2. The tarsi and related structures[4] (published courtesy of Williams & Wilkins).

opponent's head, and an avulsion of the medial aspect of the lower eyelid resulted. The match was stopped by the referee only due to external hemorrhage. Upon initial evaluation, it was determined that the medial aspect of the right lower lid had been partially avulsed, similar to Figure 3.[5]

The injury initially appeared to be a laceration, approximately 1 cm in length, that would require only a few stitches to repair. The athlete described the mechanism of injury as a glancing blow, from the opponent's head to the athlete's right cheek. This collision resulted in an inferior and lateral force, with no apparent direct contact with the medial canthal area. Hemorrhage was minimal and was readily controlled. The athlete was permitted to continue the match with no further complications. Directly following the match, the athlete was examined by the attending physician and was referred to the emergency room for further evaluation.

The emergency room physician determined that the athlete should be evaluated by an ophthalmologist due to possible involvement of the lacrimal system. The ophthalmologist diagnosed the injury as an avulsion to the medial one-sixth of the lower right eyelid, involving damage to the inferior canaliculus and complete avulsion of the inferior medial canthal tendon. Surgical intervention was indicated in order to restore the lacrimal drainage system and to ensure patency of the inferior canaliculus.

Some advocate the repair of all torn canalicular injuries.[5,7] However, some believe that only injuries to the lower canaliculus must be repaired.[11] Still others suggest that as long as the patient has one anatomically functional canaliculus, surgical repair is not indicated.[3,12]

The procedure used by the attending physician in the present case was a bicanalicular silicone intubation technique (Fig 4).[5] An operating microscope was used in order to aid in the physician's visualization of the structures. Others have suggested that in such cases this technique may be indicated.[3,9] Bicanalicular intubation entailed threading a silicon tube

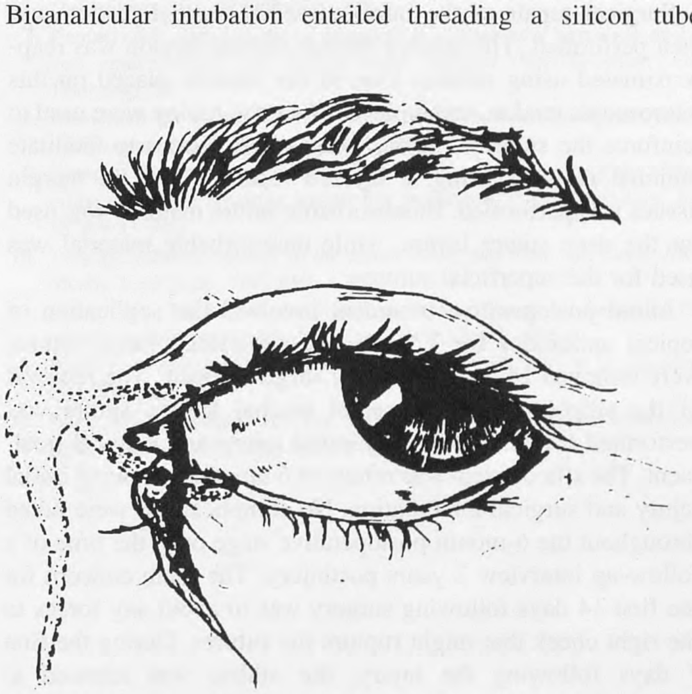


Fig 3. Avulsion involving the inferior canaliculus[5] (published courtesy of *Ophthalmic Plastic and Reconstructive Surgery*).

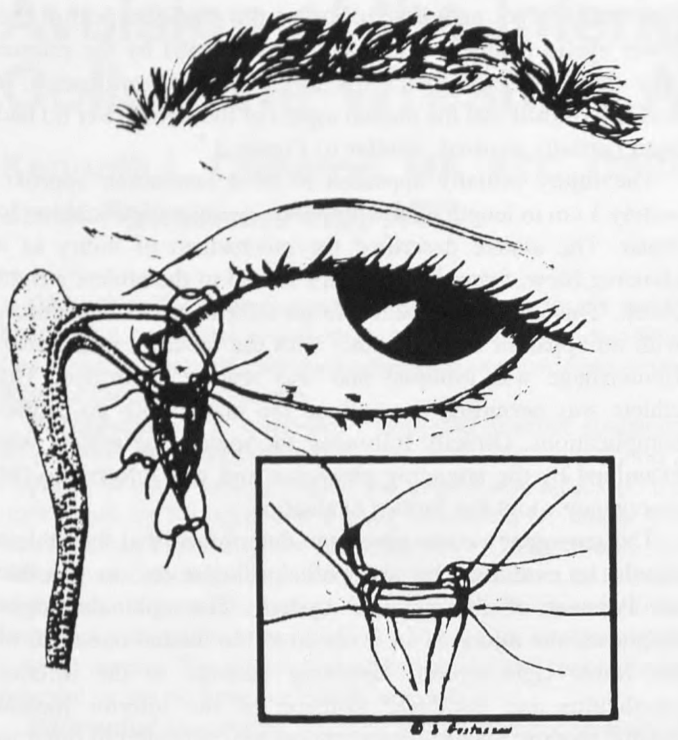


Fig 4. Bicanalicular silicon intubation of the inferior canaliculus[5] (published courtesy of *Ophthalmic Plastic and Reconstructive Surgery*).

through the intact superior canaliculus, through the common canaliculus, and back out through the inferior canaliculus. A suture was inserted through the center of the silicon tubing before the intubation. Once the silicon tubing had been threaded through both canaliculi, the suture in the middle was used to connect the ends with a knot. The knot in the lacrimal lake was then slid back around to the common canaliculus in order not to irritate the medial aspect of the globe.

Surgical repair of the inferior medial canthal tendon was then performed. The inferior medial canthal tendon was reapproximated using sutures. Due to the stresses placed on this microscopic tendon, small pieces of silicon tubing were used to reinforce the sutures. Lastly, using small sutures to facilitate minimal facial scarring, a layered repair of the lid margin tissues was performed. Bioabsorbable suture material was used for the deep suture layers, while unabsorbable material was used for the superficial sutures.

Initial postoperative treatment involved the application of topical antibiotics for 7 days. The superficial facial sutures were removed 14 days following surgical repair. The removal of the silicon-reinforced medial canthal tendon suture was performed 6 weeks following initial injury and surgical treatment. The silicon stent was removed 6 months following initial injury and surgical intervention. No complications were noted throughout the 6-month postoperative stage or at the time of a follow-up interview 2 years postinjury. The main concern for the first 14 days following surgery was to avoid any forces to the right cheek that might rupture the sutures. During the first 7 days following the injury, the athlete was allowed to participate in all forms of noncontact conditioning and in light drills with the protection of a wrestling face mask. During the second week after the injury, the athlete was allowed unrestricted participation, with the continued use of the wrestling face mask. Day 14 after the surgery, the superficial sutures were removed from the athlete's right medial lid margin, and the athlete returned to full participation with no restrictions. Approximately 1 month following initial injury and surgical repair, the athlete competed in the conference championships and won the 118-pound title, which qualified him to compete at the National Collegiate Athletic Association Championships.

DISCUSSION

Although injury to the canalicular portion of the medial eyelid occurs rather infrequently, it is imperative that these injuries be properly assessed and treated. Therefore, medical personnel should be aware of the possibility of such injury. When evaluating such an injury, it is important to have a basic understanding of the functional anatomy of the lacrimal apparatus.

Research has shown that the population most likely to suffer from lacrimal avulsion are males in their late teens and early twenties.[6,7,9] A blow to the face from a fist, elbow, or foot has been shown to be the most common mechanism of injury for the nonathletic population.[7] However, Saunders et al[9] noted that athletic accidents are one of the leading causes of lacrimal avulsion. Likewise, Kennedy et al[7] reported that 8% of the lacrimal lacerations they studied were a result of participation in sports activities, with most of the injuries occurring in basketball.

The mechanism of injury in the present case was diffuse trauma to the right cheek, producing an inferior lateral injurious force. In much of the existing literature, injury to the canaliculi are referred to as lacerations.[1–3,5,7,8,10,13] However, in this case, the resulting injury was clearly an avulsion injury. In a three-part study, Wulc and Arterberry[13] first looked at the mechanism of injury in 25 patients with canalicular injury. Injuries were divided into three groups based on the mechanism of injury. Group one consisted of injuries resulting from direct trauma with a sharp object to the medial aspect of the eye. The second group consisted of injuries from indirect trauma, where contact was made at a point distant from the canalicular portion of the eyelid. Group three consisted of injuries due to diffuse trauma, a force that was directed not at the medial portion of the eyelid but to the entire midface. Results showed that only 4 of the 25 injuries were from direct trauma from a sharp object. Four subjects sustained their injuries in high-impact automobile accidents where no clear mechanism of injury could be discerned. Of the remaining 17 cases, blunt trauma was the most common mechanism of injury (Fig 5).[13] The mechanism of injury in the current case was also considered blunt trauma.

In two following biomechanical studies, Wulc and Arterberry[13] stressed cadaver lower lid specimens to failure by applying lateral and inferior traction to the eyelid specimen at a point away from the medial portion of the lid. In 17 of 19 cases (89.5%) the lid avulsed at the canaliculus. The authors[13] suggested that this was the weakest portion of the lower lid

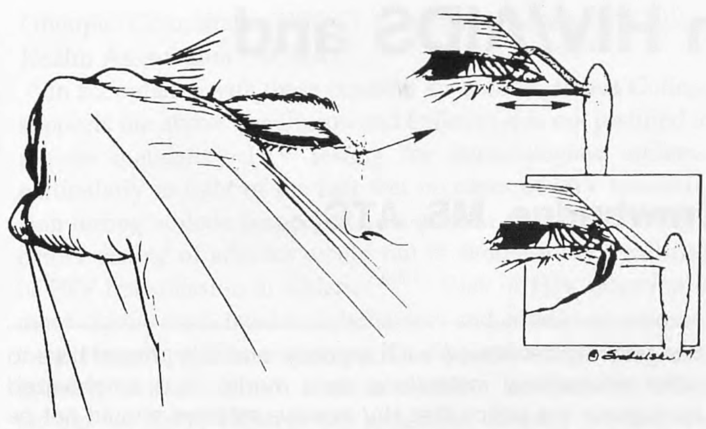


Fig 5. Glancing blow, across lateral canthus and stretching lid laterally, angled as shown in figure, may result in stretching of lid laterally (inset center) and rupture of canaliculus (inset right).[13] (Published courtesy of *Ophthalmology*)

(due to the punctal opening and the canalicular channel) and would therefore be the most common site of failure when an injurious force was applied to the lower lid.

It has been advocated that the sooner surgical repair of the injured canalicular system is undertaken following injury, the greater the success rate.[5,7] In the present case, surgical repair was performed within hours of the initial injury. The early recognition and proper treatment may have contributed to the surgical success and lack of postoperative complications.

Many surgical techniques have been advocated for repairing an avulsed canaliculus.[7] Comparative data concerning alternative methods for surgical canalicular repair remain limited. Hawes and Segrest[5] reported a success rate of 95% using a bicanalicular silicon intubation procedure similar to the one used in the current case. A number of reasons are cited for the use of silicon. The silicon material typically does not cause necrosis or corneal irritation. It is a softer, more comfortable material and is cosmetically more acceptable.[3] Reported complications from the use of silicon intubation have been minimal.[3]

Prevention of injury to the lacrimal system is very difficult and often times impractical in athletics. Kennedy et al[7] suggested that many ocular injuries, including canalicular avulsions associated with athletic participation, could be reduced through the increased use of protective eye wear. This may help in sports such as basketball; however, the use of currently available eye protection devices in sports such as wrestling and boxing is impractical and may in fact lead to injury. Boxers use lubricant on their cheeks to help reduce forces that may result in a lacrimal avulsion. Face masks are sometimes used in wrestling and other sports to dissipate the force of a blow. Such masks may limit the athlete's vision and are unsightly. In wrestling, this gear is sometimes used as a lever by the athlete's opponent.

CONCLUSION

The lacrimal drainage system and the medial lid margin are usually well protected from direct trauma by the bridge of the nose and the superior orbital rim. Injury from diffuse or indirect trauma resulting in avulsion of the medial lid margin at the canaliculus is possible. Thus, athletes without facial protection in contact sports such as soccer, basketball, wrestling, and boxing may be likely to incur such injuries. In cases of injury to the lacrimal apparatus, it is important to have a basic understanding of the functional anatomy. When injury to the medial aspect of the eye occurs, recognition of the potential for canalicular involvement is essential. Not all canalicular lacerations or avulsions are obvious to untrained individuals; therefore, all injuries to the medial lid margin should be diagnosed and treated by individuals with expertise in dealing with these injuries.

REFERENCES

1. Baylis HI, Axelrod R. Repair of the lacerated canaliculus. *Ophthalmology*. 1978;85:1271–1276.
2. Conlon MR, Smith KD, Cadera W, Shum D, Allen LH. An animal model studying reconstruction techniques and histopathological changes in repair of canalicular lacerations. *Can J Ophthalmol*. 1994;29:3–7.
3. Dortzbach RK, Angrist RA. Silicon intubation for lacerated lacrimal canaliculi. *Ophthalmic Surg*. 1985;16:639–642.
4. Fried L. *Anatomy of the Head, Neck, Face, and Jaws*. 2nd ed. Philadelphia, PA: Lea & Febiger; 1982:210–211.
5. Hawes MJ, Segrest DR. Effectiveness of bicanalicular silicone intubation in the repair of canalicular lacerations. *Ophthal Plast Reconstr Surg*. 1985;1:185–190.
6. Hurwitz JJ, Avram D, Kratky V. Avulsion of the canalicular system. *Ophthalmic Surg*. 1989;20:726–728.
7. Kennedy RH, May J, Dailey J, Flanagan JC. Canalicular laceration: an 11-year epidemiologic and clinical study. *Ophthal Plast Reconstr Surg*. 1990;6:46–53.
8. Kennerdell JS, Maroon JC. An orbital decompression for severe dysthyroid exophthalmos. *Ophthalmology*. 1982;89:467–472.
9. Saunders DH, Shannon GM, Flanagan JC. The effectiveness of the pigtail probe method of repairing canalicular lacerations. *Ophthalmic Surg*. Jun 1978;9:33–39.
10. Torg JS. *Athletic Injuries to the Head, Neck, and Face*. St. Louis, MO: Mosby-Year Book; 1991:650–670.
11. Walter WL. The use of the pigtail probe for silicone intubation of the injured canaliculus. *Ophthalmic Surg*. 1982;13:488–492.
12. Wolff E. *Anatomy of the Eye and Orbit*. New York, NY: W.B. Saunders Co; 1976:222–337.
13. Wulc AE, Arterberry JF. The pathogenesis of canalicular laceration. *Ophthalmology*. 1991;98:1243–1249.

A Model for a Policy on HIV/AIDS and Athletics

Laurie A. Bitting, MS, ATC; Cynthia A. Trowbridge, MS, ATC; Lauren E. Costello, MD

Abstract: Human immunodeficiency virus (HIV)-infected athletes exist at the collegiate level and are engaging in competitive sports, as was revealed by a 1993 NCAA survey. Unfortunately, there is a void when the issue of policy for the HIV-positive athlete and his or her participation rights at the collegiate level is addressed. Given the controversial nature of opinion on HIV and the resultant acquired immunodeficiency syndrome (AIDS), it is recommended that a policy be in place for an HIV-infected athlete *before* it is needed. Ithaca College has recently developed such a policy, and it is offered here to other educational institutions as a model. It is emphasized throughout the policy that HIV-positive athletes should not be restricted from athletic participation for the reason of infection alone, that strict confidentiality guidelines should be followed, and that mandatory testing of athletes for HIV is not justified.

Key Words: human immunodeficiency virus (HIV), acquired immunodeficiency syndrome (AIDS), policy for athletic participation

Attention given to human immunodeficiency virus (HIV)-positive athletes and their participation status has increased dramatically over the past few years. HIV infection of such high-profile athletes as Arthur Ashe, Greg Louganis, Tommy Morrison, and Earvin "Magic" Johnson has brought to the forefront the question of whether an athlete who has contracted the virus that is a precursor to the fatal acquired immunodeficiency syndrome (AIDS) should be allowed to continue to engage in competitive athletics. This issue is clearly deserving of intense scrutiny to ensure informed and prudent decisions regarding HIV-infected athletes.

Although the focus of attention has been on professional athletes infected with HIV, HIV-positive athletes competing at the collegiate level do exist, as reported in a 1993 survey of NCAA member institutions.[10] There are no numbers on the infection rate of any particular group of athletes[10] (*USA Today*. March 12, 1996:1), but the Centers for Disease Control and Prevention estimates that 1 in 200 males of college age are infected with HIV[6] (*USA Today*. March 12, 1996:1). The concern in intercollegiate athletics is the possibility of transmission of the virus from the infected to the noninfected athlete via blood contact (sweat does not carry the virus, and saliva does not carry the virus in an infectious form[12]). Unfortunately, injuries are a part of sport and can result in bleeding on the field or court. However, it has been well documented that the risk of HIV transmission in the sports arena is infinitesimally small,[1,2,4,5,7,10,11] and to date there have been no cases of such transmission.[1,2,3,6,10,11]

The possibility of a collegiate institution's having to address the issue of the participation rights of an HIV-infected athlete will continue to grow with the ever increasing HIV infection rate of college-age individuals. The aforementioned survey conducted in 1993 of NCAA member institutions concerning HIV/AIDS policies found that 92% of the departments of intercollegiate athletes had no policy to address the issue of athletic participation by HIV-positive athletes. Of the collegiate institutions that had policies concerning participation, only nine of these policies were actually in writing.[10] Therefore, a real need exists to develop effective educational and procedural guidelines for the participation of the HIV-infected athlete. We believe that institutions should be proactive regarding an HIV/AIDS and athletics policy and should have one in place before it becomes a necessity. A collaborative effort by the Medical Director for Athletic Teams and two athletic training staff/clinical faculty members was put forth at Ithaca College to formulate such a policy. The resultant guidelines are based on the best currently available medical facts regarding HIV/AIDS. The following is offered as a model to encourage the adoption of similar policies by athletic departments of colleges and other educational institutions nationwide.

Laurie A. Bitting and **Cynthia A. Trowbridge** are athletic trainers and clinical faculty members in the Department of Exercise and Sport Sciences, School of Health Sciences and Human Performance, and **Lauren E. Costello** is the Medical Director for Athletic Teams, at Ithaca College, Ithaca, NY.

ITHACA COLLEGE DIVISION OF INTERCOLLEGIATE ATHLETICS POLICY ON HIV/AIDS AND ATHLETICS

The risk of contracting HIV during the course of athletic activity is extremely low. To date, there have been no documented cases of HIV transmission during athletic activity.[1,2,4,6,7,10] Based on current medical and epidemiologic information, HIV infection alone is insufficient grounds to prohibit athletic competition. The decision to *not* restrict student athletes (hereafter referred to as athletes) merely because they are infected with HIV is supported by the joint position statement of the American Medical Society for Sports Medicine (AMSSM) and the American Academy of Sports Medicine (AASM, now known as the American Orthopedic Society for Sports Medicine)[2] and the position statements of the American Academy of Pediatrics (AAP),[1] the National Collegiate Athletic Association (NCAA),[4] the United States

Olympic Committee (USOC),[7,8] and the American College Health Association (ACHA).[9]

In accordance with these position statements, Ithaca College supports the above conclusion and believes it is not justified to require mandatory HIV testing for intercollegiate athletes, particularly in light of the fact that no cases of HIV transmission during athletic competition have been documented. Mandatory testing of athletes would fail to decrease the small risk of HIV transmission in athletics.[4,5,11] Risk of HIV infection is more closely associated with behaviors and conditions external to sports competition, more specifically, intravenous drug use, intimate sexual contact, and intrauterine transmission from mother to baby. Educational programs directed toward the traditional routes of HIV infection will teach athletes how to prevent HIV infection by acting responsibly and will also promote good health practices.[4,5,6,11] Voluntary testing is available to any student who might be at risk for HIV infection and can be arranged through the campus health center.

In accordance with Ithaca College's policy regarding the rights and privacy of individuals, members of the college community should take care to respect the confidentiality of information concerning persons with HIV infection, HIV-related conditions, or AIDS. The decision to disclose information related to this particular aspect of the athlete's medical history should remain a privilege of the infected individual, and it is of paramount importance that a strict policy of confidentiality be followed.[3,11] Adherence to this policy helps limit the risk of discrimination against those with HIV infection, HIV-related conditions, or AIDS.

The decision to allow continued athletic participation of an athlete with HIV infection, HIV-related conditions, or AIDS should be based on the athlete's current health status and should be left to the discretion of the personal physician and, if cleared for play, the athlete.[2,4,6,9,11] Eligibility to participate in athletics for the HIV-infected athlete should be determined using the same procedures and standards used for all other athletes.[6,9] Continued medical checkups are recommended for the HIV-infected athlete to ensure the best health interests of the athlete for continued sports participation.

The above policy is based on the best currently available medical facts regarding HIV/AIDS and will be continually reviewed and revised when new information warrants.

ACKNOWLEDGMENTS

We thank Robert Deming (Director of Intercollegiate Athletics at Ithaca College) and Nancy Pringle (College Attorney for Ithaca College) for their valuable opinions during the process of developing this policy.

REFERENCES

1. American Academy of Pediatrics. HIV in the athletic setting. *Pediatrics.* 1991;88:640–641.
2. American Medical Society for Sports Medicine and American Academy of Sports Medicine. Human immunodeficiency virus (HIV) and other blood-borne pathogens in sports. *Am J Sports Med.* 1995;23:510–514.
3. Arnold B. A review of selected blood-borne pathogen position statements and federal regulations. *J Athl Train.* 1995;30:171–176.
4. Guideline 2H: blood-borne pathogens and intercollegiate athletics. In: *1993–1994 NCAA Sports Medicine Handbook.* 6th ed. Benson M, ed. Overland, KS: The National Collegiate Athletic Association; 1993:24–28.
5. Calabrese L, Haupt H, Hartman L, Strauss R. HIV and sports: what is the risk? *Physician Sportsmed.* 1993;21:173–180.
6. Erickson S, Rich B. Medical staff needs to know school's policy on HIV and HBV. *NCAA Sport Sciences Education Newsletter.* Spring 1996:1,4.
7. Garl T, Hrisomalos T, Rink L. *Transmission of Infectious Agents During Athletic Competition.* Colorado Springs, CO: United States Olympic Committee; 1991:1–24.
8. Garl T. *Transmission of Infectious Agents During Athletic Competition (HIV/AIDS update).* Colorado Springs, CO: United States Olympic Committee; 1995:3.
9. Keeling RP, Wolitski RJ. Athletics and HIV infections. In: Keeling, RP, ed. *AIDS on the College Campus.* Rockville, MD: American College Health Association; 1989:113–118.
10. McGrew CA, Dick RW, Schniedwind K, Gikas P. Survey of NCAA institutions concerning HIV/AIDS policies and universal precautions. *Med Sci Sports Exerc.* 1993;25:917–921.
11. Michigan Intercollegiate Athletic Association. The Michigan Intercollegiate Athletic Association policy on blood-borne pathogens. *The Sports Medicine Standards and Malpractice Reporter.* 1993;5(2):23–25.
12. Seltzer DG. Educating athletes on HIV disease and AIDS. *Physician Sportsmed.* 1993;21(1):109–114.

19th Annual NATA Student Writing Contest

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

1. The contest is open to all undergraduate members of the NATA.
2. Papers must be on a topic germane to the profession of athletic training and can be case reports, literature reviews, experimental reports, analyses of training room techniques, etc.
3. Entries must not have been published, nor be under consideration for publication by any journal.
4. The winning entrant will receive a cash award and the paper will be published in the *Journal of Athletic Training* with recognition as the winning entry in the Annual NATA Student Writing Contest. One or more other entries may be given honorable mention status.
5. Entries must be written in journal manuscript form and adhere to all regulations set forth in the ''Authors' Guide'' of the *Journal of Athletic Training.* We suggest that authors, before starting, read: Knight, KL, Ingersoll CD. Structure of a Scholarly Manuscript: 66 Tips for What Goes Where. *J Athl Train.* 1996;31:201–206 and Knight, KL, Ingersol CD. Optimizing Scholarly Communications: 30 Tips for Writing Clearly. *J Athl Train.* 1996;31:209–213.
6. Entries must be received by March 1, 1997. Announcement of the winner will be made at the Annual Meeting and Clinical Symposia in June.
7. The Writing Contest Committee reserves the right to make no awards if, in their opinion, none of the entries is of sufficient quality to merit recognition.
8. An original and two copies of the paper must be received at the following address by March 1, 1997.

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

UNITED STATES POSTAL SERVICE™

Statement of Ownership, Management, and Circulation

(Required by 39 U.S.C. 3685)

1. Publication Title	2. Publication No.	3. Filing Date
JOURNAL OF ATHLETIC TRAINING	1062-6050	SEPTEMBER 23, 1996
4. Issue Frequency	**5. No. of Issues Published Annually**	**6. Annual Subscription Price**
Quarterly	4	$32.00

7. Complete Mailing Address of Known Office of Publication *(Street, City, County, State, and ZIP+4) (Not Printer)*
Ken Knight, PhD, ATC
Athletic Training Dept., Indiana State Univ., Terre Haute, IN 47809

8. Complete Mailing Address of Headquarters or General Business Office of Publisher *(Not Printer)*
National Athletic Trainers' Assn.
2952 Stemmons Freeway, Dallas, TX 75247

9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor *(Do Not Leave Blank)*

Publisher *(Name and Complete Mailing Address)*
National Athletic Trainers' Association
2952 Stemmons Freeway, Dallas, TX 75247

Editor *(Name and Complete Mailing Address)*
Ken Knight, PhD, ATC
Athletic Training Dept., INdiana State Univ., Terre Haute, IN 47809

Managing Editor *(Name and Complete Mailing Address)*
Ken Knight, PhD, ATC
Athletic Training Dept., Indiana State Univ., Terre Haute, IN 47809

10. Owner *(If owned by a corporation, its name and address must be stated and also immediately thereafter the names and addresses of stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address as well as that of each individual must be given. If the publication is published by a nonprofit organization, its name and address must be stated.) (Do Not Leave Blank.)*

Full Name	Complete Mailing Address
National Athletic Trainers' Assn.	2952 Stemmons Frwy, Dallas, TX 75247

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check here. ☒ None

Full Name	Complete Mailing Address

12. For completion by nonprofit organizations authorized to mail at special rates. The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes: *(Check one)*
☒ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months
(If changed, publisher must submit explanation of change with this statement)

PS Form 3526, October 1994 *(See Instructions on Reverse)*

13. Publication Name	14. Issue Date for Circulation Data Below	
Journal of Athletic Training	June 1996	
15. Extent and Nature of Circulation	**Average No. Copies Each Issue During Preceding 12 Months**	**Actual No. Copies of Single Issue Published Nearest to Filing Date**
a. Total No. Copies *(Net Press Run)*	22,566	23,984
b. Paid and/or Requested Circulation (1) Sales Through Dealers and Carriers, Street Vendors, and Counter Sales *(Not Mailed)*	-0-	-0-
(2) Paid or Requested Mail Subscriptions *(Include Advertisers' Proof Copies/Exchange Copies)*	21,848	22,823
c. Total Paid and/or Requested Circulation *(Sum of 15b(1) and 15b(2))*	21,848	22,823
d. Free Distribution by Mail *(Samples, Complimentary, and Other Free)*	79	79
e. Free Distribution Outside the Mail *(Carriers or Other Means)*	225	500
f. Total Free Distribution *(Sum of 15d and 15e)*	304	579
g. Total Distribution *(Sum of 15c and 15f)*	22,152	23,402
h. Copies Not Distributed (1) Office Use, Leftovers, Spoiled	414	582
(2) Return from News Agents	0	0
i. Total *(Sum of 15g, 15h(1), and 15h(2))*	22,566	23,984
Percent Paid and/or Requested Circulation *(15c / 15g x 100)*	97%	96%

16. This Statement of Ownership will be printed in the December issue of this publication. ☐ Check box if not required to publish.

17. Signature and Title of Editor, Publisher, Business Manager, or Owner — Date
[illegible] Business Manager 10/9/96

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions *(including fines and imprisonment)* and/or civil sanctions *(including multiple damages and civil penalties).*

Instructions to Publishers

1. Complete and file one copy of this form with your postmaster on or before October 1, annually. Keep a copy of the completed form for your records.
2. Include in items 10 and 11, in cases where the stockholder or security holder is a trustee, the name of the person or corporation for whom the trustee is acting. Also include the names and addresses of individuals who are stockholders who own or hold 1 percent or more of the total amount of bonds, mortgages, or other securities of the publishing corporation. In item 11, if none, check box. Use blank sheets if more space is required.
3. Be sure to furnish all information called for in item 15, regarding circulation. Free circulation must be shown in items 15d, e, and f.
4. If the publication had second-class authorization as a general or requester publication, this Statement of Ownership, Management, and Circulation must be published; it must be printed in any issue in October or the first printed issue after October, if the publication is not published during October.
5. In item 16, indicate date of the issue in which this Statement of Ownership will be printed.
6. Item 17 must be signed.

Failure to file or publish a statement of ownership may lead to suspension of second-class authorization.

PS Form 3526, October 1994 *(Reverse)*

N A T A

RESEARCH &
EDUCATION
FOUNDATION

REQUEST FOR PROPOSALS

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

RESEARCH GRANTS — *$75,000 Available*

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

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

EDUCATION GRANTS — *$25,000 Available*

Education Research Grants include studies investigating teaching methods and evaluation and learning tools used in the area of athletic training education. Areas of particular interest to the Foundation are computer and competency based learning and methods used to evaluate clinical learning skills. These grants range from $1,000 - $15,000.

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

To receive a copy of the Education Grant Application or the Research Grant Application, please write to:

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

E-mail the request to BrianaE@aol.com or call 800-TRY-NATA ext. 150

Call For Abstracts

NATA Research & Education Foundation
CALL FOR ABSTRACTS

1997 National Athletic Trainers' Association — Annual Meeting & Clinical Symposia
Salt Lake City, Utah • June 18-21, 1997
DEADLINE FOR ABSTRACT SUBMISSION: JANUARY 5, 1997

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

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

FREE COMMUNICATIONS ABSTRACTS

Specific Content Requirements

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

• **Basic Science** - includes controlled laboratory studies in the subdisciplines of exercise physiology, biomechanics, and motor behavior, among others, which relate to athletic training and sports medicine.

• **Clinical Studies** - includes assessment of the validity, reliability, and efficacy of clinical procedures, rehabilitation protocols, injury prevention programs, surgical techniques, and so on.

• **Educational Research** - a broad category ranging from basic surveys to detailed athletic training/sports medicine curricular development. An abstract in this category will generally include assessment of student learning, teaching effectiveness (didactic or clinical), educational materials and curricular development.

• **Sports Injury Epidemiology** - includes studies of injury patterns among athletes. These studies will generally encompass large-scale data collection and analysis. Surveys and questionnaires may be classified in this category but are more likely to come under the Observational/Informational Studies category.

• **Observational/Informational Studies** - includes studies involving surveys, questionnaires, and descriptive programs, among others, which relate to athletic training and sports medicine.

Instructions for Preparing the Abstract

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

CLINICAL CASE REPORTS

Specific Content Requirements

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

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

Instructions for Preparing the Abstract

1. An individual may submit only one clinical case report abstract as primary (presenting) author; however, there is no limit to the number of abstracts (free communications or case reports) listing an individual as coauthor.
2. Clinical case report abstracts are to be word processed or typed using a letter-quality printer with no smaller than elite (12 cpi) or 10-point font. Do not use a dot-matrix printer.
3. Top, bottom, right, and left margins should be set at 1.5" using a standard 8.5" × 11" sheet of paper. Type the title of the paper or project in all CAPITAL letters on the left margin.
4. Provide all information requested on the information form on the next page. Please note that the institution where the clinical case occurred should be cited, not the author(s)' current address, if different.
5. The title of the clinical case report should not contain information that may reveal the identity of the individual nor the specific nature of the medical problem to the reader. An example of a proper title for a clinical case report is "Chronic Shoulder Pain in a Collegiate Wrestler."
6. Complete the six different categories of information as required for a clinical case report abstract. These categories are:
   a. Personal Data/Pertinent Medical history (provide the age, gender, sport/occupation of individual, their primary complaint, and pertinent aspects of their medical history)
   b. Physical Signs and Symptoms (a brief summary of the physical findings)
   c. Differential Diagnosis (array of possible injuries/conditions)
   d. Results of Diagnostic Imaging/Laboratory Tests
   e. Clinical Course (eg, diagnosis, treatment, surgical technique, rehabilitation program, final outcome)
   f. Deviation From the Expected (a brief description of what makes this case unique)

Instructions for Submitting Abstracts

(either Free Communications or Case Reports)

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

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

ABSTRACTS POSTMARKED AFTER JANUARY 5, 1997 WILL NOT BE ACCEPTED

Mailing Address of Presenting Author:

***Please* type; provide full name rather than initials)**

☐ I am a student.

Name
Address
City
State Zip
Work Telephone
Fax #
NATA Membership Number
e-mail

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

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

☐ Clinical Case Report ☐ Free Communications

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

☐ Basic Science ☐ Clinical Studies
☐ Educational Research ☐ Sports Injury Epidemiology
☐ Observational Studies

Indicate your presentation preference:
(check one only; choice does not influence acceptance)

☐ Poster ☐ Oral ☐ Indifferent

NATA Research & Education Foundation Call for Reviewers

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

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

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

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

Reviewers
NATA Research & Education Foundation
2952 Stemmons Freeway
Dallas, TX 75247
Responses preferred by December 1, 1996

Abstracts

Clint Thompson, MS, ATC

Cross KM. A review of topically applied dimethyl sulfoxide. *J Sport Rehabil.* 1996;5:164–171.

Dimethyl sulfoxide (DMSO) was introduced to the medical community in the mid-1960s as a powerful anti-inflammatory agent. Clinical studies and subjective claims abounded about its healing effects on a variety of musculoskeletal injuries. Unfortunately, soon after the incorporation of DMSO into rehabilitation routines, the American Medical Association denounced many of the studies of DMSO as being unscientific in nature, and the possibility of toxic effects on the optical lens was noted in an experiment using primates as subjects. As a result, the use of DMSO in the medical community was halted. The exact mechanisms by which DMSO affects the healing process are unknown; however, several studies from the 1980s noted specific effects during various phases of the inflammatory process, such as monocyte and fibroblast activity. Presently, DMSO is considered an investigational drug and has not been approved by the Food and Drug Administration for use with musculoskeletal disorders.

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

DeCarlo M, Malone K, Gerig B, Hunker M. Evaluation of shoulder instability braces. *J Sport Rehabil.* 1996; 5:143–150.

The comparative abilities of three types of shoulder orthoses to limit motion following isokinetic exercise were studied on 10 male subjects. Maximum active abduction, forward flexion, and external rotation were measured under a control and three braced conditions. Braced conditions included Sawa, Duke Wyre, and Shoulder Subluxation Inhibitor. Subjects performed 10 repetitions each of flexion-extension and abduction-adduction exercise at isokinetic speeds of 120° and 180°/s. Data were analyzed using a paired *t* test and ANOVA. Significant differences were found for each of the devices in pre-post goniometric measurements of forward shoulder flexion. Only the Sawa brace demonstrated significant pre-post change for shoulder abduction. No significant differences were detected in any of the devices for external rotation. A trainer who is selecting a motion-limiting shoulder device for an athlete returning to competition following injury should consider the loosening effect that may occur during activity as well as the desire for overhead motion.

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

McDonough A, Weir JP.The effect of postsurgical edema of the knee joint on reflex inhibition of the quadriceps femoris. *J Sport Rehabil.* 1996;5:172–182.

The purpose of this case study was to investigate reflex inhibition of the quadriceps femoris in a subject with postsurgical edema of the left knee. The subject was a 45-year-old male with a traumatic knee injury with resultant edema who underwent elective arthroscopic surgery. Reflex inhibition was assessed by H-reflex elicitation in the femoral nerve and surface electromyography of the quadriceps. To assess the degree of edema, direct circumferential measurements were taken. On the first presurgical visit, the left knee demonstrated mild edema with a decrease in H-reflex amplitudes. Two days after surgery, a further reduction in amplitudes and more swelling were demonstrated followed by an increase in amplitudes and a reduction in edema on the 28th postoperative day. These findings document a relationship between reflex inhibition and joint swelling that was previously described in experimental material when joint edema was imitated.

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

Udry E. Social support: exploring its role in the context of athletic injuries. *J Sport Rehabil.* 1996;5:151–163.

The vast majority of research dealing with athletic injuries has examined injuries from physical or environmental perspectives. However, there has been a growing awareness of the role of psychosocial factors in the injury process. Specifically, social support has been identified as a variable that may play a significant role in both the etiology of and recovery from athletic injuries. The overall purpose of this discussion is to review and integrate the literature that has examined the role of social support as it relates to athletic injuries. More specifically, this paper will (a) discuss conceptual issues related to social support, (b) explore the role of social support as a potential moderator variable in the life stress-injury relationship, (c) examine the contribution of social support to the rehabilitation process, and (d) suggest directions for future research based on the extant social support literature.

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

Terry GC, LaPrade RF. The biceps femoris muscle complex at the knee. *Am J Sports Med.* 1996;24:2–8.

We dissected 30 cadaveric knees to provide a detailed anatomic description of the biceps femoris muscle complex at the knee. The main components of the long head of the muscle are a reflected arm, a direct arm, an anterior arm, and a lateral and an anterior aponeurosis. The main components of the short head of the biceps femoris muscle are a proximal attachment to the long head's tendon, a capsular arm, a confluence of the biceps and the capsuloosseous layer of the iliotibial tract, a direct arm, an anterior arm, and a lateral aponeurosis. We examined 82 consecutive, acutely injured knees with clinical signs of anterolateral-anteromedial rotatory instability for the incidence and anatomic location of injuries to the biceps femoris muscle. Injuries to components of that muscle were identified in 59 (72%) of these knees; 29 knees (35.4%) had multiple components injured. There were 3 injuries to the long head of the biceps femoris muscle (all in the reflected arm) and 89 to the short head. A statistically significant correlation ($p = 0.01$) was found between increased anterior translation with the knee at 25° of flexion as demonstrated by the Lachman test and injury to the biceps-capsuloosseous iliotibial tract confluens. Additionally, adduction laxity at 30° of flexion correlated with a Segond fracture ($p = 0.04$). These data establish, in part, the relationship of the biceps femoris complex injury to anterior translation instability.

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

Veltri DM, Deng X, Torzilli PA, Maynard MJ, Warren RF. The role of the popliteofibular ligament in stability of the human knee. ***Am J Sports Med.*** **1996;24:19–27.**

The popliteal tendon has a significant attachment to the fibula, the popliteofibular ligament. The role of the ligament in knee stability has not been determined. In this study we used selective cutting techniques to measure the static contributions of the popliteal tendon attachments to the tibia and the popliteofibular ligament for stability of the knee. Sectioning of all the posterolateral structures except the popliteal tendon attachments to the tibia or the popliteofibular ligament resulted in increased primary posterior translation, varus rotation, external rotation, and coupled external rotation. Although statistically significant, these increases were small. Sectioning of all the posterolateral structures resulted in larger increases in primary posterior translation, varus rotation, external rotation, and coupled external rotation. Our data indicate that the popliteal tendon attachments to the tibia and the popliteofibular ligament are important in resisting posterior translation and varus and external rotation. If an isolated injury to the posterolateral structures occurs, anatomic reconstruction of the major ligaments that restrain posterior translation and varus and external rotation may provide the best functional result. Reconstruction for isolated posterolateral instability should include anatomic attachment of the popliteal tendon to the tibia and the popliteofibular ligament.

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

Sallay PI, Poggi J, Speer KP, Garrett WE. Acute dislocation of the patella: a correlative pathoanatomic study. ***Am J Sports Med.*** **1996;24:52–60.**

The objective of our study was to elucidate the characteristic pathoanatomy associated with patellar dislocation and report the preliminary results of early surgical repair. Twenty-three patients with documented patellar dislocation had standard radiographs and a magnetic resonance imaging scan. Intraarticular lesions were evaluated and treated arthroscopically followed by an open exploration of the medial aspect of the knee in 16 patients. Twelve patients were observed for a minimum of 2 years after surgical repair (average, 34 months). Eleven patients returned for a follow-up examination. Magnetic resonance imaging revealed effusion (100%), tears of the femoral insertion of the medial patellofemoral ligament (87%), increased signal in the vastus medialis muscle (78%), and lateral femoral condyle (87%) and medial patellar bone bruises (30%). Arthroscopic examination revealed osteochondral lesions involving the patella and the lateral femoral condyle in 68% of cases. Open surgical exploration revealed tears of the medial patellofemoral ligament off the femur in 15 of 16 patients (94%). After medial patellofemoral ligament repair, none of the patients experienced recurrent dislocation. Overall 58% of the results were considered to be good or excellent and 42% were fair. Fifty-eight percent of the group returned to their previous sport with no or minor limitations.

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

Kowall MG, Kolk G, Nuber GW, Cassisi JE, Stern SH. Patellar taping in the treatment of patellofemoral pain. ***Am J Sports Med.*** **1996;24:61–66.**

The purpose of this prospective study was to evaluate the efficacy of a patellar taping program in the conservative management of patellofemoral pain. Twenty-five patients with patellofemoral pain were randomized into two groups. One group underwent a standard physical therapy program for patellofemoral pain. The other group underwent the same physical therapy program, but use of a patellar taping technique was added to this program. Results of a subjective visual analog scale and changes in isokinetic strength and electromyographic activity of the quadriceps muscle were analyzed. Both the tape and no-tape groups experienced a statistically significant decrease in symptoms ($p < .05$), but no difference in improvement of patellofemoral pain was noted between the groups. Likewise, both groups demonstrated significant improvement in quadriceps muscle isokinetic strength ($p < 0.05$) and activity ($p < 0.001$), but no difference in improvement was noted between groups. The results of this study suggest no beneficial effect of adding a patellar taping program to a standard physical therapy program in the conservative treatment of patellofemoral pain. Larger prospective studies are warranted to support this opinion.

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

Kim S, Min B, Han D. Paradoxical phenomena of the McMurray Test. ***Am J Sports Med.*** **1996;24:83–87.**

We evaluated 200 patients who had a positive McMurray test and found atypical McMurray test results in 24 patients (12%). These patients revealed pain or clicking or both either in the medial compartment of the knee when the leg was internally rotated or in the lateral compartment of the knee when the leg was externally rotated. The authors analyzed these paradoxical findings at arthroscopic examination to identify the relationship between the type of meniscal tear and the direction of leg rotation that elicited the catching and displacement of the torn meniscal portion during the McMurray test. Contrary to conventional McMurray test findings, three different types of meniscal tears were found on the side of the knee where pain or a clicking sound occurred. The three types were 1) anteriorly based posterior oblique tears with anterior displacement of the meniscus, 2) bucket-handle tears in the posterior half of the menisci, and 3) peripheral detachment of discoid menisci in the posterior half of the torn portions.

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

Myrer JW, Schulthies SS, Fellingham GW. Relative and absolute reliability of the KT-2000 arthrometer for uninjured knees. *Am J Sports Med.* 1966; 24:104–108.

We assessed the reliability of the KT-2000 knee arthrometer at 67, 89, 134, and 178 N and at manual maximum forces on 30 college students who were free from present or previous knee injuries. Two examiners tested all subjects on two occasions. Anterior laxity ($p < 0.0001$) and side-to-side difference ($p < 0.05$) significantly increased as force increased. There was a significant difference ($p < 0.0001$) between testers for anterior laxity but not for side-to-side difference. We used intraclass correlation coefficients to estimate relative reliability. Anterior laxity intraclass correlation coefficients (2,1) between testers ranged from 0.81 to 0.86 and within tester correlations ranged from 0.92 to 0.95. Intraclass correlation coefficients for between testers for side-to-side differences ranged from 0.38 to 0.58 and within tester correlations ranged from 0.53 to 0.64. Subject-to-subject variability needs to be taken into account when interpreting intraclass correlation coefficient values. Our absolute reliability estimates (95% confidence intervals) were small, indicating little variability. Our data demonstrate the KT-2000 arthrometer to be reliable. Researchers should present both relative and absolute reliability estimates, although we believe absolute estimates are of greater clinical value. Side-to-side differences are better discriminators than individual absolute values. We recommend that a <3 mm side-to-side difference be used to indicate stable knees.

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

Bouten CV, Lichtenbelt WD, Westerterp KR. Body mass index and daily physical activity in anorexia nervosa. *Med Sci Sports Exerc.* 1966;28:967–973.

The level of daily physical activity in 11 nonhospitalized women with anorexia (age: 21–48 yr, body mass index (BMI): 12.5–18.3 kg·m^2), compared with 13 normal-weight women (age: 20–35 yr, BMI 19.2–26.7 kg·m^2), was studied in relation to BMI. Daily physical activity over a 7-day period was determined from movement registration and by combining measurements of average daily metabolic rate (using the doubly labeled water method) and sleeping metabolic rate (measured in a respiration chamber). Group averages of daily physical activity were similar for subjects with anorexia and control subjects. However, women with anorexia had either a low or a high level of daily physical activity, whereas most control subjects had a moderate level of daily physical activity. In the women with anorexia, daily physical activity was significantly related to BMI ($r = 0.84$). Subjects with a BMI $\sim$ 17 kg·m^2 were equally or more active compared with control subjects, while subjects with a BMI 17 kg·m^2 were equally or less active compared with control subjects. The increased physical activity at BMI r 17 kg·m^2 is considered to be facilitated by an improving physical capacity combined with the advantages of a low body mass during weight-bearing activities. At lower BMI, undereating and declining physical capacity may have caused the observed decrease in daily physical activity.

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

Robinson AJ. Transcutaneous electrical nerve stimulation for the control of pain in musculoskeletal disorders. *J Orthop Sports Phys Ther.* 1996;24: 208–226.

The literature on the use of transcutaneous electrical nerve stimulation (TENS) for pain control in several common musculoskeletal disorders is reviewed. The need for this review stems from apparently contradictory results of numerous studies designed to address the efficacy of electrical stimulation procedures for pain control. The focus of the review is on the efficacy of TENS in the management of low-back pain syndromes. Other areas discussed include TENS use in arthritic conditions, soft tissue inflammatory disorders, and in postoperative pain following orthopaedic surgical procedures. Methodologic strengths and weaknesses of TENS studies are emphasized in order to assist the reader in understanding the relative value of TENS studies, which either support or refute the efficacy of electrical stimulation procedures for pain control.

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

Sluka KA. Pain mechanisms involved in musculoskeletal disorders. *J Orthop Sports Phys Ther.* 1996;24:240–254.

This manuscript is intended to give a basic review of the peripheral and spinal neuronal mechanisms involved in the processing of musculoskeletal pain. There is a complicated neuronal network in the periphery and the spinal cord for the processing of nociceptive information. Injury to a muscle (inflammation or ischemia) or a joint (inflammation) results in sensitization of peripheral nociceptors. There is then an increased transmission to and increased release of neurotransmitters in the dorsal horn of the spinal cord. Dorsal horn neurons sensitized by the peripheral injury demonstrate increased background activity, increased receptive field size, and increased responses to peripherally applied stimuli. The increased release of neurotransmitters and the sensitization of dorsal horn neurons is dependent on activation of *N*-methyl-D-aspartate (NMDA), non-NMDA excitatory amino acid, and neurokinin 1 receptors. Behavioral changes typical of inflammatory pain are observed in arthritic rats. These behavioral changes can be modified by a variety of drugs, including opioids, excitatory amino acid receptor antagonists, or neurokinin receptor antagonists. In addition to processing nociceptive information following joint or muscle injury, the spinal cord controls peripheral joint inflammation. Production of dorsal root reflexes, antidromic action potentials, would be expected to result in the release of inflammatory neuropeptides (substance P and calcitonin gene-related peptide ICGRPII) from the terminals of primary afferents at the site of injury. The release of substance P and CGRP would potentiate the inflammatory response in the periphery.

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

Friedman MH, Nelson AJ. Head and neck pain review: traditional and new perspectives. *J Orthop Sports Phys Ther.* 1996;24:268–69.

A variety of conditions are frequently associated with the occurrence of head and neck pain. The purposes of this review are to describe the characteristics of several musculoskeletal, neurologic, and systemic conditions frequently cited as possible causes of head and neck pain and to suggest a new technique for treating head and neck pain. The characteristics of musculoskeletal conditions, such as muscle spasm, tendinitis, trigger points, and joint inflammation, and their relationship to head and neck pain are considered. The features and clinical implications of neurologic conditions, such as atypical facial pain, trigeminal and glossopharyngeal neuralgia, reflex sympathetic dystrophy, and neurogenic inflammation, are also described. The distinguishing characteristics of headaches, including cluster, tension, chronic daily, rebound, posttraumatic, and postlumbar puncture, are detailed. This review also addresses the contributions of systemic disorders, such as osteoarthritis, rheumatoid arthritis and the variants, and rheumatoid-related conditions, like dermatomyositis, temporal arteritis, Lyme's disease, and fibromyalgia, to head and neck pain. The results of a recent pilot study of the effectiveness of intraoral circulating ice water for resolving symptoms related to head and neck pain secondary to neurogenic inflammation are presented in this work. Ice water circulating through hollow metal tubes was placed intraorally for 15 minutes in the posterior maxillary area on 12 individuals with cervical pain and muscle spasm. In nine of these individuals, reduced cervical pain perception, upper trapezius electromyography signal reduction, and increased cervical range of motion was produced. Six of 72 individuals had accompanying headache, which was reduced or eliminated in four cases. These findings suggest a strong trigeminocervical relationship to neck pain and headache.

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

Book Reviews

Laboratory Activities for Therapeutic Modalities
Chad Starkey and Sara D. Brown
F. A. Davis Company, Philadelphia, PA
1995
150 pages
ISBN: 0-8036-0049-6
Price: $17.95

This text, as the title might suggest, is a lab manual intended as a companion to a therapeutic modalities text. While it would seem most obvious to pair it with *Therapeutic Modalities for Athletic Trainers* by Starkey (FA Davis, 1993), one might find *Lab Activities* a worthwhile supplement to other texts as well. As Starkey and Brown state in the introduction, modalities courses run the peril of creating "technicians rather than clinicians." Therefore, the purpose of this text is to guide the student's exploration of why athletic trainers apply therapeutic modalities and what the effects are of those treatments.

The book is divided into 17 separate class activities. While this closely parallels the school calendar, many of these activities may be combined into a single class session, and so trying to schedule one activity per week is not necessary. Each of the class activities is very clearly defined in terms of the objective, materials needed, and the procedures. In addition, a short discussion section, questions, and charts are provided. In many instances, photographs and drawings are effectively used to help clarify procedural points that may be confusing.

The actual content of the class activities is broken up into several large chunks. Six activities are concerned with heat and cold, seven with electrical stimulation, three with ultrasound, two with biofeedback, and one with traction. Unfortunately, no activities are provided for massage, spray and stretch, whirlpools, or compression units. One other criticism may be added. Many of the electrical generators available today are capable of providing a staggering range of currents. The class activities investigate the manipulation of pulse duration and current density, but activities that compare and contrast wave form, current polarity, pulse rate, ramping, on/off times, and current interference are not provided.

Three class exercises are also provided that should help students clarify points of confusion from lectures that may need to be addressed before the lab session. In addition, a nine-part appendix, references, credits, and additional charts for students are included in the back of the text.

This text is fairly unique in its content; the reviewer is not aware of other modalities texts that are dedicated to lab activities. At the publisher's suggested price of $17.95, it is a relatively cheap supplement to a modalities text. While educators may find it necessary to use additional supplemental materials to address some of the shortcomings of the manual, *Laboratory Activities for Therapeutic Modalities* would be a worthwhile purchase for the undergraduate athletic training student.

Jeff Rudy, MS, ATC
Kansas State University
Manhattan, KS

Physical Therapy Procedures
Ann H. Downer, MS, PT
Charles C. Thomas, Springfield, IL
1996
5th Edition
396 pages
ISBN: 0-398-06556-X
Price: $47.95

The fifth edition of the text, *Physical Therapy Procedures*, presents step-by-step techniques developed by the author for the appropriate management of specific treatment modalities. This edition of the text is presented in outline form and is written primarily as a clinical manual for physical therapy assistants and for students in physical therapy, athletic training, and other sports medicine education programs. The text is basically a "how to" text that also includes basic information on the physics, indications, and contraindications of treatment modalities. The text presents general information that every therapist should follow when treating patients and presents detailed step-by-step techniques for the 39 treatment modalities discussed. The text also includes two appendices that provide the names, addresses, and telephone numbers of 85 equipment manufacturers selected by the author.

The format of the text presents specific step-by-step procedures for managing various treatment modalities and enables the student to quickly locate the section of the text that discusses a specific treatment modality. This format differentiates this text from others. Each treatment modality is presented as a separate chapter; the content includes information on 1) preparation for treatment, 2) starting of treatment, and 3) termination of treatment.

The text is most suitable as a clinical manual for undergraduate students entering the clinical phase of their education, but only as a supplement to a more comprehensive textbook on treatment modalities. As a supplement, the cost is somewhat high. However, if used as a primary text, the cost is within reason. Practitioners should also find the text to be of use as a reference manual.

William B. Biddington, EdD, ATC
California University of Pennsylvania
California, PA

Essentials of Strength Training and Conditioning
Editor: Thomas Baechle
Human Kinetics, Champaign, IL
1994
544 pages
ISBN: 0-87322-694-1
Price: $45.00

According to the editor, *Essentials of Strength Training and Conditioning* is designed for the student and professional as a comprehensive guide to the principles, concepts, and theories for exercise methodology and training. The major focus of the text includes the structure and function of the anatomic systems, adaptation from training, exercise methodology, exercise program design, methods of evaluation, and facility management.

This is a well-represented and organized text on a broad topic. The organization of the text consists of five individual sections. The first section contains 14 chapters detailing the physiology of exercise training. This section covers physiologic topics such as neuromuscular adaptation and training. Even though many of the topics discussed in this chapter are found in other texts, the authors do an excellent job connecting each chapter to the relationship between exercise training and adaptation. The second section details techniques of exercise evaluation and testing. Each chapter in this section provides statistical examples and testing protocols for each provided analysis. The third section describes exercise techniques ranging from the warm-up to specific methods of speed, strength, and endurance training. The fourth section brings together the principles of strength training and details a plan for the implementation of a specific exercise program to meet achievable goals. The training methodology section is well designed and addresses such topics as exercise selection, load, volume, and training frequency. The fifth section is designed to provide the reader with the organization and administration of a facility to meet the needs of the exercise or sports medicine specialist.

This text was edited by a certified strength and conditioning specialist, and the tests at the end of each chapter serve as a study guide for future certified strength and conditioning specialists. The format of this book makes comprehension of the material easy, providing a handy reference that could be useful in any rehabilitative setting.

For a general reference, this text is a comprehensive and easy to use guide for any strength and conditioning or sports rehabilitative specialist. The authors do an excellent job integrating theory and practical application in the development and implementation of strength and conditioning training. In summary, while quite expansive at 544 pages, the text is relatively inexpensive at $45.00. I would recommend this text for the professional library of athletic trainers and other health care professionals.

Jack Ransone, PhD, ATC
San Jose State University
San Jose, CA

Water Exercise
Martha White
Human Kinetics, Champaign, IL
1995
171 pages
ISBN: 0-87322-726-3
Price: $14.95

The purpose of this text is to provide the reader with an introduction to water exercises. The author begins by giving a brief explanation of the benefits of water exercise on the body. General components of rehabilitation such as muscle reeducation and strengthening are mentioned. The text is well organized with chapter subjects covering the benefits of water exercise, getting prepared, and beginning, intermediate, advanced, and deep water exercise. This text also includes chapters divided by joint on water programs for selected injuries. There is also a chapter on programs for selected fitness, which includes a small section on special populations.

I was most impressed with the chapters on water exercises. Each exercise has a good account of position, description, notes, and precautions. The position and description discuss the proper mechanics in the water and give a very good explanation of how to do the exercise, areas where stress on the body part is increased due to a particular exercise, and how to modify this stress. There are illustrations with each exercise. Approximately 78 water exercises are discussed, ranging from beginning to advanced. The exercises not only are traditional movement exercises but also include tubing and isotonic exercises performed in the water.

This book is an excellent guide for athletic trainers, physical therapists, exercise specialists, or anyone who works with aquatic therapy. I would recommend this text as a supplement for any undergraduate or graduate course dealing with rehabilitation and conditioning.

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

Manual of Athletic Taping
Sports Medicine Council of British Columbia
F. A. Davis Company, Philadelphia, PA
1995
3rd Edition
106 pages
ISBN: 0-8036-0115-8
Price: $21.95

The purpose of the *Manual of Athletic Taping* is to provide information on techniques for taping and wrapping of athletic injuries, as well as entry-level information about athletic injury recognition and care. The manual was originally designed as a reference for the British Columbia Sports Aid Program.

The *Manual of Athletic Taping* is divided into eight chapters and a section of references and resources. Chapter 1 provides objectives of taping and wrapping and general information about muscle structure and function and joint anatomy.

Chapter 2 covers injury recognition and management. Topics include HOPS (history, observation, palpation, strength, and special tests), mechanism of injury, emergency care basics, and basic principles of soft tissue healing and repair.

Chapter 3, "General Taping Considerations," covers information about taping theory. Topics include when to tape, first aid kit supplies, principles of taping and wrapping, and general information on techniques for applying tape.

Chapters 4 through 8 each cover one of the following areas of the body: the ankle and foot, the knee, the wrist and hand, the elbow, and muscles and tendons. Each chapter follows the same basic format of anatomy of the body part, common injuries that occur to the body part, and techniques for taping and wrapping the body part. Chapter 9 serves as a reference section, including a glossary, list of athletic training and sports medicine-related organizations, reference list, information on NATA-BOC certification, and diagrams.

This manual does a very good job of tying information about common athletic injuries that occur to a body region to the taping and wrapping techniques used in the region. The authors have attempted to provide concise, step-by-step instructions, diagrams, and points to consider for the user of the manual. The emphasis on the points to consider, or "tips," is unique to this manual and helpful to the student learning to tape.

The information on injury mechanism, assessment, disposition, and care of athletic injuries is very basic. It appears this manual would be directed toward populations such as youth coaches or others who require a basic understanding of athletic injuries and taping techniques.

The only area of weakness is the use of line drawings instead of photographs to illustrate the taping and wrapping techniques covered in the manual. Although the diagrams are clear, the student in athletic training would be served by the addition of photographs to demonstrate the proper application of taping and wrapping techniques.

I would recommend this book as a shelf reference to assist in the teaching of taping and wrapping techniques. The clarity of explanations and helpful points allow it to be a useful adjunct to instruction. I would recommend this book highly for situations where youth sports coaches, program supervisors, or other coaching personnel are required to learn the basics of athletic injury care and taping.

David A. Middlemas, MA, ATC
William Paterson College
Wayne, NJ

Psychological Bases of Sport Injuries
Editor: David Pargman
Fitness Information Technology, Inc., Morgantown, WV
1993
302 pages
ISBN: 0-9627926-3-2
Price: $38.00

This text is a synthesis of the growing body of information related to psychosocial variables and athletic injury. The chapter authors include many of the leading experts on the topic. The text as a whole is an excellent theoretical overview. There is, however, considerable redundancy between many of the chapters, which is difficult to avoid when multiple authors are involved. Another concern is the limited number of application/practical materials. There are occasional case studies but not enough to allow readers many metacognitive opportunities to think and apply what they are reading. The focus is more on declarative material emphasizing the rehabilitation domain. An expanded discussion of the role of psychosocial variables in predicting and preventing athletic injury would have enhanced the completeness of the text.

Despite these concerns most chapters provide valuable insights. Chapter 8, "The Dimensions of Social Support When Dealing With Sport Injuries," presents an excellent discussion of social support, including types of support that involve listening support, emotional support, task appreciation, and personal assistance. A framework for social support-based interventions when dealing with the injured athlete is presented, emphasizing the multiple opportunities the athletic trainer has to provide and enhance social support for the injured and noninjured athlete.

Chapter 9, "Counseling Strategies For Enhanced Recovery of Injured Athletes Within A Team Approach," develops a detailed discussion of the roles of athletes and athletic health care team members in supporting the athletes' need for different levels of help and counseling. The roles of the coach, peer athletes, athletic trainer, and other athletic health care professionals, working as a team, are delineated. Emphasis is placed on the importance of referral to a counselor or psychologist, when indicated, and how to approach this with the athlete. This chapter is supported by a series of excellent case studies that effectively reinforce the chapter content.

Section 4, "Counseling Athletes With Permanent Disabilities," includes a series of three chapters discussing helping and counseling strategies for athletes with disabilities. This is a well-timed section, with the dramatic increase in athletes with disabilities participating in all forms of sport and physical activity at all age levels.

I recommend this text as a supplemental resource for both undergraduate and graduate athletic training courses that include discussion of the psychosocial aspects of athletic injury. Course instructors would be able to support their instruction and learning experiences by introducing selected readings from the text. The text would be of significant value to students and faculty completing research in this area. The thorough theoretical overviews of most topics are very good, and the reference lists with each chapter provide excellent direction for further reading and literature reviews.

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

The Ultimate Sports Nutrition Handbook
Ellen Coleman and Suzanne Nelson Steen
Bull Publishing Co., Menlo Park, CA
1996
224 pages
ISBN: 0-923521-34-8
Price: $14.95

This book, as written, is versatile enough to be used as a supplemental textbook for those educating athletic training students, as a resource for athletic trainers practicing in the field, or for the weekend athlete concerned about nutrition. It is written in a clear, concise, and easy-to-read style. The text begins with an overview of the nutrients in chapter one. The nutrients are revisited in detail in Chapters 5, 6, 7, 8, and 9. The later chapters explain many issues confronted by practicing athletic trainers, such as body composition, weight control, the use of supplements, and eating disorders. The authors cover the whole spectrum of the nutritional needs of athletes with chapters dedicated to the active woman, child athletes, and older athletes. Of particular interest is the last chapter, which gives athletic trainers excellent ideas for feeding the team while on the road.

The authors of this text, Ellen Coleman and Suzanne Nelson Steen, are well known in the sports nutrition discipline. Their collaboration has produced a topnotch text that should become a part of every active athletic trainer's professional library.

Bruce D. Barnhart, EdD, ATC
California University of Pennsylvania
California, PA

Psychology of Sport Injury
John Heil, DA
Human Kinetics, Champaign, IL
1993
352 pages

ISBN: 0-87322-463-9
Price: $45.00

As the author states in the introduction, this text is written equally for the sport psychologist, the clinical psychologist, the physician, and the sports medicine specialist (the author's term for athletic trainers and physical therapists, collectively). As such, it attempts to educate all these diverse groups to the fact that athletics and athletic injuries are intertwined with psychological factors that must be dealt with for optimal healing of the mind and body to occur. The common theme throughout the text is that a team approach is necessary to deal with injuries. The text is organized into six sections that encompass the breadth of material and diversity of the readers.

Part I consists of three chapters authored by a former athlete, a team physician, and a sport psychologist, each presenting a perspective on athletic injury. The chapters by the athlete and the physician offer many valuable insights for athletic trainers. Part II consists of two chapters dealing with behavioral risk factors for sport injury. Part III comprises three chapters on the diagnostic assessment of athletes needing psychological treatment. The majority of this section is directed to the psychologist. However, the "Sports Medicine Injury Checklist" of items that may signal the need for referral is something all athletic trainers should be knowledgeable about. Part IV consists of four chapters on the psychological management of sport injury. This section is directed primarily to the psychologist, but it also educates the physician and athletic trainer on the techniques and methods that would be used by the psychologist. It is also presented for the physician and athletic trainer to employ under the guidance of a psychologist. This section also reemphasizes the team approach to treatment. Part V contains the two chapters of most use to athletic trainers. Topics included here are managing pain, alcohol and drug problems, and eating disorders; building rapport and communicating effectively; the referral process; coordination of care (especially as it relates to coaches and parents); confidentiality issues; and when (and how) to return the athlete to play. Part VI finishes with chapters on the biology of pain and pharmacologic management of pain. These chapters are meant to educate the psychologist, but they provide a nice review for athletic trainers.

Psychology of Sport Injury would be better utilized as a supplemental text in courses that incorporate the psychological factors of injury and rehabilitation. The material would be best applied to upper-level students with experience in injury and rehabilitation. There is material in this text, specifically the material in part V and the "Sports Medicine Injury Checklist," that is very important to any athletic trainer, but I feel the overall content would not be clinically relevant to most athletic trainers. Considering the ratio of relevant information to irrelevant information for most athletic trainers the cost of this text is slightly high, but a student or ATC with an interest in sport psychology would find this text as money well spent.

The text is somewhat difficult to read, particularly the sections directed toward psychologists. However, the author has prefaced each section with an overview that allows the reader to find pertinent topics and subjects easily, eliminating the need to read the entire text.

This text differs from most other resources on sport psychology in that its primary emphasis is directed to the management of sport injury, not methods and techniques to improve performance, etc. There is much valuable information in this text that I have found available only through talking with psychologists working with athletes. I would recommend to the author that future editions be developed as separate texts for psychologists and physicians and athletic trainers. The texts could contain the same content areas, with the material differently emphasized for each of the two groups.

Daniel Sedory, ATC
University of New Hampshire
Durham, NH

Video Review

Sports Taping Basics
David Perrin and Melinda Flegel
Human Kinetics
Champaign, IL
1996
66 minutes (two videotapes, lower and upper body)
ISBN: 0–88011-606-4
$59.00

The use and application of tape and elastic wraps has evolved into an art and a science in athletic training. These skills are essential to athletic trainers, coaches, and student athletic trainers. These videotapes provide a step-by-step approach to the basic fundamentals of taping and wrapping. David Perrin and Melinda Flegel cover 17 basic patterns throughout the lower and upper extremities.

The videos are presented by body segment with information regarding the types of injuries that occur at each of these areas, with a simple review of some mechanisms of injury. Each specific pattern is demonstrated, with a clear, concise explanation of the pattern to be used, the preparation of the area to be taped, and methods for removing the tape. At the conclusion of each demonstration, key elements of the procedure are reviewed and highlighted.

The patterns that have been chosen for these videotapes are basic, with little variation. This provides the viewer with the opportunity to comprehend fundamental patterns. The demonstrations are complemented by the athletic trainer's use of a combination of nonelastic tape, elastic tape, and compression wraps to complete a procedure.

These videotapes would be suitable in a basic athletic training course directed toward students preparing for entry into an athletic training program, students preparing for coaching, and for coaches wanting to learn more about basic taping and wrapping procedures. These videotapes would best be used as a secondary or supplemental source for students and coaches. Reference is made to David Perrin's book *Athletic Taping and Bracing* for additional information on the use and application of tape and wraps.

Future editions of these videotapes might include additional information to help students better understand and appreciate the use of tape and wraps. It might serve the user of these videotapes to understand the anatomical structure and function of each joint and to have a greater understanding of the common mechanisms by which injury occurs. And lastly, information could be provided for the student or coach to better understand the purposes for which tape is applied: restricting movement, limiting movement, or support.

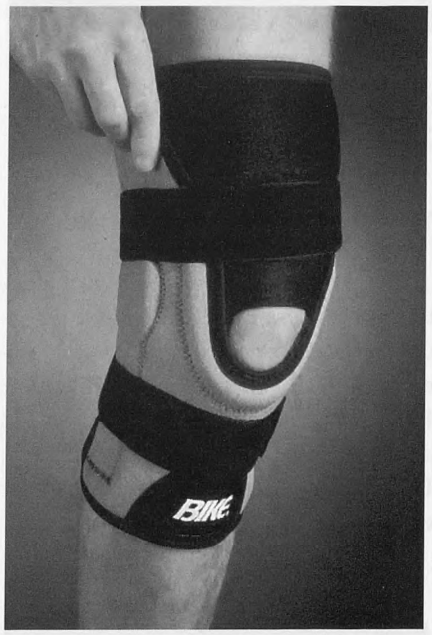
Overall, I found these videotapes to be beneficial to students, coaches, and any individual who wants to learn the basic fundamentals of taping and wrapping.

John Cottone, EdD, ATC
State University of New York at Cortland
Cortland, NY

New Products

The All-Sport Hinged Knee Brace From BIKE

BIKE Athletic Company has added a new line of heavy-duty braces to its product line. The All-Sport Hinged Knee Brace offers custom, injury-specific features to stabilize movement and optimize protection during therapeutic exercise or athletic activity. The All-Sport features stainless steel medial and lateral hinges to provide superior stability and a reinforced patella buttress to minimize movement. The brace is designed with nylon-covered, 1/8-inch neoprene, to provide heat retention, compression, and support, and a plush terry lining for comfort and moisture absorption.



For more information, call (800) 251-9230.

OMNI Align Custom Composite Knee Orthosis

OMNI Scientific, Inc. introduces the OMNI Align Custom Composite pre-stressed corrective knee orthosis. The brace is designed and engineered to correct the alignment of an affected knee compartment and to reduce symptomatic pain and compartment instability associated with a variety of conditions, including mild to severe osteoarthritis. The Align Composite can be used for patients radiographically diagnosed with valgus and varus malalignment by correcting the alignment toward the mechanical neutral position and providing load transfer of stress at the joint. The Align Custom Composite is a high-strength, lightweight, custom-fabricated carbon composite employing an advanced cast mold technique to produce a precise correction and fit. The orthosis incorporates OMNI's X-Cell thigh restraint system, which accommodates soft tissue changes, eliminating brace pistoning and migration for high-level patient compliance.

For more information, call (800) 448-6664

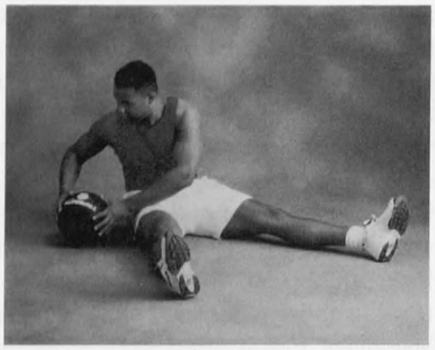
Monarch Knee Brace from Smith & Nephew DonJoy Inc.

Smith and Nephew DonJoy, Inc. has introduced its latest solution for treating osteoarthritis pain, the Patient-Ready Monarch Knee Brace. The Patient-Ready Monarch functions by applying force to the side of the knee to relieve the pain of bone-to-bone friction in patients with osteoarthritis. It is the first fully adjustable, varus-valgus brace available in an "off-the-shelf" model and is designed to address industry demands for immediate, in-the-field sizing, cost containment, and conservative treatment protocols. The Patient-Ready Monarch provides a custom-like fit through the use of an adjustable hinge. Flexible thigh and calf cuffs pivot within a rigid aluminum brace frame for greater conformity to the leg. A pneumatic pad allows patients to fine tune the pain-relieving force.

For more information, call (800) 336-5690

Don Chu's Plyoballs™ from OPTP

OPTP Conservative Care Specialist introduces Don Chu's Plyoballs.™ Olympians, professionals, and elite amateur athletes alike have discovered the speed and power gains from plyometric exercise. Chu's patented Plyoballs feel soft to the catch, yet are easy to grip. Plyoballs are the only weighted balls to offer zero internal oscillation, meaning the catcher does not have to overcome inertia or weight changes. Plyoballs will not bounce or roll away. Available in 2, 3, 6, 8, 10, 12 and 15 pounds.



For more information, call (800) 367-7393

Exercises Xpress™ 2.0 Software from The Saunders Group

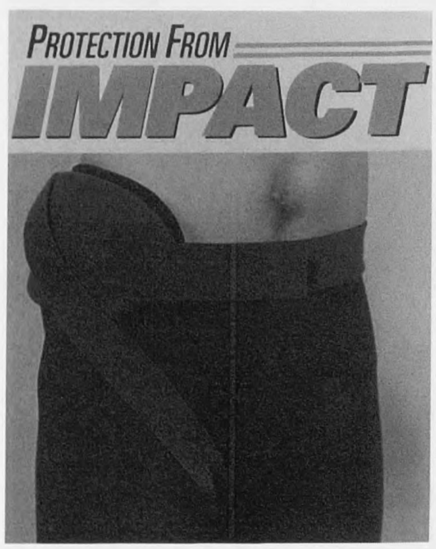
The Exercises Xpress™ 2.0, upgraded version of Exercises Xpress,™ provides access to the largest international library of full body strengthening and flexibility exercises available on the market today. Exercises Xpress™ 2.0 is a Windows-based software program containing 900 exercises (popularized from the previous version) with the addition of 50 new or improved exercises. Highlights include facial and jaw stretching and strengthening, neural tension stretching for upper and lower extremities, closed chain exercises for knee rehabilitation, and additional scapular stabilization exercises. Additional exercise collections such as hydrotherapy, pediatrics, and weight training are available, and future collections are planned.

Exercises Xpress™ 2.0 allows users to customize and store their own protocols and client-specific programs in addition to supplied instructions. Sorting capabilities enable users to precisely pinpoint exercises required for a patient protocol more easily than ever before. Users can print up to five exercises per page in any sequence desired. Printouts can be further customized by scanning the facility logo or up to 50 of the user's own exercises. A Quick Start Tutorial allows even a novice computer user to begin using Exercises Xpress™ 2.0 in less than 10 minutes.

For more information, call (800) 456-1289

Protection for Hip Pointers

Arthron, Inc. of Brentwood, TN introduces universal, off-the-shelf protection for hip pointers with the IMPACT™ Hip Pad. This patented pad eliminates athletic trainers from having to use their valuable time making their own pads while still providing the proven protection that an athlete needs to play without worry or fear of further injury. Enclosed in a cushioned envelope is a high-density shell with a centrally located bubble, called the ShockRing, which intercepts potentially damaging blows and disperses those forces away from the injured area. No part of the pad rests on the injured portion of the hip. The material properties of the shell allow it to be custom fitted for almost any athlete. Two different thicknesses of interchangeable foam pads are provided, one for recent injuries and another for when the tenderness subsides. The neoprene strapping system eliminates not only any shifting of the pad but also the need for expensive taping that other handmade devices might require. It's so simple to apply that any player, once instructed, can easily put on the pad without assistance.



For more information, call (615) 377-6595.

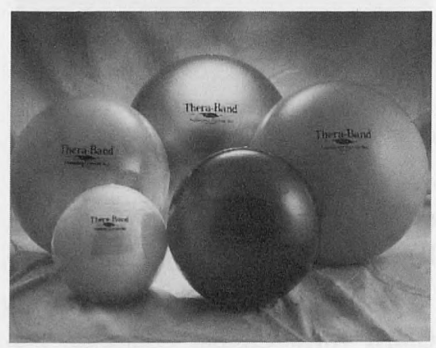
Combat Mouse Use Problems

The new Mouse Stage from AliMed® combats muscle strain by bringing the mouse closer to the user. The uniquely designed, elevated mouse pad slides conveniently over the numeric portion of the keyboard, reducing required reach by eight or more inches. Mouse Stage is available with AliMed's exclusive Soft Wrist Rest, which helps maintain the wrist in a straight, neutral position. This additional support relieves damaging pressure on the carpal tunnel of the wrist, reducing risk of carpal tunnel syndrome.

For more information, call (800) 225-2610.

Theraband™ Exercise Balls

The Hygenic Corporation, manufacturers of Thera-Band® Resistive Exerciser, has introduced Thera-Band™ Exercise Balls. Thera-Band™ Exercise Balls are available in five color-coded sizes ranging from 45 cm up to 85 cm. Each ball bears the size of the ball for easy identification.



For more information, call (800) 321-2135.

Regulated Cold Therapy Treatment

Smith & Nephew DonJoy Inc. has introduced a new approach to cold therapy with its ICEMAN™ cold therapy unit. By regulating and measuring temperature at the inlet, before the cold water reaches the patient, the ICEMAN is designed to reduce the possibility of temperature-related problems. Other cold therapy units regulate and measure the temperature of the water after it has been warmed by the patient's skin, allowing the patient to be exposed to water temperature that may be near freezing and potentially injurious. The portable ICEMAN unit is ideal for helping reduce the need for pain medication following surgery, for temporarily reducing localized swelling, and for facilitating faster rehabilitation. It offers 6 to 8 hours of therapy time, thus reducing the labor needed to apply cold therapy. Because it is designed to accommodate a variety of pads, the most appropriate pad for the patient's injured area can be applied to optimize the treatment.

For more information call (800) 551-6911, Ext. 4ICE.

Current Literature

Clint Thompson, MS, ATC

ANKLE

Regis D, Montanari M, Magnan B, Spagnol S, Bragantini A.Dynamic orthopaedic brace in the treatment of ankle sprains. *Foot Ankle Int.* 1995; 16:422–426.

Beard DJ, Dodd CA, Trundle HR, Simpson AH. Proprioception enhancement for anterior cruciate ligament efficiency: a prospective randomised trial of two physiotherapy regimens. *J Bone Joint Surg Br.* 1994;76:654–659.

van Dijk CN, Bossuyt PM, Marti RK. Medial ankle pain after lateral ligament rupture. *J Bone Joint Surg Br.* 1996;78:562–567.

Anderson SJ. Evaluation and treatment of ankle sprains. *Compr Ther.* 1996;22:30–38. Review article: 52 Refs.

Miller CD, Shelton WR, Barrett GR, Savoie FH, Dukes AD. Deltoid and syndesmosis ligament injury of the ankle without culture. *Am J Sports Med* 1995;23:746–750.

Scola AJ, Peters BD, Edell SL. MRI of the foot and ankle: an overview for the referring physician. *Del Med J.* 1995;67:570–579.

Kuwada GT. Current concepts in the diagnosis and treatment of ankle sprains. *Clin Podiatr Med Surg.* 1995;12:653–665. Review article: 39 Refs.

Tatro-Adams D, McGann SF, Carbone W. Reliability of the figure-of-eight method of ankle measurement. *J Orthop Sports Phys Ther.* 1995; 22:161–163.

Ballesteros R, Chacon M, Cimarra A, Ramos L, Gomez-Barrena E. Traumatic dislocation of the tibialis posterior tendon: a new surgical procedure to obtain a strong reconstruction. *J Trauma.* 1995;39:1198–1200.

Chandnani VP, Bradley YC. Achilles tendon and miscellaneous tendon lesions. *Magn Reson Imaging Clin N Am.* 1994;2:89–96. Review article: 21 Refs.

Mesgarzadeh M, Schneck CD, Tehranzadeh J, Chandnani VP, Bonakdarpour A. Magnetic resonance imaging of ankle ligaments: emphasis on anatomy and injuries to lateral collateral ligaments. *Magn Reson Imaging Clin N Am.* 1994; 2:39–58. Review article: 48 Refs.

Ho CP. Magnetic resonance imaging of the ankle and foot. *Semin Roentgenol.* 1995;30:294–303.

McCaskie AW, Gale DW, Finlay D, Allen MJ. Chronic ankle instability: the value of talar tilt under general anaesthesia. *Br J Sports Med.* 1995;29:103–104.

McPoil TG, Hunt GC. Evaluation and management of foot and ankle disorders: present problems and future directions. *J Orthop Sports Phys Ther.* 1995;21:381–388. Review article: 16 Refs.

Rodgers JA, Fitzgibbons TC, Crosby LA. Intraarticular fracture of the calcaneus. *Nebr Med J.* 1995;80:140–145.

Marder RA. Current methods for the evaluation of ankle ligament injuries. *Instr Course Lect.* 1995;44:349–57. Review article: 58 Refs.

Roberts CS, DeMaio M, Larkin JJ, Paine R. Eversion ankle sprains. *Orthopedics.* 1995;18: 299–304. Review article: 31 Refs.

Trevino SG, Kodros S. Controversies in tarsometatarsal injuries. *Orthop Clin North Am.* 1995; 26:229–238.

Kilkelly FX, McHale KA. Acute rupture of the peroneal longus tendon in a runner: a case report and review of the literature. *Foot Ankle Int.* 1994;15:567–569. Review article: 10 Refs.

Marcus RE, Pfister ME. The enigmatic diagnosis of posterior tibialis tendon rupture. *Iowa Orthop J.* 1993;13:171–177.

CREATINE

Kearney JT. Training the Olympic athlete. *Sci Am.* 1996;274:52–57,60–63.

Takahashi H, Inaki M, Fujimoto K, Katsuta S, Anno I, Niitsu M, Itai Y. Control of the rate of phosphocreatine resynthesis after exercise trained and untrained human quadriceps muscles. *Eur J Appl Physiol.* 1995;71:396–404.

HAND

Crosby CA, Wehbe MA. Early motion protocols in hand and wrist rehabilitation. *Hand Clin.* 1996;12:31–41.

Crimmins CA, Jones NF. Stenosing tenosynovitis of the extensor carpi ulnaris. *Ann Plast Surg.* 1995;35:105–107.

Bainbridge LC, Robertson C, Gillies D, Elliot D. A comparison of post-operative mobilization of flexor tendon pairs with passive flexion-active extension and controlled active motion techniques. *J Hand Surg [Br].* 1994;19:517–521.

Rasul AT Jr, Fischer DA. Primary repair of quadriceps tendon ruptures: results of treatment. *Clin Orthop.* 1993;289:205–207.

HEAD

Ferrera PC, Reicho PR. Acute confusional migraine and trauma-triggered migraine. *Am J Emerg Med.* 1996;14:276–278.

Fitzgerald DC. Head trauma: hearing loss and dizziness. *J Trauma.* 1996;40:488–496. Review article: 83 Refs.

Masdeu JC, Van Heertum RL, Kleiman A, Anselmi G, Kissane K, Horng J, Yudd A, Luck D, Grundman M. Early single-photon emission computed tomography in mild head trauma. A controlled study. *J Neuroimaging.* 1994;4:177–181.

Maretsis M, Adam D. Transient brachial diplegia (crossed paralysis): etiopathogeny and differential diagnosis. *Rom J Neurol Psychiatry.* 1993; 31:269–272.

Brady W, Kefer M. Hypoglycemia masquerading as head trauma [letter]. *Am J Emerg Med.* 1994;12:383–384.

Chandrasekaran S, Zainal J. Delayed traumatic extradural haematomas. *Aust N Z J Surg.* 1993; 63:780–783.

IONTOPHORESIS

Singh J, Bhatia KS. Topical iontophoretic drug delivery: pathways, principles, factors, and skin irritation. *Med Res Rev.* 1996;16:285–296. Review article: 88 Refs.

Vanbever R, LeBoulenge E, Preat V. Transdermal delivery of fentanyl by electroporation. I. Influence of electrical factors. *Pharm Res.* 1996; 13:559–565.

van der Geest R, Hueber F, Szoka FC Jr, Guy RH. Iontophoresis of bases, nucleosides, and nucleotides. *Pharm Res.* 1996;13:553–558.

Huang YY, Wu SM, Wang CY. Response surface method: a novel strategy to optimize iontophoretic transdermal delivery of thyrotropin-releasing hormone. *Pharm Res.* 1996;13:547–552.

Humphries SA, Johnson MH, Long NR. An investigation of the gate control theory of pain using the experimental pain stimulus of potassium iontophoresis. *Percept Psychophys.* 1996; 58:693–703.

Yoshida NH, Roberts MS. Prediction of cathodal iontophoretic transport of various anions cross-excised skin from different vehicles using conductivity measurements. *J Pharm Pharmacol.* 1995;47:883–890.

Kassan DG, Lynch AM, Stiller MJ. Physical enhancement of dermatologic drug delivery: iontophoresis and phonophoresis. *J Am Acad Dermatol.* 1996;34:657–666. Review article: 74 Refs.

Kalia YN, Guy RH. The electrical characteristics of human skin in vivo. *Pharm Res.* 1995;12: 1605–1613.

Singh P, Anliker M, Smith GA, Zavortink D, Maibach HI. Transdermal iontophoresis and solute penetration across excised human skin. *J Pharm Sci.* 1995;84:1342–1346.

Grossmann M, Jamieson MJ, Kellogg dL Jr, Kosiba WA, Pergola PE, Crandall CG, Shepherd AM. The effect of iontophoresis on the cutaneous vasculature: evidence for current-induced hyperemia. *Microvasc Res.* 1995;50:444–452.

Gangarosa LP Sr, Ozawa A, Ohkido M, Shimomura Y, Hill JM. Iontophoresis for enhancing penetration of dermatologic and antiviral drugs. *J Dermatol.* 1995;22:865–875. Review article: 39 Refs.

Thysman S, Van Neste D, Preat V. Noninvasive investigation of human skin after in vivo iontophoresis. *Skin Pharmacol.* 1995;8:229–23.6

McFadden EA. Iontophoresis for pain management. *J Pediatr Nurs.* 1995;10:331.

Kamath SS, Gangarosa LP Sr. Electrophoretic evaluation of the mobility of drugs suitable for iontophoresis. *Methods Find Exp Clin Pharmacol.* 1995;17:227–232.

Singh P, Anliker M, Maibach HI. Facilitated drug delivery during transdermal iontophoresis. *Curr Probl Dermatol.* 1995;22:184–188.

Singh J, Singh S. Transdermal iontophoresis: effect of penetration enhancer and iontophoresis on drug transport and surface characteristics of human epidermis. *Curr Probl Dermatol.* 1995; 22:179–183.

KNEE

Roos H, Adalberth T, Dahlberg L, Lohmander LS. Osteoarthritis of the knee after injury to the anterior cruciate ligament or meniscus: the influence of time and age. *Osteoarthritis Cartilage.* 1995;3:261–267.

Twaddle BC, Hunter JC, Chapman JR, Simonian PT, Escobedo EM. MRI in acute knee dislocation. A prospective study of clinical, MRI, and surgical findings. *J Bone Joint Surg Br.* 1996; 78:573–579.

Gagliardi S, Mughetti M, Gualtieri G, Gualtieri I. Diagnostic accuracy of CT scan in intra-articular lesions of the knee (arthroscopic confirmation of 100 cases). *Chir Organi Mov.* 1995; 80:301–307.

Noyes FR, Dunworth LA, Andriacchi TP, Andrews M, Hewett TE. Knee hyperextension gait abnormalities in unstable knees: recognition and preoperative gait retraining. *Am J Sports Med.* 1996;24:35–45.

Lee SH, Petersilge CA, Trudell DJ, Haghighi P, Resnick DL. Extrasynovial spaces of the cruciate ligaments: anatomy, MR imaging, and diagnostic implications. *Am J Roentgenol.* 1996;166: 1433–1437.

Grontvedt T, Engebretsen L, Rossvoll I, Smevik O, Nilsen G. Comparison between magnetic resonance imaging findings and knee stability: measurements after anterior cruciate ligament repair with and without augmentation. A five- to seven-year followup of fifty-two patients. *Am J Sports Med.* 1995;23:729–735.

Orava S, Kujala UM. Rupture of the ischial origin of the hamstring muscles. *Am J Sports Med.* 1995;23:702–705.

Ghalambor N, Vangsness CT Jr. Traumatic dislocation of the knee: a review of the literature. *Bull Hosp Jt Dis.* 1995;54:19–24. Review article: 39 Refs.

Williams S, Ireland J. Meniscal nodule. *Knee Surg Sports Traumatol Arthrosc.* 1993;1:216.

Petermann J, von Garrel T, Gotzen L. Non-operative treatment of acute medial collateral ligament lesions of the knee joint. *Knee Surg Sports Traumatol Arthrosc.* 1993;1:93–96.

Sonin AH. Magnetic resonance imaging of the extensor mechanism. *Magn Reson Imaging Clin N Am.* 1994;2:401–411. Review article: 30 Refs.

Fitzgerald SW. Magnetic resonance imaging of the meniscus: advanced concepts. *Magn Reson Imaging Clin N Am.* 1994;2:349–364. Review article: 49 Refs.

Firooznia H, Golimbu C, Rafii M. MR imaging of the menisci: fundamentals of anatomy and pathology. *Magn Reson Imaging Clin N Am.* 1994;2:325–347. Review article: 46 Refs.

Shino K, Horibe S, Nakata K, Maeda A, Hamada M, Nakamura N. Conservative treatment of isolated injuries to the posterior cruciate ligament in athletes. *J Bone Joint Surg Br.* 1995;77:895–900.

Sonin AH, Fitzgerald SW, Hoff FL, Friedman H, Bresler ME. MR imaging of the posterior cruciate ligament: normal, abnormal, and associated injury patterns. *Radiographics.* 1995;15:551–561.

Shelbourne KD, Martini DJ, McCarroll JR, VanMeter CD. Correlation of joint line tenderness and meniscal lesions in patients with acute anterior cruciate ligament tears. *Am J Sports Med.* 1995;23:166–169.

Hoher J, Munster A, Klein J, Eypasch E, Tiling T. Validation and application of a subjective knee questionnaire. *Knee Surg Sports Traumatol Arthrosc.* 1995;3:26–33.

Sonin AH, Fitzgerald SW, Bresler ME, Kirsch MD, Hoff FL, Friedman H. MR imaging appearance of the extensor mechanism of the knee: functional anatomy and injury patterns. *Radiographics.* 1995;15:367–382.

Staron RB, Haramati N, Feldman F, Kiernan HA, Pfaff HC, Rubin SJ, Zwass A. O'Donoghue's triad: magnetic resonance imaging evidence. *Skeletal Radiol.* 1994;23:633–636.

Klein W, Shah N, Gassen A. Arthroscopic management of postoperative arthrofibrosis of the knee joint: indication, technique, and results. *Arthroscopy.* 1994;10:591–597.

Haygood TM, Monu JU, Pope TL Jr. Magnetic resonance imaging of the knee. *Orthopedics.* 1994;17:1067–1072. Review article: 30 Refs.

Yao L, Dungan D, Seeger LL. MR imaging of tibial collateral ligament injury: comparison with clinical examination. *Skeletal Radiol.* 1994;23: 521–524.

Daniel DM, Stone ML, Dobson BE, Fithian DC, Rossman DJ, Kaufman KR. Fate of the ACL-injured patient: a prospective outcome study [see comments]. Comment in: *Am J Sports Med.* 1995;23:372–373. *Am J Sports Med.* 1994;22: 632–644.

Pope TL Jr. MRI of knee ligaments. *Semin Ultrasound CT MR.* 1994;15:366–382. Review article: 61 Refs.

NECK

Gargan MF. What is the evidence for an organic lesion in whiplash injury? *J Psychosom Res.* 1995;39:777–781. Review article: 27 Refs.

Diebener J, Sundaram M. Radiologic case study. Os odontoideum. *Orthopedics.* 1994;17:1083–1085.

Ducker TB. Os odontoideum. *J Spinal Disord.* 1993;6:364–365; discussion 365–369.

Ryan M, Klein S, Bongard F. Missed injuries associated with spinal cord trauma. *Am Surg.* 1993;59:371–374.

PAIN

Gurnani A, Sharma PK, Rautela RS, Bhattacharya A. Analgesia for acute musculoskeletal trauma: low-dose subcutaneous diffusion of ketamine. *Anaesth Intensive Care.* 1996;24:32–36.

Gomez JE, Neufeld MD, Cosby BK. Ability of middle-school soccer players to localize overuse leg pain correctly using a graphic self-report form. *Percept Mot Skills.* 1996;82:335–338.

Berlemann U, Bayley I. Tenodesis of the long head of biceps brachii in the painful shoulder: improving results in the long term. *J Shoulder Elbow Surg.* 1995;4:429–435.

Spicher C, Kohut G. Rapid relief of a painful, long-standing posttraumatic digital neuroma treated by transcutaneous vibratory stimulation (TVS). *J Hand Ther.* 1996;9:47–51.

Davis KD, Meyer RA, Turnquist JL, Filloon TG, Pappagallo M, Campbell JN. Cutaneous pretreatment with the capsaicin analog NE-2,1610 prevents the pain to a burn and subsequent hyperalgesia. *Pain.* 1995;62:373–378.

Gleeson AP, Stuart MJ, Wilson B, Phillips B. Ultrasound assessment and conservative management of inversion injuries of the ankle in children: plaster of Paris versus tubigrip. *J Bone Joint Surg Br.* 1996;78:484–487.

Kannus P, Leppala J, Lehto M, Sievanen H, Heinonen A, Jarvinen M. A rotator cuff rupture produces permanent osteoporosis in the affected extremity, but not in those with whom shoulder function has returned to normal. *J Bone Miner Res.* 1995;10:1263–1271.

Wintman BI, Gelberman RH, Katz JN. Dynamic scapholunate instability: results of operative treatment with dorsal capsulodesis. *J Hand Surg [Am].* 1995;20:971–979.

Patterson J, Fetzer D, Krall J, Wright E, Heller M. Eye patch treatment for the pain of corneal abrasion. *South Med J.* 1996;89:227–229.

Lester B, Halbrecht J, Levy IM, Gaudinez R. Press test for office diagnosis of triangular fibrocartilage complex tears of the wrist. *Ann Plast Surg.* 1995;35:41–45.

Baranowski AP, Priestley JV, McMahon S. Substance P in cutaneous primary sensory neurons–a comparison of models of nerve injury that allow varying degrees of generation. *Neuroscience.* 1993;55:1025–1036.

Curtis KA, Roach KE, Applegate EB, Amar T, Benbow CS, Genecco TD, Gualano J. Development of the Wheelchair User's Shoulder Pain Index (WUSPI). *Paraplegia.* 1995;33:290–293.

Hoher J, Munster A, Klein J, Eypasch E, Tiling T. Validation and application of a subjective knee questionnaire. *Knee Surg Sports Traumatol Arthrosc.* 1995;3:26–33.

Mitchell MJ, Bielecki D, Bergman AG, Kursunoglu-Brahme S, Sartoris DJ, Resnick D. Localization of specific joint causing hindfoot pain: value of injecting local anesthetics into individual joints during arthrography. *Am J Roentgenol.* 1995;164:1473–1476.

Maffet MW, Gartsman GM, Moseley B. Superior labrum-biceps tendon complex lesions of the shoulder. *Am J Sports Med.* 1995;23:93–98.

Benoliel R, Eliav E, Elishoov H, Sharav Y. Diagnosis and treatment of persistent pain after trauma to the head and neck. *J Oral Maxillofac Surg.* 1994;52:1138–1147; discussion 1147–1148.

Rao GP, Scott JA, King A, Blyth C, Ramesh A, Neoh C, Kaye SB. No eye pad for corneal abrasion [letter; comment]. Comment on: *Eye.* 1993;7 (Pt 3):468–471. *Eye.* 1994;8 (Pt 3):371–372.

Magnusson T. Extracervical symptoms after whiplash trauma. *Cephalalgia.* 1994;14:223–227; discussion 181-182.

Larsson SE, Alund M, Cai H, Oberg PA. Chronic pain after soft-tissue injury of the cervical spine: trapezius muscle blood flow and electromyography at static loads and fatigue. *Pain.* 1994;57:173–180.

Peterson L, Gillies R, Cook SC, Schick B, Little T. Developmental patterns of expected consequences for simulated bicycle injury events. *Health Psychol.* 1994;13:218–223.

Scott JL, Smith MS, Sanford SM, Shesser RF, Rosenthal RE, Smith JP, Feied CF, Ghezzi KT, Hunt DM. Effectiveness of transnasal butorphanol for the treatment of musculoskeletal pain. *Am J Emerg Med.* 1994;12:469–471.

Moffet H, Richards CL, Malouin F, Bravo G, Paradis G. Early and intensive physiotherapy accelerates recovery postarthroscopic meniscectomy: results of a randomized controlled study. *Arch Phys Med Rehabil.* 1994;75:415–426.

Authors' Guide

(Revised July 1996)

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

SUBMISSION POLICIES

1. Submit one original and three copies of the entire manuscript (including photographs, artwork, and tables) to: *Journal of Athletic Training* Submissions, Hughston Sports Medicine Foundation, Inc.; 6262 Veterans Parkway; Columbus, GA 31908.
2. All manuscripts must be accompanied by a letter signed by each author and must contain the following statements: "This manuscript 1) contains original unpublished material that has been submitted solely to the *Journal of Athletic Training*, 2) is not under simultaneous review by any other publication, and 3) will not be submitted elsewhere until a decision has been made concerning its suitability for publication by the *Journal of Athletic Training*. In consideration of the NATA's taking action in reviewing and editing my submission, I the undersigned author hereby transfer, assign, or otherwise convey all copyright ownership to the NATA, in the event that such work is published by the NATA. Further, I verify that I have contributed substantially to this manuscript as outlined in item #3 of the current Authors' Guide." By signing the letter, the authors agree to comply with all statements. Manuscripts that are not accompanied by such a letter will not be reviewed.
3. Each author must have contributed to the article. This means that all coauthors should have made some useful contribution to the study, should have had a hand in writing and revising it, and should be expected to be able to defend the study publicly against criticism.
4. Financial support or provision of supplies used in the study must be acknowledged. Grant or contract numbers should be included whenever possible. The complete name of the funding institution or agency should be given, along with the city and state in which it is located. If individual authors were the recipients of funds, their names should be listed parenthetically.
5. Authors must specify whether they have any commercial or proprietary interest in any device, equipment, instrument, or drug that is the subject of the article in question. Authors must also reveal if they have any financial interest (as a consultant, reviewer, or evaluator) in a drug or device described in the article.
6. Materials taken from other sources, including text, illustrations, or tables, must be accompanied by a written statement giving the *Journal of Athletic Training* permission to reproduce the material. Photographs of individuals must be accompanied by a signed photograph release form. Accepted manuscripts become the property of the National Athletic Trainers' Association, Inc.
7. The *Journal of Athletic Training* uses a double blind review process. Authors should not be identified in any way except on the title page.
8. Manuscripts are edited to improve the effectiveness of communication between the author and the readers, and to aid the author in presenting a work that is compatible with the style policies found in the *AMA Manual of Style*, 8th ed. (Williams & Wilkins) 1989. The author agrees to accept any minor corrections of the manuscript made by the editors. Page proofs are sent to the author for proofreading when the article is typeset for publication. It is important that they are returned within 48 hours. Important changes are permitted, but authors will be charged for excessive alterations.
9. Published manuscripts and accompanying work cannot be returned. Unused manuscripts will be returned if submitted with a stamped, self-addressed envelope.

STYLE POLICIES

10. The active voice is preferred. Use the third person for describing what happened, "I" or "we" (if more than one author) for describing what you did, and "you" (the imperative) for instruction.
11. Each page must be typewritten on one side of 8½ × 11 inch plain paper, double spaced, with one-inch margins. Do not right justify pages.
12. Manuscripts should contain the following, organized in the order listed below, with each section beginning on a separate page:
    a. Title page
    b. Acknowledgments
    c. Abstract and Key Words (first numbered page)
    d. Text (body of manuscript)
    e. References
    f. Tables-each on a separate page.
    g. Legends to illustrations
    h. Illustrations
13. Begin numbering the pages of your manuscript with the abstract page as #1; then, consecutively number all successive pages.
14. Titles should be brief within descriptive limits (a 16-word maximum is recommended). If a disability is the relevant factor in an article, the name of the disability treated should be included in the title. If a technique or type of treatment is the principal reason for the report, it should be in the title. Often both should appear.
15. The title page should also include the names, titles, and affiliations 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.
16. A structured abstract of 75 to 200 words must accompany all manuscripts. Number this page one, type the complete title (but not the authors' names) on the top, skip two lines, and begin the abstract. Items that are needed differ by type of article and should include: **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. Definitions of these terms can be found in reference a, item 21, below.
17. Begin the text of the manuscript with an introductory paragraph or two in which the purpose or hypothesis of the article is clearly developed and stated. Tell why the study needed to be done or the article written and 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.
18. 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 methodology section, a presentation of the results, and a discussion of the results. The methodology section should contain sufficient detail concerning the methods, procedures, and apparatus employed so that others can reproduce the results. The results should be summarized using descriptive and inferential statistics, and a few well-planned and carefully constructed illustrations.
    b. The body of a **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 Study** should include the following components: personal data (age, sex, race, marital status, and occupation when relevant—but not name), chief complaint, history of present complaint (including symptoms), results of physical examination (example: "Physical findings relevant to the rehabilitation program were . . ."), medical history (surgery, laboratory results, exam, etc), diagnosis, treatment and clinical course (rehabilitation until and after return to competition), criteria for return to competition, and deviation from the expected (what makes this case unique). NOTE: It is mandatory that the *Journal of Athletic Training* receive, with the manuscript, a release form signed by the individual being discussed in the case study. Case studies cannot be reviewed if the release is not included.
    d. The body of a **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.
19. 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.
20. Each citation in the text of the manuscript takes the form of a superscripted number that indicates the number assigned to the citation. It is placed directly after the reference or the name of the author being cited. References should be used liberally. It is unethical to present others' ideas as your own. Also, use references so that readers who desire further information on the topic can benefit from your scholarship.
21. The reference page(s) accompanying a manuscript should list authors numerically and in alphabetical order and should be in the following form: a) articles: author(s)(list all) with the family names then initials, title of article, journal title with abbreviations as per *Index Medicus* (italicized or underlined), volume, year, inclusive pages; b) books: author(s), title of book (italicized or underlined), city and state of publication, publisher, year, inclusive pages of citation. Examples of references to a journal, book, and presentation at a meeting are illustrated below. See the *AMA Manual of Style* for other examples.
    a. Knight KL, Ingersoll CD. Structure of a scholarly manuscript: 66 tips for what goes where. *J Athl Train.* 1996;31:201–206.
    b. Day RA. *Scientific English: A Guide for Scientists and Other Professionals*. 2nd ed. Phoenix, AZ: Oryx Press; 1995:73–74.
    c. Leadbetter WB. An introduction to sports-induced soft-tissue inflammation. In: Leadbetter WB, Buckwalter JA, Gordon SL, eds. *Sports-Induced Inflammation.* Park Ridge, IL: American Academy of Orthopaedic Surgeons; 1990:3–23.
    d. Stone JA. Swiss ball rehabilitation exercises. Presented at the 47th Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association; June 12, 1996; Orlando, FL.
22. Tables must be typed. See references cited in #8 or #21a for table formatting
23. Type legends to illustrations on a separate page followed by xerox copies of the illustration. Photographs should be glossy black and white prints. Do not use paper clips, write on photos, or attach photos to sheets of paper. Carefully attach a write-on label to the back of each photograph so that the photograph is not damaged. Graphs, charts, or figures should be of good quality; should be clearly presented on white paper 3½" or 7¼" wide with black ink, 8- to 10-point sans serif typeface, and no box; and should be printed on a laser printer—no dot matrix.
24. All artwork to be reproduced should be submitted as camera-ready black and white line art. If artwork is to be reproduced in black plus a second (or more) color, it should be submitted as black and white line art. Clearly mark each area of color, or areas of shading or screening (a percent or tint of black or a color), on a separate photocopy. Author pays for color.

CEU Quiz

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

Please note the new procedure for participating in this program. Read the material in this issue carefully and record your test answers on this page. If you prefer, you may photocopy this page for submission. Fill in your name, address, and other information and mail with $20 for processing to the address below. **FOR CREDIT, the form must be postmarked by March 15, 1997.**

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

Answers to September '96 CEU Quiz
Volume 31, Number 3

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

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

❑ NATA Membership Number or
❑ NATABOC Certification Number
(please check one)__________________

Social Security Number__________________

Name____________________________

Mailing Address______________________

____

City__________ State ______ Zip ________

Please indicate below the setting in which you work:

❑ High School ❑ Junior College ❑ College
❑ University ❑ Sports Medicine Center
❑ Other (please specify) __________________

INSTRUCTIONS

1. Carefully read the articles in this issue.
2. Record your answers below by darkening the appropriate letter of your answer.
3. Mail with $20 fee (check or money order only payable to **Journal of Athletic Training**) postmarked by March 15, 1997 to:

JAT— CEU Quiz
Hughston Sports Medicine Foundation, Inc.
6262 Veterans Parkway, P.O. Box 9517
Columbus, GA 31908-9517

CEU Quiz Evaluation

1. **Questions challenging enough? . . . ❑Yes ❑No**
2. **Presented clearly? . . . . ❑Yes ❑No**
3. **Material covered well? . . . . ❑Yes ❑No**
4. **Will information be useful to you in your work? . . . . ❑Yes ❑No**

Please add any suggestions on how to improve the CEU Quiz on the back of this form when you are finished.

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

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

MARK ANSWERS ON PREVIOUS PAGE.

1. The results of the salary survey conducted on certified athletic trainers in Delaware, New Jersey, New York, and Pennsylvania indicate:
   a. highest salaries were earned by teacher-athletic trainers.
   b. lowest salaries were earned by athletic trainers in the college or university practice setting.
   c. salaries earned by athletic trainers holding a doctoral degree were higher than salaries earned by those with a physical therapy degree.
   d. salaries reported in New York were higher than those in the other District 2 states.

2. Studies that have assessed the protective effects of prophylactic knee bracing for noninjured athletes indicate there is clearly:
   a. a reduction in injury occurrence.
   b. a reduction in injury severity.
   c. a reduction in injury occurrence and severity.
   d. no protective effect.
   e. a set of mixed results and no clear consensus has been reached.

3. When comparing the effectiveness of various materials used in prophylactic upright brace construction, the nylon material resulted in ligament tension, at high-impact conditions, greater than that which resulted with no brace at all.
   a. True
   b. False

4. Assessment of functional strength:
   a. may be a better estimate of an athlete's ability to return to sport than isolated joint testing.
   b. evaluates complex skills that are necessary for sport-specific movement.
   c. has yet to be clearly defined.
   d. a and b.
   e. all of the above.

5. When evaluating functional leg strength using the vertical jump, the most reliable measure would be:
   a. reach height.
   b. vertical impulse.
   c. peak vertical ground reaction force.
   d. All of the above are reliable measures.
   e. None of the above is a reliable measure.

6. The application of gel pads as a coupling agent in ultrasound treatments:
   a. is not recommended for use over areas with excessive subcutaneous fat.
   b. lowers the transmission of acoustic energy.
   c. is similar to water in its transmissivity.
   d. is useful in improving coupling over uneven body surfaces.
   e. can be used only in combination with a topical gel.

7. Which of the following is not a sign or symptom of temporomandibular dysfunction?
   a. ear ache
   b. toothache
   c. decreased mandibular motion
   d. crepitus, clicking, or grating associated with mandibular movement
   e. facial pain

8. An aggressive 6-week DAPRE leg press protocol performed from 0 to 90° of knee flexion:
   a. improves both concentric and eccentric peak torque.
   b. improves time in a functional hop test.
   c. improves distance in a functional hop test.
   d. only a and b
   e. all of the above

9. Which of the following caused the greatest increase in supine hamstring flexibility?
   a. stretching and heat
   b. stretching alone
   c. stretching and ice
   d. All were equally effective in increasing flexibility
   e. None effectively increased flexibility

10. What is the main concern following surgical intervention after an avulsion of the inferior canaliculus?
    a. infection
    b. avoiding forces in the cheek of the ipsilateral side
    c. impaired optical capacity of the eye
    d. facial scarring

11. In football and rugby athletes, tension/anxiety mood states are related to:
    a. injury frequency.
    b. injury severity.
    c. depression/dejection.
    d. all the above.
    e. a & b.

12. The decision to allow continued athletic participation of an athlete with HIV infection should be based upon:
    a. public knowledge of the athlete's health records.
    b. the athlete's current health status.
    c. the athlete's discretion.
    d. a strict no-tolerance policy for the HIV infected athlete.

13. A concern in athletics is the possibility of transmission of HIV via:
    a. sweat.
    b. saliva.
    c. tears.
    d. blood.
    e. all the above.

14. Differences between MHI subjects and control subjects are most evident:
    a. at day 10 following injury.
    b. when sensory input is altered.
    c. when the platform is perturbed in a plantar flexion-dorsiflexion direction.
    d. all of the above
    e. b & c

15. The findings related to skin surface temperature changes with repeated ice pack application suggest:
    a. a reapplication protocol of 30 minutes on and 90 minutes off is suitable after showering.
    b. ice should be reapplied immediately after an athlete showers.
    c. showering and changing clothes causes body parts to warm less quickly than previously thought.
    d. skin temperature changes following ice pack application are identical for the thigh, ankle, forearm, and fingers.

Indexes

AUTHOR INDEX
Volume 31

A

Adeyanju M: see Sandrey MA
Amato HK, Smith LA: Adaptation of a foot plate for use in an isokinetic and isotonic leg press, 31:169
Armstrong CW: see Cordova ML
Arnold BL, VanLunen BL, Gansneder BM, Szczerba JE, Mattacola CG, Perrin DH: 1994 athletic trainer employment and salary characteristics, 31:215

B

Bazluki J: Surgical intervention and rehabilitation of chronic patellar tendinitis, 31:65
Bell SL: see Loudon JK
Benoit TG, Martin DE, Perrin DH: Hot and cold whirlpool treatments and knee joint laxity, 31:242
Bettis B: see Simpson S
Bitting LA, Trowbridge CA, Costello LE: A model for a policy on HIV/AIDS and athletics, 31:356
Brodowicz GR, Welsh R, Wallis J: Comparison of stretching with ice, stretching with heat, or stretching alone on hamstring flexibility, 31:324

C

Cameron KL, Kersey RD, Ransone J: Avulsion of the inferior canaliculus in a collegiate wrestler: a case study, 31:352
Carrier D: see Rosen LW
Casterline M, Osowski S, Ulrich G: Femoral stress fracture, 31:53
Catizone PV: see Wawrzyniak JR
Collins KS, Streitz W: Bilateral Jones fractures in a high school football player, 31:253
Cordova ML, Armstrong CW: Reliability of ground reaction forces during a vertical jump: implications for functional strength assessment, 31:342
Costello LE: see Bitting LA
Cross KM, Wilson RW, Perrin DH: Functional performance following an ice immersion to the lower extremity, 31:113
Cvengros RD, Lazor JA: Pneumothorax—a medical emergency, 31:167

D

Davis Jr CF: see Misasi SP
Davis VL: see Keskula DR
Denegar CR, Siple BJ: Bilateral foot pain in a collegiate distance runner, 31:61
Dewald L, Zientek C: A survey of athletic trainers as health care advocates for testicular and breast self-examination in athletic populations, 31:19
Draper DO: see Rose S
Drawbert JP: see Oliphant JG
Duncan JB: see Keskula DR
Durrant E: see Rose S

E

Eachus PL: Positive drug screen for benzodiazepine due to a Chinese herbal product, 31:165
Eason J: see Patterson PE

F

Fincher AL, Wright KE: Use of computer-based instruction in athletic training education, 31:44
Finley PW: see Keskula DR
Flint F: see Lavallée L

G

Gansneder BM: see Arnold BL; Guskiewicz KM
Goldenberg MS: Wound care management: proper protocol differs from athletic trainers' perceptions, 31:12
Gulick DT, Kimura IF, Sitler M, Paolone A, Kelly JD IV: Various treatment techniques on signs and symptoms of delayed onset muscle soreness, 31:145
Guskiewicz KM, Perrin DH, Gansneder BM: Effect of mild head injury on postural stability in athletes, 31:300

H

Heck JF: The incidence of spearing during a high school's 1975 and 1990 seasons, 31:31
Henry TJ: see Swanik CB
Herbertson J: see Simpson S
Holcomb WR, Mangus BC, Tandy R: The effect of icing with the Pro-Stim Edema Management System on cutaneous cooling, 31:126

I

Ingersoll CD: see Knight KL; Thieme HA

J

Jones JD, Kleiner DM: Awareness and identification of athletes with sickle cell disorders at historically black colleges and universities, 31:220

K

Kaminski TW, Perrin DH: Effect of prophylactic knee bracing on balance and joint position sense, 31:131
Kelly IV JD: see Gulick DT
Kersey RD: see Cameron KL
Kersey RD: Anabolic-androgenic steroid use among California community college student-athletes, 31:237
Keskula DR, Duncan JB, Davis VL, Finley PW: Functional outcome measures for knee dysfunction assessment, 31:105
Khelifa M: see Wagman D
Kimura IF: see Gulick DT
Kleiner DM: see Jones JD
Klucinec B: The effectiveness of the Aquaflex Gel Pad in the transmission of acoustic energy, 31:313
Knight KL: see Palmer JE; Thieme HA
Knight KL, Ingersoll CD: Optimizing scholarly communication: 30 tips for writing clearly, 31:209
Knight KL, Ingersoll CD: Structure of a scholarly manuscript: 66 tips for what goes where, 31:201

L

Lavallée L, Flint F: The relationship of stress, competitive anxiety, mood state, and social support to athletic injury, 31:296
Lazor JA: see Cvengros RD

Lephart SM: see Swanik CB
Levitsky K: see Rossi T
Loudon JK, Bell SL: The foot and ankle: an overview of arthrokinetics and selected joint techniques, 31:173

M

Mangus BC: see Holcomb WR
Martin DE: see Benoit TG
Mattacola CG: see Arnold BL
McKeag DB: see Rosen LW
Misasi SP, Davis Jr CF, Morin GE, Stockman D: Academic preparation of athletic trainers as counselors, 31:39
Morin GE: see Misasi SP
Moss CL: 1994 entry-level athletic training salaries, 31:25
Murray R: Dehydration, hyperthermia, and athletes: science and practice, 31:248

N

Norton P: see Whitehill WR

O

Oliphant JG, Drawbert JP: Gender differences in anterior cruciate ligament injury rates in Wisconsin intercollegiate basketball, 31:245
Osowski S: see Casterline M
Ozmun JC: see Thieme HA

P

Palmer JE, Knight KL: Ankle and thigh skin surface temperature changes with repeated ice pack application, 31:319
Paolone A: see Gulick DT
Patterson PE, Eason J: The effects of prophylactic brace construction materials on the reactive responses of the MCL during repetitive impacts, 31:329
Perrin DH: see Arnold BL; Benoit TG; Cross KM; Guskiewicz KM; Kaminski TW
Perrin DH: Editorial. Transitions, 31:293

R

Ransone J: see Cameron KL
Rello MN: The importance of state regulation to the promulgation of the athletic training profession, 31:160
Rosen LW, Smokler C, Carrier D, Shafer CL, McKeag DB: Seasonal mood disturbances in collegiate hockey players, 31:225
Rose S, Draper DO, Schulthies SS, Durrant E: The stretching window part two: rate of thermal decay in deep muscle following 1-MHz ultrasound, 31:139
Rossi T, Levitsky K: Osteoid osteoma of the calcaneus: an unusual cause of hindfoot pain in an adolescent athlete, 31:71

S

Sailors ME: Evaluation of sports-related temporomandibular dysfunctions, 31:346
Sandrey MA, Zebas CJ, Adeyanju M: Prevention of injuries in excessive pronators through proper soccer shoe fit, 31:231
Schulthies SS: see Rose S
Sevier TL: see Weidner TG
Shafer CL: see Rosen LW
Simpson S, Bettis B, Herbertson J: Unloaded treadmill training therapy for lumbar disc herniation injury, 31:57
Siple BJ: see Denegar CR
Sitler M: see Gulick DT
Smith LA: see Amato HK
Smokler C: see Rosen LW
Somerville J, Stanwood M: Salary survey of certified athletic trainers in Delware, New Jersey, New York, and Pennsylvania, 31:309
Stanwood M: see Somerville J
Stockman D: see Misasi SP
Storrow RR: see Wawrzyniak JR
Streitz W: see Collins KS
Swanik CB, Henry TJ, Lephart SM: Chronic brachial plexopathies and upper extremity proprioception and strength, 31:119
Szczerba JE: see Arnold BL

T

Tandy R: see Holcomb WR
Thieme HA, Ingersoll CD, Knight KL, Ozmun JC: Cooling does not affect knee proprioception, 31:8
Thornton JL, Webster JA: The "tape cast" functional taping for the injured athlete, 31:179
Toy BJ: Conservative treatment of bilateral sural nerve entrapment in an ice hockey player, 31:68
Tracy JE: see Wawrzyniak JR
Trowbridge CA: see Bitting LA

U

Ulrich G: see Casterline M

V

VanLunen BL: see Arnold BL

W

Wagman D, Khelifa M: Psychological issues in sport injury rehabilitation: current knowledge and practice, 31:257
Wagner DR: Body composition assessment and minimal weight recommendations for high school wrestlers, 31:262
Wallis J: see Brodowicz GR
Wawrzyniak JR, Tracy JE, Catizone PV, Storrow RR: Effect of closed chain exercise on quadriceps femoris peak torque and functional performance, 31:335
Webster JA: see Thornton JL
Weidner TG, Sevier TL: Sport, exercise, and the common cold, 31:154
Welsh R: see Brodowicz GR
Whitehill WR, Norton P, Wright KE: Navigating the library maze: introductory research and the athletic trainer, 31:50
Wilson RW: see Cross KM
Wright KE: see Fincher AL

Z

Zebas CJ: see Sandrey MA
Zientek C: see Dewald L

Indexes

SUBJECT INDEX
Volume 31

A

ACL injuries, 31:245
Acquired immunodeficiency virus, policy on HIV and, 31:356
Adolescence, wrestling body composition assessment, 31:262
Anabolic steroids, use in community college, 31:237
Ankle injuries, foot and, arthrokinematics, 31:173
Ankle injuries, ice application, 31:319
Ankle injuries, tape cast and, 31:179
Ankle taping, 31:179
Anterior cruciate ligament, injury rates, 31:245
Aquaflex gel pad, ultrasound and, 31:313
Arthrokinematics, foot and ankle, 31:173
Arthrometry, knee joint laxity, 31:242
Athletes, anabolic steroid use, 31:237
Athletes, college hockey players and SAD, 31:225
Athletes, sickle cell disorders and, 31:220
Athletic injuries, 31:296
Athletic injuries, ice application, 31:319
Athletic injuries, temporomandibular dysfunctions, 31:346
Athletic participation, policy on HIV and AIDS, 31:356
Athletic trainers, athletes and sickle cell disorders, 31:220
Athletic trainers, as advocates of testicular and breast self-examination, 31:19
Athletic trainers, education as counselors, 31:39
Athletic trainers, employment and salary 1994, 31:215
Athletic trainers, library research and computer databases, 31:50
Athletic trainers, perceptions and wound care management, 31:12
Athletic trainers, student, 31:197
Athletic training, education, 31:44
Athletic training, entry-level salaries in 1994, 31:25
Athletic training, salary survey, 31:309
Athletic training profession, state regulation, 31:160

B

Balance, mild head injury and, 31:300
Basketball injuries, anterior cruciate ligament, 31:245
Benzodiazepine, positive drug screening, 31:165
Body fat, wrestling body composition assessment, 31:262
Brachial plexopathies, 31:119
Bracing, knee, 31:131
Bracing, MCL protection, 31:329

C

Calcaneus, osteoid osteoma of, 31:71
Canaliculus avulsion, wrestler, 31:352
Chinese herbal medicine, benzodiazepine positive drug screening and, 31:165
Closed kinetic chain exercise, 31:335, 31:342
Collapsed lung, 31:167
Common cold, sport/exercise and, 31:154
Community colleges, anabolic steroid use, 31:237
Compensation, certified athletic trainer salary survey, 31:309
Competitive anxiety, athletic injury and, 31:296
Concussions, postural stability and, 31:300
Cooling, knee proprioception and, 31:8
Counseling, education for athletic trainers, 31:39
Credentials, athletic trainers, 31:215
Cryotherapy, 31:T7, 31:113
Cryotherapy, compression/electrical stimulation and, 31:126
Cryotherapy, skin surface temperature, 31:319
Cryotherapy, thermotherapy and, 31:242
Cutaneous cooling, 31:126

D

Dehydration, hyperthermia and, 31:248
Delayed union, Jones fracture, 31:253
Distance runner, bilateral foot pain, 31:61
Drug screening, benzodiazepine, 31:165

E

Eccentric activities, delayed onset muscle soreness and, 31:145
Edema, 31:126
Education, computer-based instruction in athletic training, 31:44
Elbow flexion, 31:5
Employment setting, athletic trainers, 31:215
Ergogenic aids, anabolic steroid use, 31:237
Exercise performance, 31:248

F

Femur, stress fracture, 31:53
Flexibility, hamstring, 31:324
Foot, ankle and, arthrokinematics, 31:173
Foot, bilateral pain, 31:61
Football, Jones fracture, 31:253
Football, pneumothorax and, 31:167
Football, spearing and, 31:31
Foot measurements, static and dynamic, 31:231
Foot plate, leg press and, 31:169
Fractures, femoral stress, 31:53
Functional outcomes, knee dysfunction, 31:105
Functional performance, ice immersion and, 31:113
Functional strength assessment, vertical jump, 31:342
Functional testing, closed chain exercise, 31:335

G

Gel pads, Aquaflex, ultrasound and, 31:313
Gender, ACL injury rate differences, 31:245
Ground reaction forces, 31:342

H

Head injuries, postural stability and, 31:300
Health care, state regulation of athletic training profession, 31:160
Heat illness, 31:248
Hindfoot pain, osteoid osteoma of the calcaneus and, 31:71
Hockey players, seasonal mood disturbances, 31:225
Human immunodeficiency virus, policy on AIDS and, 31:356
Hyperthermia, dehydration and, 31:248

I

Ice application, skin surface temperature, 31:319
Ice hockey, sural nerve entrapment and, 31:68
Ice immersion, lower extremity, 31:113
Inertial exercise, 31:5
Infection, upper respiratory illness, 31:154
Injury prevention, excessive pronators and, 31:231
Interventions, psychology and sport injury rehabilitation, 31:257
Isokinetic testing, closed chain exercise, 31:335

J

Joint techniques, arthrokinematics and, 31:173
Jones fracture, high school football, 31:253

K

Knee, patellar tendinitis, 31:65
Knee dysfunction, 31:105
Knee injuries, anterior cruciate ligament, 31:245
Knee injuries, bracing and, 31:329, 31:131
Knee joint laxity, 31:242
Knee proprioception, 31:8
Knee rehabilitation, leg presses, 31:169

L

Lacerations, canaliculus avulsion, 31:352
Lacrimal system, canaliculus avulsion, 31:352
Leg presses, 31:335
Leg presses, foot plate adaptation, 31:169
Library instruction, student athletic trainers and, 31:197
Lumbar disc, herniation injury, 31:57, 31:197

M

MCL protection, knee bracing, 31:329
Medial collateral ligament, knee bracing and, 31:329
Mood disturbances, SAD in collegiate hockey players, 31:225
Mood state, athletic injury and, 31:296
Muscle soreness, delayed onset, 31:145

N

National Athletic Trainers' Association, 31:309
Nerve injuries, brachial plexus, 31:119

O

Osteoid osteoma, calcaneus, 31:71

P

Pneumothorax, 31:167
Postural sway, mild head injury and, 31:300
Pronation, injury prevention, 31:231
Prophylaxis, knee bracing, 31:131
Proprioception, knee, 31:8
Proprioception, upper extremity, 31:119
Pro-Stim Edema Management System, 31:126
Psychology, sport injury rehabilitation, 31:257

R

Rehabilitation, functional strength assessment, 31:342
Rehabilitation, sport injuries and psychology, 31:257
Research, athletic trainers and, 31:50
Respiratory illness, sport/exercise/common cold, 31:154
Rigid internal fixation, Jones fracture, 31:253

S

Salaries, entry-level athletic training, 31:25
Salary, athletic trainers, 31:215
Salary, certified athletic trainers, 31:309
Scholarly manuscripts, 31:209
Scholarly manuscripts, structure and tips, 31:201
Scientific writing, scholarly manuscripts, 31:209
Scientific writing, scholarly manuscripts, structure and tips, 31:201
Seasonal affective disorder, collegiate hockey players, 31:225
Self-examination, testicular and breast, 31:19
Sickle cell disorders, athletes and, 31:220
Silicone casting, 31:101
Skinfolds, body composition assessment, 31:262
Soccer shoe fit, excessive pronators and, 31:231
Social support, athletic injury and, 31:296
Soft tissue injuries, ultrasound and, 31:139
Spearing, high school football, 31:31
Spine, disc herniation injury and treadmills, 31:57
Spine, lumbar disc herniation injury, 31:197
Sports, injuries, rehabilitation and psychology, 31:257
Sports drinks, 31:248
Sports injuries, temporomandibular dysfunctions, 31:346
State regulation, athletic training profession, 31:160
Stress, athletic injury and, 31:296
Stretching, joint mobilization and, 31:139
Stretching, with ice and heat, 31:324
Sural nerve entrapment, 31:68
Surgery, chronic patellar tendinitis, 31:65
Survey, athletic trainers, 31:215

T

Tape cast, 31:179
Temporomandibular dysfunctions, 31:346
Tendinitis, patellar, 31:65
Thermotherapy, 31:324
Thermotherapy, cryotherapy and, 31:242
Transmissivity, acoustic energy, 31:313
Treadmills, lumbar disc herniation injury, 31:57, 31:197
Treatment, delayed onset muscle soreness, 31:145

U

Ultrasound, Aquaflex gel pad and, 31:313
Ultrasound, stretching and, 31:139

V

Vertical jump, ground reaction forces, 31:342

W

Whirlpool, hot and cold treatments, 31:242
Wound care management, 31:12
Wrestling, body composition and, 31:262
Wrestling, canaliculus avulsion, 31:352
Writing, scholarly manuscripts, 31:209
Writing, scholarly manuscripts, structure and tips, 31:201

ADVERTISERS' INDEX

AIRCAST, INC. 328
BAILEY MFG. CO. 308
BALL DYNAMICS 317
BRACE INTERNATIONAL 334
BREATHE RIGHT/CNS INC. 292
CRAMER PRODUCTS .... Cover 4
FOOT MGMT, INC. 384
GATORADE 307
HUMAN KINETICS 351
JAYBIRD & MAIS 341
JOHNSON & JOHNSON 294–295
LENOX HILL .... Cover 3
McDAVID KNEE GUARD, INC. 318
MULTIAXIAL, INC. 311
OPTP 327
POLYMEDICA HEALTHCARE, INC. 306
PRO ORTHOPEDIC DEVICES .... Cover 2
SWEDE-O, INC. 290, 312