ATHLETIC TRAINING

THE JOURNAL OF THE NATIONAL ATHLETIC TRAINERS' ASSOCIATION, INC. • VOLUME 26 • NUMBER 1 • SPRING 1991

NATIONAL ATHLETIC TRAINERS' ASSOCIATION

NATA

* 1950 *

ATHLETIC TRAINING

The Journal of the
National Athletic Trainers' Association, Inc.

Athletic Training, JNATA (ISSN 0 160 8320) is published quarterly ($28 for one year subscription, $35 foreign) by the National Athletic Trainers' Association, Inc., 2952 Stemmons Freeway, Dallas, TX 75247. Second-class postage paid at Dallas, TX and at additional mailing offices. POSTMASTER: Send address changes to: *Athletic Training, JNATA* 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. Send address changes to: *Athletic Training, JNATA* c/o NATA, 2952 Stemmons Freeway, Dallas, TX 75247. ADVERTISING: Although advertising is screened, acceptance of the advertisement does not necessarily imply NATA endorsement of the product or the views expressed. Advertising rates available upon request. The views and opinions in *Athletic Training, JNATA* are those of authors and not necessarily of the National Athletic Trainers' Association, Inc. Printed by The William Byrd Press, Richmond, VA 23227. Typesetting by the Virginia Health Council, Inc., Richmond, VA, 23221.

National Athletic Trainers' Association, Inc.

President
Mark J. Smaha, MS, ATC
Washington State University
Bohler Gymnasium
Pullman, Washington 99164-1610
Phone (509) 335-0238 • FAX (509) 335-0333

Executive Director/Secretary
Alan A. Smith, Jr.
NATA National Headquarters
2952 Stemmons Freeway
Dallas, Texas 75247-6103
Phone (214) 637-6282 • FAX (214) 637-2206

Assistant Executive Director
Amanda W. Culbertson
NATA National Headquarters
2952 Stemmons Freeway
Dallas, Texas 75247-6103
Phone (214) 637-6282 • FAX (214) 637-2206

Board of Directors

District 1
Charles J. Redmond, MEd, MSPT, ATC
Springfield College
Springfield, MA 01109
(413) 788-3231

District 2
Joseph J. Godek, III, ATC
West Chester University
South Campus Complex
West Chester, PA 19383
(215) 436-2386

District 3
Terry L. O'Brien, MEd, ATC
Towson State University
Towson, MD 21204
(301) 830-2737

District 4
John W. Schrader, ATC
Indiana University
Assembly Hall
Bloomington, IN 47405
(812) 855-4509

District 5
James M. Booher, PhD, RPT, ATC
South Dakota State University
Athletic Department
Brookings, SD 57007
(605) 688-5824

District 6
Paul T. Zeek, ATC
Lamar University
P.O. Box 10115
Beaumont, TX 77710
(409) 880-8332

District 7
Mike E. Nesbitt, ATC
Northern Arizona University
Box 15400
Flagstaff, AZ 86011
(602) 523-4151

District 8
Julie Max, MEd, ATC
California State University, Fullerton
800 North State College
Fullerton, CA 92634-9480
(714) 773-2219

District 9
James Doug May, MA, ATC
The McCallie School
Chattanooga, TN 37403
(615) 622-2163

District 10
Dennis Sealey, PT, ATC
University of Washington
Graves Building, GC-20
Seattle, WA 98195
(206) 543-2239

ATHLETIC TRAINING

THE JOURNAL OF THE NATIONAL ATHLETIC TRAINERS' ASSOCIATION • VOLUME 26 • NUMBER 1 • Spring 1991

CEU CREDIT QUIZ

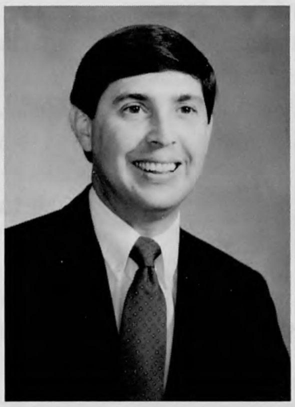
ARTICLES

TIP FROM THE FIELD

STUDENT ATHLETIC TRAINER FORUM

Departments

Editor-in-Chief's Comments



Steve Yates, MEd, ATC
Wake Forest University
Winston-Salem, NC 27109

To the Editor-in-Chief

Dear Mr. Yates:

It is a significant step in the history of the National Athletic Trainers' Association for your profession to be formally recognized by the American Medical Association and its Council on Medical Education. This recognition is a positive step in the education of professional athletic trainers, and it will have far reaching effects in the areas of increased professionalism and research. I note that the efforts of your association were supported by the American Physical Therapy Association, the American Academy of Family Practitioners, and the Academy of Orthopedic Surgeons for Sports Medicine.

At Wake Forest University we have recognized athletic training as an allied health profession since 1980. By housing our professionals in this area under the Sports Medicine Unit at the Bowman Gray School of Medicine at the University, we endorsed early, and continued to support enthusiastically the recognition of athletic trainers as allied health professionals.

My best to you and your association as you continue to move in the right direction.

Thomas K. Hearn, Jr.
President
Wake Forest University
Winston-Salem, NC

Letters to the Editor

EDITOR'S NOTE:

The following letter from Dr. Kumamoto and his correspondence from the Illinois Department of Professional Regulation were so strong that I invited responses from the author of the article in question. In addition, two dentists who have expertise in sports medicine, and who periodically review manuscripts for us, were asked to respond. After reading these, I'm sure you'll want to reevaluate your own practices and the laws in your state.

Dear Dr. Knight:

I need to inform you of some problems that might arise because of an article that was published in your Fall 1990 *Athletic Training, JNATA*. The article in question was written by Scott T. Doberstein and it was entitled "A Procedure for Fitting Mouth-formed Mouthguards." The article implies that mouth-formed mouthguards may be altered by athletic trainers. In the State of Illinois, the alteration or adjustment of a mouthguard by an athletic trainer constitutes the practice of dentistry, which is illegal. I have enclosed a copy of a letter from the Department of Professional Regulation which answers questions I asked about mouthguard fabrication by athletic trainers.

Each state differs in the regulation of dental procedures performed by auxiliary personnel, and I think that you should inform your readers to check the law in their particular area.

I know that it is difficult to find dentists willing to assist athletic trainers. That is why we have our elective course to teach dentists and athletic trainers to work together. I feel comfortable working with the athletic trainers at our university, and they have done an outstanding job evaluating dental problems in athletes. The Academy for Sports Dentistry is continually trying to get dentists to volunteer their services to athletic programs. I would urge athletic trainers to recruit dentists in their area.

Perhaps I misinterpreted Mr. Doberstein's message, but I thought it should be brought to your attention.

David P. Kumamoto, DDS
Department of Operative Dentistry
College of Dentistry
The University of Illinois at Chicago
Chicago, IL

Dear Dr. Kumamoto:

I am writing in reply to your letter of February 5, 1990.

You have asked whether athletic trainers are permitted to adjust athletic mouthguards that were purchased in a store. They are not. Adjustments of an oral appliance, even one that is prefabricated, constitutes the practice of dentistry.

Athletic trainers may not take impressions from which mouthguards will be fabricated. Only a dentist may take impressions from which any appliance or prosthesis will be fabricated.

Athletic trainers may fabricate mouthguards extraorally from models poured from impressions taken by a dentist. They should not deliver mouthguards to players since the fit of mouthguards should be checked by a dentist.

It may be permissible in an emergency situation for an athletic trainer to replant a tooth since this quick action may result in the tooth being saved. The athletic trainer should, after replanting, arrange for the player to be transported to a dental facility or emergency room as quickly as possible.

Should you have any further questions, do not hesitate to contact me.

Barbara A. West
Attorney for the Department
Illinois Department of Professional Regulation
Springfield, IL

Dear Dr. Knight:

I would like to sincerely thank Dr. Kumamoto for his concerns regarding my recent article, "A Procedure for Fitting Mouth-formed Mouthguards."

I agree with Dr. Kumamoto in that athletic trainers should check their state laws concerning the practice of dentistry, and our roles in mouthguard formulation. However, my article explicitly states several times that athletic trainers should closely supervise, educate, and inspect the mouthguard fitting procedure, which many athletes perform haphazardly or not at all. After all, one of our main roles is the prevention of injury.

It was not my intention to imply that athletic trainers assume the role of dentists. Rather my goal was to educate coaches, athletes, and athletic trainers about the fitting process, and to give them concrete guidelines so that athletes will receive the optimal benefits from the guard.

I also don't believe that my article implies that athletic trainers may or should alter mouthguards. An unmolded, store-bought, "boil and bite" type of mouthguard gives instructions for individual fitting. If you mean that the initial fitting supervised by an athletic trainer, or anyone else, constitutes an illegal alteration, then how does the mouthguard become formed? Certainly you don't imply that the only person who can assist or supervise the athlete in this critical fitting procedure is a dentist, especially with a $1.00 guard bought at any sporting goods store. This implication severely limits the athletic trainer's role in injury prevention, and compounds his or her job with more potentially serious and needless injuries. In addition, I state effectively that alterations of any kind to the already formed guards are prohibited.

I would again like to thank Dr. Kumamoto for his insight. I look forward to his contributions to the literature on sports dentistry.

Scott T. Doberstein, MS, ATC/R
Milliken University
Decatur, IL

Dear Dr. Knight:

In response to your inquiry regarding the article on athletic mouthguards and who should place them, I submit my thoughts for your consideration.

The heat sensitive mouthguards, which are issued by athletic trainers in athletic programs and are formed in the mouth, should keep the athletic trainer well within the law in most states. Each athletic trainer should have a dental consultant available to him or her to be sure that it is the case in that particular state. If impressions are made by the athletic trainer and poured up, and a mouthguard constructed on the model, then the athletic trainer would be in violation of the dental practice act in most states. It is unlawful for an athletic trainer to take dental impressions or to alter a retainer or mouthguard in the states in which I hold licensure. I believe this would be the case in most states, although I suppose many states have never addressed the problem because it probably is not a problem.

The best answer would be for all athletic trainers to have a dentist as a consulting member of his or her particular program. Together they should outline, within the law of that state, their approach to the mouthguard situation. This would allow the athletic trainer to do most of the mouthguards — as is presently the case, but would also allow the dentist to be available for special situations where adjustment or special fabrication is necessary. I believe most dentists would readily respond to be of assistance, as prevention is really what dentistry is all about.

Richard C. Whitehead, DDS
St. George, UT

Dear Dr. Knight:

I have read with interest the article "A Procedure for Fitting Mouth-formed Mouthguards" by Scott T. Doberstein in the Fall 1990 issue of *Athletic Training, JNATA* and I believe some comment might be appropriate.

Although I am not an attorney, I believe that certain statements in the article may be in conflict with dental practice laws in some states. Though laws differ in the various states, such statements as "It is important to educate athletic trainers because they understand the advantages of this vital piece of protective equipment, and are responsible for the proper fitting and supervision of its use" and "Eastern Illinois University athletic trainers have had a reasonable level of success in fitting the intraoral mouth-formed guards using the procedure below" may not be in concert with dental practice laws in other states. "Fitting" mouthguards may be considered (in some states) part of the practice of dentistry. Thus while I support the concept of athletic trainers' monitoring mouthguard use by their players, it might be prudent to be aware of what their state's dental practice laws do or do not permit.

In addition, one might question the author's statement, "The advantages of this mouthguard when fit properly, can virtually match the efficacy and comfort of the custom mouthguard." No references are provided and I am unaware of literature citations that would support this statement. In fact, surveys of players who have had the opportunity to compare both types indicate the opposite in so far as comfort and distinct speech are concerned.

Another statement that is bothersome is "The gums may bleed slightly showing a red stain on the mouthguard when it is removed. This slight bleeding is the result of the high temperature and the force of the vacuum by the mouthguard on the gums, and does not constitute a pathological concern." While bleeding of the gums may occur as described, it can also be indicative of problems totally unrelated to fitting a mouthguard and of far more significance to the athlete's oral health. Gingival bleeding should constitute a concern for the athlete and the athletic trainer, and follow-up by the athlete's dentist is indicated.

Finally, the article points out quite rightly, in my opinion, the tendency for some athletes to alter their mouthguards to the point of rendering them ineffective. The author's statement that athletic trainers monitor such modifications is well taken.

Obviously a well-fitting mouthguard is an important step in preventing oral injuries, and I think the author is to be congratulated for presenting an effective method by which the athlete can fit his or her mouth-formed mouthguard.

Certainly we are all interested in preventing oral injuries in athletes and a cooperative effort of athletic trainers, team physicians, and dentists can mutually contribute to achieving this goal.

Robert M. Morrow, DDS
Professor and Head
Graduate Division
Department of Prosthodontics
The University of Texas
Health Science Center at San Antonio
San Antonio, TX

CEU Credit Quiz

Prevention and Treatment of Patellar Entrapment Following Intra-Articular ACL Reconstruction

Joseph E. Tomaro, PT, ATC

ABSTRACT: Patellar entrapment is a significant complication following intra-articular reconstruction of the anterior cruciate ligament. Postoperative adhesion formation may occur at the patellofemoral joint, resulting in decreased patellar mobility. This will cause a loss of knee extension with significant subjective symptoms and functional limitations for the athlete. Patellar entrapment can require a prolonged course of treatment with possible permanent residual effects. Early detection and intervention are the most effective means for preventing significant complications. This article presents principles and techniques that can be utilized both in the prevention of patellar entrapment and in the rehabilitation of this syndrome, should it develop. The etiology and pathogenesis of patellar entrapment also is discussed.

Over the past ten years, reconstructive surgery has become a common treatment for anterior cruciate ligament (ACL) injuries. Despite surgical advances and more aggressive rehabilitation procedures, significant complications still can follow this surgery. One common problem is fibroarthrosis, the development of intra-articular adhesions with resultant capsular contracture (2,13,14,20). This condition commonly progresses to patellar entrapment. If it results in a loss of knee extension and an inferior patellar position, then it is called infrapatellar contracture syndrome (IPCS) (16).

Paulos et al. (16) reviewed 28 cases of IPCS, 19 of which followed intra-articular ACL reconstruction. Sachs et al. (18) reviewed 126 cases of ACL reconstruction from 1982 to 1986 and found a loss of knee extension of greater than five degrees in 24% of the patients. A slight decrease in the degree of knee flexion is a minor problem for the athlete; however, a loss of five to ten degrees of knee extension produces more subjective patellofemoral complaints and greater functional limitations during sports. Because of the debilitating effects, early recognition and intervention is important in the treatment and prevention of patellar entrapment (16).

Joseph Tomaro is Clinical Chief, Sports Medicine Services, Pittsburgh, Pennsylvania, 15212.

ANATOMY OF THE PARAPATELLAR TISSUES

To understand the development of patellar entrapment, it is necessary to review the pertinent soft tissue anatomy of the anterior knee, as this is the common site for adhesion formation (Figures 1,2). The fibrous capsule of the knee joint does not extend over the patella but blends indistinguishably into the expansions of the vastus medialis and the vastus lateralis. These expansions are attached anteriorly to the patella, distally to the patellar tendon, and posteriorly to the collateral ligaments forming the medial retinaculum and the lateral retinaculum. The latter is strengthened by the iliotibial band (22).

Superiorly, the joint capsule forms recesses relative to the patella, including the suprapatellar bursa and the medial and lateral parapatellar recesses (9).

The patellar tendon is surrounded by fascial and fibrofascial tissue planes. Posterior to the patellar tendon is a highly vascular fibrofatty pad, which is firmly adherent to the distal pole of the patella and the patellar tendon. This infrapatellar fat pad extends into the joint to the medial and lateral menisci. The patellomeniscal ligaments (Kaplan's ligaments) extend from the inferior pole of the patella through the infrapatellar fat pad to the anterior horns of the medial and lateral menisci (22).

PATELLOFEMORAL KINEMATICS

The total patellar movement in the femoral sulcus during complete knee extension is 8 cm. During knee extension, the

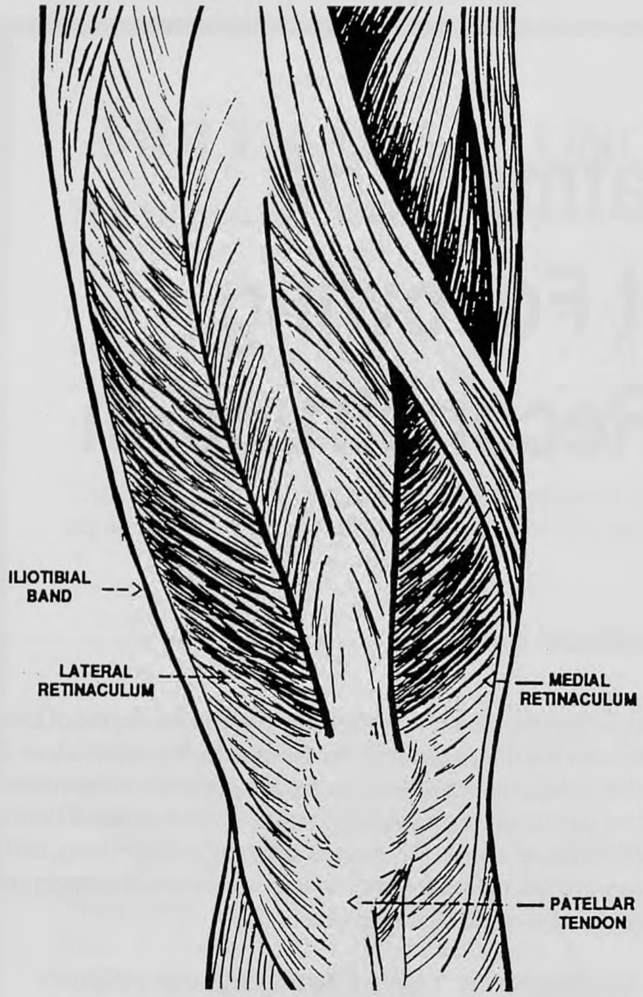


Figure 1. Medial retinaculum, lateral retinaculum, and the iliotibial band and their attachments to the patellar tendon complex

patella glides superiorly on the femur secondary to the contraction of the quadriceps. The line of pull depends upon the resultant force vector of the quadriceps and the bony considerations (9). As knee extension proceeds, the contact area on the patella moves distally, extending across the medial and lateral facets with a continuous decrease in contact area. At 20 degrees of flexion, only the inferior margin of the patella contacts the trochlear surface of the femur. With the knee in complete extension and the quadriceps contracted, the patella will lie proximal to the trochlear groove (7). Restoring the superior glide of the patella on the femur to allow complete knee extension is essential in the prevention of patellar entrapment.

PATHOGENESIS OF PATELLAR ENTRAPMENT

Following intra-articular ACL reconstruction, an inflammatory reaction of hyperemia and edema occurs at the synovial membrane of the joint capsule. Vasodilation of the small synovial vessels produces a release of fluid containing granulocytes, which deposit fibrin on the synovial surfaces. Lysomal enzymes are also released, which cause localized areas of synovial membrane necrosis. The fibrin deposition, along with the necrotic areas, form a scaffold upon which adhesions may be established (16). The joint capsule and the surrounding soft tissue structures begin to shrink, and the fibrofatty connective tissue encroaches into the joint. This will eventually obliterate the joint cavitity, leading to adhesion formation (4).

With patellar entrapment, there is severe thickening and fibrosis of the capsular and synovial tissues and of the infrapatellar fat pad. A dense fibrosclerotic reaction of disorganized collagen develops in these tissues. The patella firmly adheres to the fat pad as the fat pad enlarges to occupy the entire anterior joint space from the intercondylar notch to the joint line and the patellar tendon (16). The adhesions in the intercondylar notch may also attach to the reconstructed ACL (4,20). With the fibrotic reaction that occurs during patellar entrapment, patella infera likely will develop. The patella becomes entrapped in the lower femoral sulcus because of the adhesions about the patellar tendon. This decreases the ability of the patella to glide superiorly on the femur. An inhibition of the quadriceps that frequently occurs following ACL reconstruction, in combination with the patellar entrapment, will lead to patella infera and the resultant loss of knee extension (16,18).

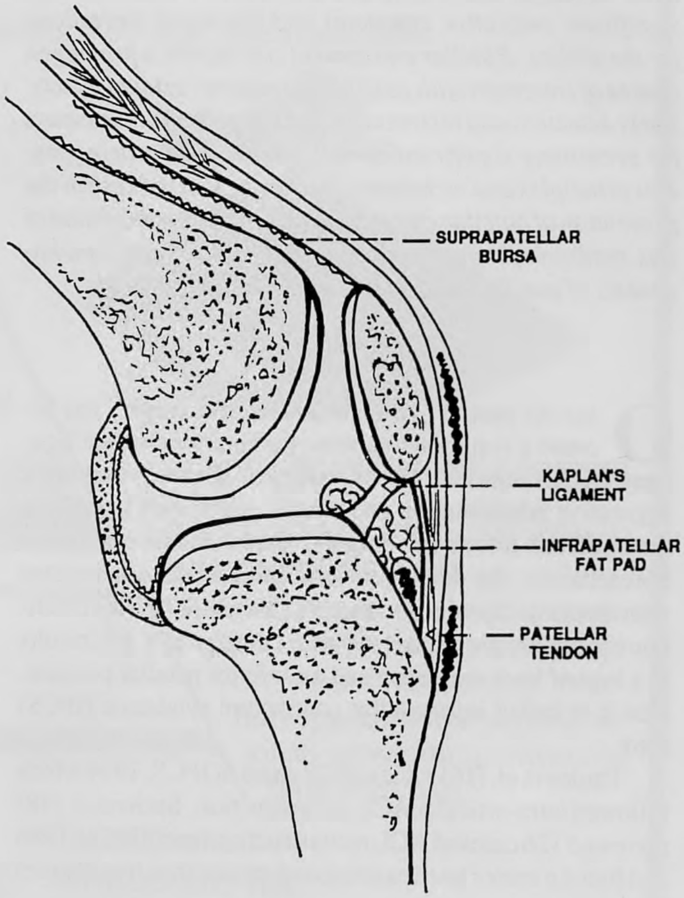


Figure 2. Sagittal section with soft tissue structures of the anterior knee which are common sites for adhesion formation during patellar entrapment

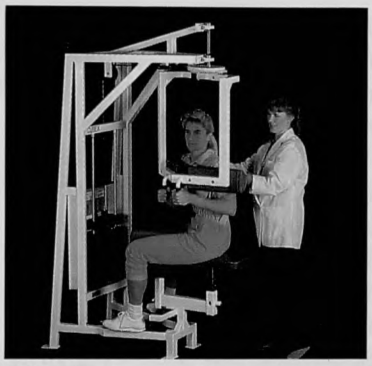
A BODY OF WORK

CYBEX STRENGTH SYSTEMS

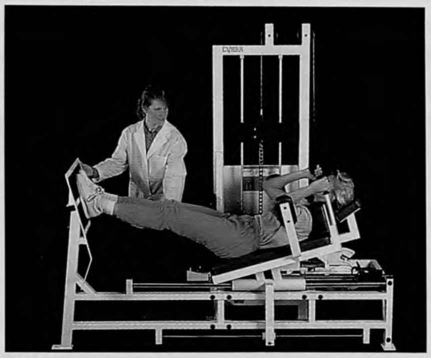
#1 in rehabilitation for good reasons.

■ *Cable Column*

- **Resistance profiles modeled after** CYBEX torque curves assure the safest, most effective and efficient method of performing functional eccentrics.
- **Safe, visible range-of-motion limiting** retains the integrity of the cam profile providing a correct resistance curve regardless of the range selected.
- **Special rehabilitation weight stacks and** counterbalanced exercise arms provide lower starting weights for earlier and safer rehabilitation.
- **Units fit back-to-back and in corners** with weight stacks accessible from the exercise position for maximum space and time efficiency.
- **Biomechanically engineered for optimal** positioning and stabilization assuring safe, comfortable exercise for men and women 4'10" to 6'6".
- **CYBEX delivers the highest level of** customer support available from planning to installation to service from CYBEX Factory Trained Personnel.
- **More than 50 selectorized and free** weight units enable you to customize your facility to your caseload or area of specialization.


■ *Rotary Torso*


■ *Leg Extension*


■ *Leg Press*

Strengthen your practice.

Call 1-800-645-5392

CYBEX®
STRENGTH SYSTEMS

Partner in Research
FOUNDATION For Physical Therapy 1989-1990

CYBEX 2100 Smithtown Ave., PO Box 9003, Ronkonkoma, NY 11779-0903 • 1-800-645-5392
In Canada 1-800-227-9547 • International Department • 516-737-5902 • TWX 510 228 7198 FAX 516-737-5908

Patellar entrapment may also have significant permanent effects on the articular cartilage of the femoral condyles and the patella. The fibrosclerotic infrapatellar fat pad will impinge on the medial and lateral femoral condyles causing pressure ulcerations to develop. Additionally, the inflammatory pannus from the medial and lateral parapatellar recesses will infiltrate the noncontact surfaces of the patellofemoral joint and adhere to the articular cartilage. The articular cartilage will become softened and fibrillated as a result of a loss of ground substance (16).

In the later stages of patellar entrapment, closed manipulation or vigorous passive stretching to gain knee extension can cause excessive patellofemoral compression. This increases the risk of significant injury to the joint surfaces, because of the changes that are already present in the articular cartilage (20).

ETIOLOGY AND PREVENTION OF PATELLAR ENTRAPMENT

Patellar entrapment following ACL reconstruction can have both surgical and non-surgical causes. Procedures performed during arthrotomy have been shown to cause more synovial membrane changes and subsequent adhesions than arthroscopic procedures (10). Arthoscopy for ACL reconstruction should help to decrease the occurrence of patellar entrapment. Improper graft positioning and tensioning also can cause patellar entrapment, because of the loss of knee extension that usually accompanies these surgical procedures. If the graft is placed in a nonisometric position on the tibia, there can be impingement at the intercondylar notch, which will block knee extension. A graft under excessive tension also can prevent the normal movement of the tibia that is necessary for complete knee extension (16,20). Recent research has been useful in determining better graft positioning and tensioning, which will assist in preventing patellar entrapment (11,21).

Postoperative rehabilitation procedures also can cause patellar entrapment. When the patellar tendon is used as an intra-articular autograft, great surgical damage is done to the parapatellar tissues, increasing the possibility for adhesions. Prolonged immobilization at 30 to 60 degrees of knee flexion, with no quadriceps activity, had been used in this type of reconstruction to protect the graft until adequate bony healing could take place at the distal ends (15). This further increased the risks of patellar entrapment, articular cartilage changes, and muscular inhibition and atrophy (11).

Because of the immobilization effects, changes have been made in the rehabilitation procedures following surgery. Current recommendations are for range-of-motion exercise using a constant passive motion (CPM) machine from 0 to 90 degrees beginning on the second post-operative day (11). Exceptions to this include reconstructions done in combination with a meniscal repair or a medial collateral ligament repair. Isometric exercises for the hamstrings and quadriceps are also initiated on the second postoperative day, and self patellar mobilization is begun within the first five days. With these treatment guidelines, Noyes et al. believe that the graft should not be affected and that the deleterious effects of immobilization will disappear.

These guidelines are not universally accepted in immediate post-operative care. Many physicians believe that early motion will lead to instability by overstressing the graft (5). Communication with physicians concerning their recommended rehabilitation is important, and appropriate modifications in the athlete's care should be made. The specific effects and guidelines for the use of CPM machines, isometric exercises, and patellar mobilization will be discussed further in the treatment section of this article.

EVALUATION OF THE ATHLETE WITH PATELLAR ENTRAPMENT

If an athlete has not gained full knee extension at four to six weeks following ACL reconstruction, patellar entrapment may be the cause. The athlete will complain of stiffness and decreased motion at the knee and possibly crepitation at the patellofemoral joint during movement. Inspection of the knee reveals an obvious flexion contracture and, in some cases, swelling (2,16) (Figure 3). Moderate to severe quadriceps atrophy is present and a shelf can be detected in most patients. This occurs when thickening of the infrapatellar fat pad and the retinacular tissues extends to the distal attachment of the patellar tendon and creates an abrupt step-off or shelf from the patellar tendon to the tibial tubercle. The patellar tendon and the articular recesses are obscured by the thickening of the parapatellar tissues. Patella infera with a shortened patellar tendon also may be present (Figure 4).

Figure 3. Flexion deformity that usually accompanies patellar entrapment

In their study of 28 patients with inferior patellar entrapment, Paulos et al. (16) noted a decrease in knee extension from 7 to 35 degrees, with the average loss being 17 degrees. There was a firm tissue block to knee extension secondary to the changes in the parapatellar tissues. Knee flexion ranged from 60 to 139 degrees. Patellofemoral crepitus was present during active range of motion in 75% of the cases.

The individual with patellar entrapment has a substantial loss of both active and passive superior gliding of the patella on the femur. This restriction of patellar mobility is caused by the adhesions in the parapatellar tissues.

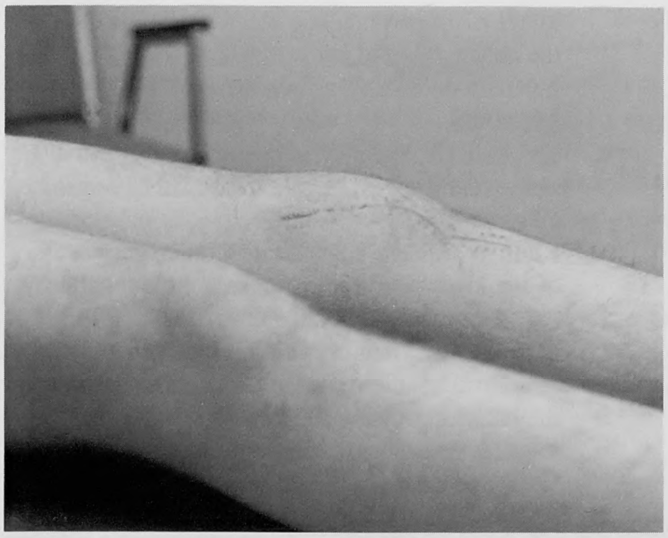


Figure 4. Induration of the infrapatellar fat pad and retinacular tissues in the left knee, obscuring the borders of the patella

Figure 5. Superior gliding of the patella to enhance knee extension

Manual muscle testing often reveals an inability of the athlete to perform a complete quadriceps contraction because of the changes in the parapatellar tissues. An extension lag may develop from this quadriceps insufficiency, leading to a decrease in patellar mobility and a loss of knee extension.

During palpation, increased warmth about the joint is noted, but no findings indicate sympathetic reflex dystrophy. The articular recesses are difficult to palpate because of the induration of the surrounding tissues. Retinacular thickening, especially laterally, and adhesion formation in the suprapatellar pouch can also be palpated (16).

Observation of the gait in the athlete with patellar entrapment reveals a decreased stride length on the involved side, resulting from the loss of complete knee extension in the late swing phase. There is also a "short-leg" gait during midstance because of the loss of knee extension and the resultant functional shortness of the leg. This leads to an antalgic gait pattern with a resultant early heel rise at propulsion.

TREATMENT OF THE ATHLETE WITH PATELLAR ENTRAPMENT

Following the recognition of patellar entrapment, early intervention is important. Transverse friction massage and ultrasound can be used to treat parapatellar adhesions and retinacular thickening. The effects of ultrasound are well documented in relaxing the polypeptide bonds in adherent connective tissue (6). Transverse friction massage at the lateral retinaculum, the suprapatellar pouch, and the infrapatellar tendon has also been suggested as effective means of decreasing scar formation (1), although this has not been supported by *in vivo* research.

Patellar mobilization is important in treating patellar entrapment. This mobilization is performed with the knee in slight flexion in order to avoid pinching the synovial tissues. The mobilizing hand is placed at the inferior pole of the patella to provide a superior force (17) (Figure 5). This technique can be combined with a quadriceps isometric exercise to further enhance the return of a normal superior glide of the patella. The athlete can be instructed in self patellar mobilization to be performed at frequent intervals throughout the day.

CPM is another technique that is used to increase knee extension. The continuous generation of proprioceptive impulses from a moving joint may "block" the transmission of pain impulses to the cerebrum, thus allowing greater, pain-free motion. CPM can also help to decrease the hemarthrosis following surgery, which is an important consideration in the prevention of patellar entrapment. Additionally, CPM is a means of stimulating the healing and regeneration of articular cartilage (19).

In treating patellar entrapment, the initiation of a quadriceps contraction is important. In early postoperative treatment, this quadriceps contraction must be done with a hamstring co-contraction to prevent excessive graft tension. When performing this co-contraction, the hamstring contraction should be initiated first. This exercise helps to prevent muscle atrophy following surgery, and places minimal tension on the reconstruction (8). Electrical stimulation and electromyographic feedback to the quadriceps also can effectively facilitate a quadriceps contraction (3).

A drop-out cast is sometimes used in the early stages of patellar entrapment. The upper thigh is completely encircled with the exception of the patella and the parapatellar tissues. The lower leg is enclosed on the posterior aspect only. Further knee extension can be achieved by placing padding under the ankle, providing a low-grade force for a prolonged period of time. Caution must be exercised when using this forceful extension maneuver, since articular cartilage damage can occur. The articular cartilage is susceptible because of the softening and fibrillation that is present with patellar entrapment (16).

If conservative treatment proves to be inadequate, surgical intervention could be necessary. This may include combinations of arthroscopic adhesiolysis with anterior fat pad and intercondylar notch debridement, arthrotomy with lateral retinacular release, or partial fat pad resection with release of the parapatellar tissues. The selection of a procedure will depend on the degree of adhesion formation and the movement loss. Examination of the reconstructed ACL will be performed to determine if its position and tension are correct.

The period between the ACL reconstruction and adhesion release depends upon the athlete's progress. In most cases, if full knee extension is not achieved within two months, the follow-up surgery is performed. Early surgical intervention can minimize damage to the patellar articular surface, which could occur with vigorous manual attempts to improve knee extension (2,13,14,20).

Following surgery, gentle manipulation is performed and CPM is immediately initiated (16,20). The treatment procedures discussed previously are begun on the next day.

If patellar entrapment occurs, the rehabilitation process becomes more involved and prolonged with the potential for long-term patellofemoral complications. Because of this, when treating an athlete following reconstructive surgery, it is important to be aware of the clinical signs and symptoms of patellar entrapment. When proper surgical and post-operative procedures are followed, patellar entrapment can be successfully prevented in the majority of cases.

ACKNOWLEDGEMENTS

I would like to thank Adi Chadran for providing the photographs and Nancy Bevan for providing the illustrations for this manuscript.

REFERENCES

1. Cyriax JH, Cyriax PJ: *Illustrated Manual of Orthopaedic Medicine*. London: Butterworths, 1983, pp. 19-20.
2. Delpizzo W, Fox JM, Freidman MJ, Snyder SJ, Ferkel RD: Operative arthroscopy for the treatment of arthrofibrosis of the knee. *Contemporary Orthopaedics* 10: 67-72, 1985.
3. Draper V: Electromyographic feedback and recovery of quadriceps femoris muscle function following anterior cruciate ligament reconstruction. *Phys Ther* 70: 11-17, 1990.
4. Enneking WF, Horowitz M: The intra-articular effects of immobilization of the human knee. *J Bone Joint Surg* 54A: 973-985, 1972.
5. Gerber C, Matter P: Biomechanical analysis of the knee after rupture of the ACL and its primary repair: an instant-centre analysis of function. *J Bone Joint Surg* 65B: 391-399, 1983.
6. Griffen JE, Karselis TC: *Physical Agents for Physical Therapists*. Springfield MA: Charles C. Thomas, 1982, pp. 290-291.
7. Hungerford DS, Barry M: Biomechanics of the patellofemoral joint. *Clin Orthop* 144: 9-15, 1979.
8. Kain CC, McCarthy JA, Arms S, Pope MH, Steadman JR, Shively RA: An *in vivo* analysis of the effect of transcutaneous electrical stimulation of the quadriceps and hamstrings on anterior cruciate ligament deformation. *Am J Sports Med* 16: 147-152, 1988.
9. Kapandji IA: *The Physiology of Joints, Volume II: Lower Limbs*. New York: Churchill Livingstone, 1970, pp. 96-105.
10. Klein W, Jensen KA: Arthroscopic synovectomy of the knee joint: Indications, technique, and follow-up results. *Arthroscopy* 4: 63-71, 1988.
11. Melhorn JM, Henning CE: The relationship of the femoral attachment site to the isometric tracking of the anterior cruciate ligament graft. *Am J Sports Med* 15: 539-542, 1987.
12. Noyes FR, Mangine RE, Barber S: Early knee motion after open and arthroscopic anterior cruciate ligament reconstruction. *Am J Sports Med* 15: 149-159, 1987.
13. O'Conner RL: Intra-articular adhesions and fibrous anklyosis of the knee. In Shahriarle H(ed): *O'Conner's Textbook of Arthroscopic Surgery*. Philadelphia: JB Lippincott, 1984, pp. 289-297.
14. Parisien JS: The role of arthroscopy in the treatment of post-operative fibroarthrosis of the knee joint. *Clin Orthop* 229: 185-193, 1988.
15. Paulos LE, Noyes FR, Grood E, Butler DL: Knee rehabilitation after ACL ligament reconstruction and repair. *Am J Sports Med* 9:140-149, 1981.
16. Paulos LE, Rosenburg TD, Drawbert J, Manning J, Abbott P: Infrapatellar contracture syndrome: An unrecognized cause of knee stiffness with patella entrapment and patella infera. *Am J Sports Med* 15: 331-341, 1987.
17. Quillen WS, Gieck JH: Manual therapy: Mobilization of the motion-restricted knee. *Athletic Training, JNATA* 23: 123-130, 1988.
18. Sachs RA, Daniel DM, Stone ML, Garfein RF: Patellofemoral problems after anterior cruciate reconstruction. *Am J Sports Med* 17: 760-765, 1989.
19. Salter RB, Hamilton HW, Wedge JH, Tile M, Torode JA, O'Driscoll SW, Murnaghan JJ, Saringer JH: Clinical application of basic research on continuous passive motion for disorders and injuries to the synovial joints: A preliminary report of a feasibility study. *J Orthop Res* 1: 325-341, 1984.
20. Sprague NF: Motion-limiting arthrofibrosis of the knee: The role of the arthroscopic management. *Arthroscopy* 6: 537-549, 1988.
21. Yoshiya S, Andrish JT, Manley MT, Bauer TW: Graft tension in anterior cruciate ligament reconstruction. *Am J Sports Med* 15: 464-470, 1987.
22. Williams PL, Warwick R: *Gray's Anatomy*. Philapdelphia: WB Saunders, 1980, pp. 482-488.

CEU Credit Quiz

PREVENTION AND TREATMENT OF PATELLAR ENTRAPMENT FOLLOWING INTRA-ARTICULAR ACL RECONSTRUCTION

Joseph E. Tomaro, PT, ATC

As an organization accredited for continuing medical education, the Hahnemann Medical College and Hospital certifies that this continuing education offering meets the criteria for .3 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.

To participate in this program, read the material carefully and answer the questions in the test. Mark your answer by placing an X in the proper square. Then photocopy the test sheet, fill in your name, address, and other information, and mail these with $12 for processing to Hahnemann University, School of Continuing Education, Broad and Vine, Philadelphia, PA 19102.

The NATA National Headquarters will be notified of all members with passing scores over 70%. CEU credit will be entered on each member's record at that time. Participation is confidential.

Questions	a	b	c	d	e
1. The development of post surgical intra-articular adhesions with resultant capsular contracture is referred to as: a) intrapatellar contracture syndrome b) fibroarthrosis c) patellar entrapment d) a and c only e) none of the above					
2. The fibrous capsule of the knee joint extends distally over the patella. a. True b. False					
3. Expansions of the vastus medialis and vastus lateralis form the medial and lateral retinacula. a. True b. False					
4. A highly vascular fibrofatty pad is positioned a. anterior to the patella tendon b. anterior to the patella c. posterior to the patella tendon d. posterior to the patella e. none of the above					
5. When the knee demonstrates complete extension (i.e., maximal quadriceps femoris contraction), the patella is located proximal to the femoral trochlear groove. a. True b. False					
6. The following changes accompany patellar entrapment: a. fibrofatty connective tissue encroachment into the joint b. minimal collagen development c. thickening and fibrosis of the capsular and synovial tissues d. all of the above e. a and c only					

Questions	a	b	c	d	e
7. In the late phases of patellar entrapment, the following will reduce the possibility of patellofemoral compression: a. closed manipulation b. vigorous passive stretching into extension c. both a and b d. neither a nor b					
8. Current recommendations for postoperative rehabilitation of comparatively uncomplicated repairs include: a. prolonged immobilization in some knee flexion b. use of a constant passive motion (CPM) machine c. isometric exercises for the hamstring and quadriceps muscles d. all of the above e. a and c only					
9. Following anterior cruciate ligament reconstruction, an athlete is expected to gain full knee extension within _________ unless patellar entrapment occurs. a. 4 to 6 months b. 4 to 6 weeks c. 4 to 6 days d. 1 year e. none of the above					
10. In athletes with patellar entrapment syndrome, complete contraction of the __________ often is not achieved. a. quadriceps b. hamstring c. both a and b d. neither a nor b					

FOR CREDIT, form must reach
Hahnemann University by June 15, 1991

Name ______________________________

Institution or Team ______________________________

Address ______________________________

City ______________ State ______________ Zip ______________

Social Security Number ______________________________

Mail with $12 fee to:
Hahnemann University
School of Continuing Education
Broad and Vine
Philadelphia, PA 19102

Check One

❒ certified membership number ______________

❒ associate membership number ______________

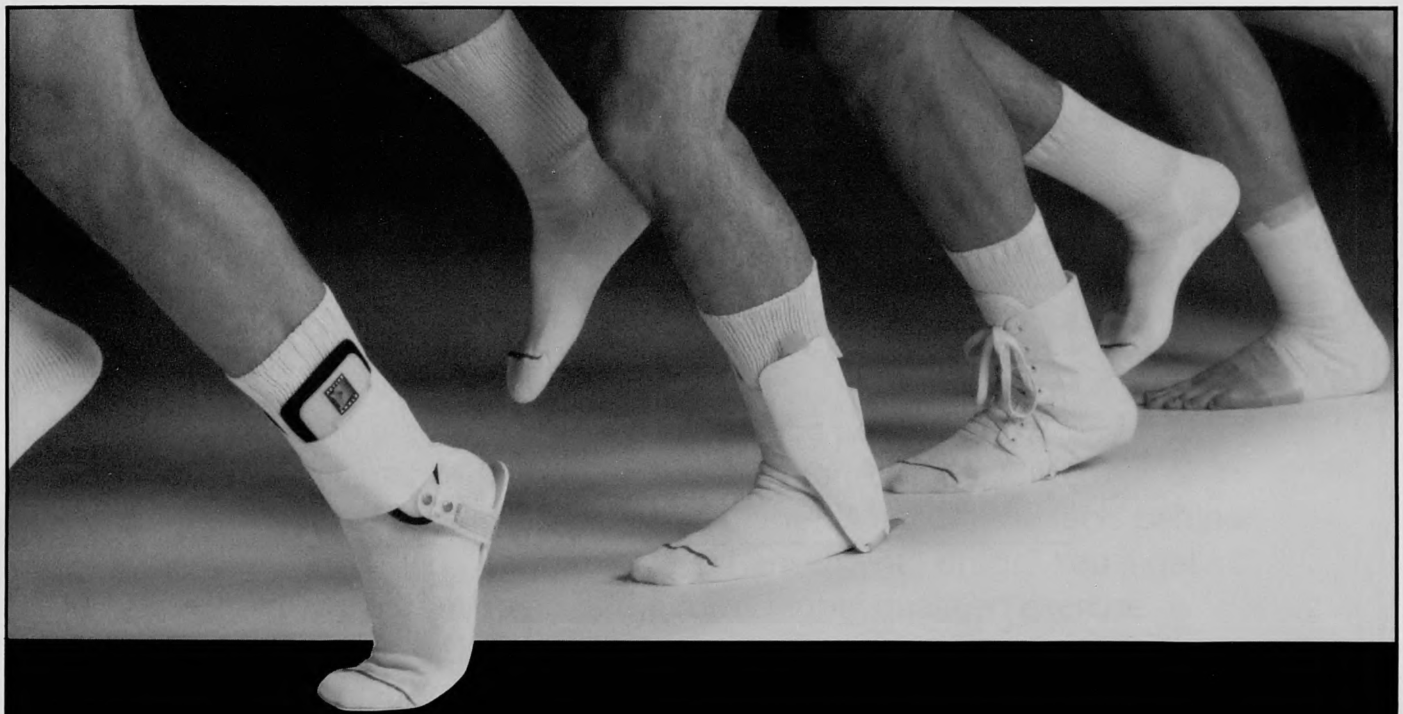
Please indicate below the level at which you are now working.

_____ High School _____ University

_____ Junior College _____ Sports Medicine Center

_____ College Other (please specify) ______________

(May be photocopied)



ANSWERS TO PREVIOUS CEU CREDIT QUIZ
"Podiatric Examination Techniques For In-The-Field Assessments"

1.	d	6.	e
2.	a	7.	b
3.	b	8.	d
4.	d	9.	a
5.	c	10.	c

Knee Rehabilitation Following Anterior Cruciate Ligament Repair/Reconstruction: An Update

James G. Case, MA, ATC
Bernard F. DePalma, MEd, ATC, RPT
Russell R. Zelko, MD

ABSTRACT: Changes in surgical techniques and post-operative treatments have led athletic trainers to reconsider their anterior cruciate ligament (ACL) rehabilitation protocols. Using research, closed kinetic chain principles, and clinical experiences, our previous ACL rehabilitation program (11) was revised to reflect these recent modifications. The program presented is practical for the student athlete, requires no sophisticated equipment, and minimizes time lost from classes and activities of daily living. Applying the behavioral approach to rehabilitation, the student athlete addresses each phase, creating short and long-term goals to accomplish the tasks required. The student athlete is rehabilitated functionally to accelerate a return to normal daily activities, and to realistically prepare for a return to competitive athletics.

Knee rehabilitation following primary repair and/or reconstruction of the anterior cruciate ligament (ACL) has met with varying degrees of success over the last ten years (1,4,7,8,16,20,23,24,25,26). Research investigating anterior cruciate deficient knees, as well as various surgical techniques, has led to numerous protocols for rehabilitation. The program presented in this paper is an update of a previously published program (11) and is based on research, closed kinetic chain principles, and clinical follow-up. Specific variables, including patient population (individuality), time parameter, and goal setting will be discussed in light of existing research. Finally, our rehabilitation program will be presented. Our experiences over the last ten years are based on the rehabilitation of the competitive collegiate student athlete population in an environment where time absent from classes must be minimized. Arthroscopic-assisted anterior cruciate ligament reconstruction is now routinely performed, and the rehabilitation program is equally effective for both open and arthroscopic-assisted procedures.

Specific, realistic goals must be reached before the athlete is permitted to compete. These goals include: independence around campus, full and pain-free range of motion (ROM), neuromuscular coordination of both dynamic movers and joint stabilizers, strength of the dynamic movers and joint stabilizers, power, agility, joint speed, muscular and cardiovascular endurance, and a return to preinjury functional levels (26). These goals must be accomplished within the constraints of the healing process and under protection against undue stresses (11,15). A long-term goal of our program is to attain functional levels higher than those attained prior to injury.

PROGRAM PRINCIPLES

A successful rehabilitation program is based on sound scientific principles. Our program is based on research specifically related to closed kinetic chain exercise principles, early hamstring exercises, and clinical opinion. We began using closed chain principles in 1986 (11), and subsequent research supports our practice (24,25,28,30). Closed chain exercises are achieved by fixing the distal end of the extremity to the ground in a weight bearing position. Even after the athlete returns to competition, closed chain exercises are capable of conditioning the knee to handle the high and rapid loading typical of ground based sports (5,11). To date, information on the kinematics of closed chain exercises is limited. However, it seems reasonable to suggest that by fixing the distal attachment of a biarticular muscle (one that crosses two joints) in a closed chain fashion, the origin and insertion of

James Case is Assistant Athletic Trainer at Cornell University, Ithaca, New York, 14853.

Bernard DePalma is Head Athletic Trainer/Physical Therapist at Cornell University.

Russell Zelko is an orthopedic surgeon and Director of Sports Medicine at Cornell University.

that muscle group is reversed. Contraction of that muscle in a compound movement allows more than one joint to move while accomplishing a physical task. This will allow the athlete to develop neuromuscular strength, power, and endurance without exposure to the unwanted stresses on the joint being rehabilitated. We also believe closed chain exercises may facilitate tri-contraction of the knee-stabilizing muscles (hamstrings, quadriceps, and gastrocnemius) that surround the knee joint. These muscles compress and dynamically stabilize the knee.

The principles of closed and open chain exercises differ in several ways. Voight (28) outlined the advantages of closed chain exercises by dividing open and closed chain exercises into components. Differences in end segment, axis of motion, muscle contractions, movement, load, velocity, stress and strain rate, stabilization, proprioception, and exercise techniques were explained in considerable detail. As mentioned earlier, the end segment is always fixed in a closed chain exercise. The axis of motion is not isolated to one joint, but movement occurs proximal and distal to the joint. Closed chain exercises allow for a variety of muscle contractions to occur within one movement. For example, a squat utilizes an eccentric, isometric, and concentric contraction with each repetition. The load placed on the knee is analogous to that which occurs in a more practical and functional situation. Closed chain exercises allow variable velocity, and are dependent on the functional speed of the exercise. Stress and strain on the knee is more consistent in closed chain exercise. In contrast, open chain exercises vary in the range of motion, which changes the stress and strain placed on the knee joint.

Another feature of closed chain activities is that artificial stabilization is absent. Open chain exercises often require stabilization straps proximal to the joint in order to complete the movement (28). Closed chain activities rely on postural stabilization which is more functional. Proprioception occurs in a more practical and normal situation. The body has a functional situation to react to, rather than one that does not mimic daily life. Finally, closed chain exercises are not limited to equipment; imagination and creativity are important components.

Further research supports the successful use of closed kinetic chain exercises in rehabilitation programs (8,11,24,25). The free weight squat has been found to place less strain on the ACL than an isotonic knee extension (11,15,30). Henning et al.(15) found that a one-legged squat places 21% elongation (of the ACL) compared to the 50% elongation (of the ACL) produced by active resistive knee extensions. Wheildon et al. (30) discovered that anterior tibial displacement was significantly greater during isotonic knee extension then during squatting. The authors concluded that weight bearing, closed chain exercises are more appropriate for ACL deficient knees. Arms et al. (2) found that eccentric quadriceps exercise with the knee externally rotated places minimal strain on the ACL, compared to a passive normal strain. In fact, at no point in the range of motion is there a positive percent strain (2). With the externally rotated foot position, the descent, eccentric component of the squat places very little strain on the ACL.

A second basic feature of our rehabilitation program is early hamstring exercises. These have been found to be safe with no detrimental effects on the ACL. Many authors have confirmed their effective early use in the rehabilitation program (2,3,15,21,27,30). Hamstring exercises decrease the level of strain on the ACL throughout the entire range of motion (2,21). Other researchers have actually expanded the role of the hamstrings in knee stability. Solomonow et al. (27) describe the role of the hamstrings as joint stabilizers in the absence of the ACL. They established that a reflex arc exists between the joint capsule or musculature and the hamstrings, which activate in episodes of knee instability. As a result of this finding, the authors conclude that hamstring strengthening improves the stability of the knee joint in ACL deficient patients. Walla et al. (29) demonstrated a "reflex level" hamstring control amongst ACL deficient patients who were functioning at a high activity level.

We acknowledge the importance of early range of motion in a rehabilitation program and the physiological and psychological advantages of using a continuous passive motion (CPM) machine (6,18,23,24,25,26). However, we also emphasize the importance of maintaining terminal extension, realistic goals, and the need for more specific guidelines (in an academic environment) for the successful use of a CPM (23,25,26). The time commitment described in the literature required for effective use of CPM is 6 to 10 hours per day (23,24,26). This is unrealistic for our student athlete population. Immediately post-surgery, the main concerns of our student athletes include pain, ambulation, class schedules, and mobility around campus. After experimenting with numerous immediate post-surgical programs (CPM, hinge-brace, functional brace, and casting), we have found that a rehabilitative knee brace locked in extension, or casting in full extension, is the most practical and realistic treatment in the immediate post-operative period (7 to 10 days). Post-operative pain is minimized and the student is often back to classes by the third or fourth post-operative day, and full extension of the knee is retained.

To summarize, bracing or casting the student athlete in full extension for seven to ten days and permitting full weight bearing as tolerated has allowed the student maximum mobility around campus with the least amount of pain. Clinically, our experiences have been that patients who used early post-operative CPM encountered greater pain and extended hospital time. In addition, if the athlete was not supervised very closely, terminal extension was not maintained. CPM does not always permit terminal extension, which may result in extension lag or a fixed flexion contracture. Our rehabilitation program is presented emphasizing the importance of closed kinetic chain principles, early hamstring exercises, and maintenance of terminal extension.

REHABILITATION PROGRAM

Pre-surgical Phase

We use the pre-surgical phase to introduce our student athletes to the behavioral approach to rehabilitation. We emphasize individuality in setting short-term and long-term goals. A review of the behavioral approach and how it is used in athletic rehabilitation is warranted prior to designing a rehabilitation program (12,14,17). Prior to surgery, the physician, the athletic trainer, and the athlete should discuss the long-term goals of the rehabilitation program. As the long-term goals are formulated, they are broken down into short-term subgoals, and placed in a calendar form of days, sets, and repetitions (12,17). These subgoals should be extremely specific, challenging, and realistic (12). For example, on day one, or immediately following the removal of the cast, the most important goal in Phase I is to maintain terminal knee extension. The athlete is given a series of exercises to help achieve that goal. (See Phases I and II.) Having prepared these exercises on a calendar in the pre-surgical phase when discussing the behavioral approach and how it will be used throughout the rehabilitation program, the athlete finds it easier to attain the goal because the exercises are familiar and have been written down. The short-term goal is moderately difficult and specific, but advances toward the long-term goal of full range of motion. Constant positive reinforcement is needed until each specific goal is accomplished.

In addition to the effective use of goal setting, we introduce the athlete to other athletes who have successfully completed the rehabilitation program. Reassurance from a peer who has experienced the same program adds a positive outlook to the future. In addition, the athlete's progress is updated weekly. Subjective and objective data are considered, and new subgoals are formulated.

Rehabilitation begins as soon as possible before surgery, and again following surgery.

PHASES OF REHABILITATION

Phase I, 0 - 10 Days

Phase I begins immediately following surgery with the athlete in a rehabilitative hinged-knee brace locked in extension or in a straight legged cast. The goals of this phase are to maintain terminal extension, retard muscle atrophy through isometric exercises, begin strengthening the hip and ankle musculature, and maintain or slightly increase cardiovascular endurance. We also use this phase to allow the student athlete to adjust to normal living under new circumstances.

Phase I begins with seven daily exercises for the affected knee. The first exercise is isometric quadriceps setting and is performed immediately post-operative in both a supine and prone position. The prone position allows gravity to assist the athlete in achieving terminal extension. When lying prone the patella is situated over the end of a table. The athlete is asked to hold the contraction in terminal extension for six to ten seconds with a five second rest between contractions. The athlete is encouraged to repeat the quadriceps setting in terminal extension throughout the day until at least one hundred repetitions can be performed.

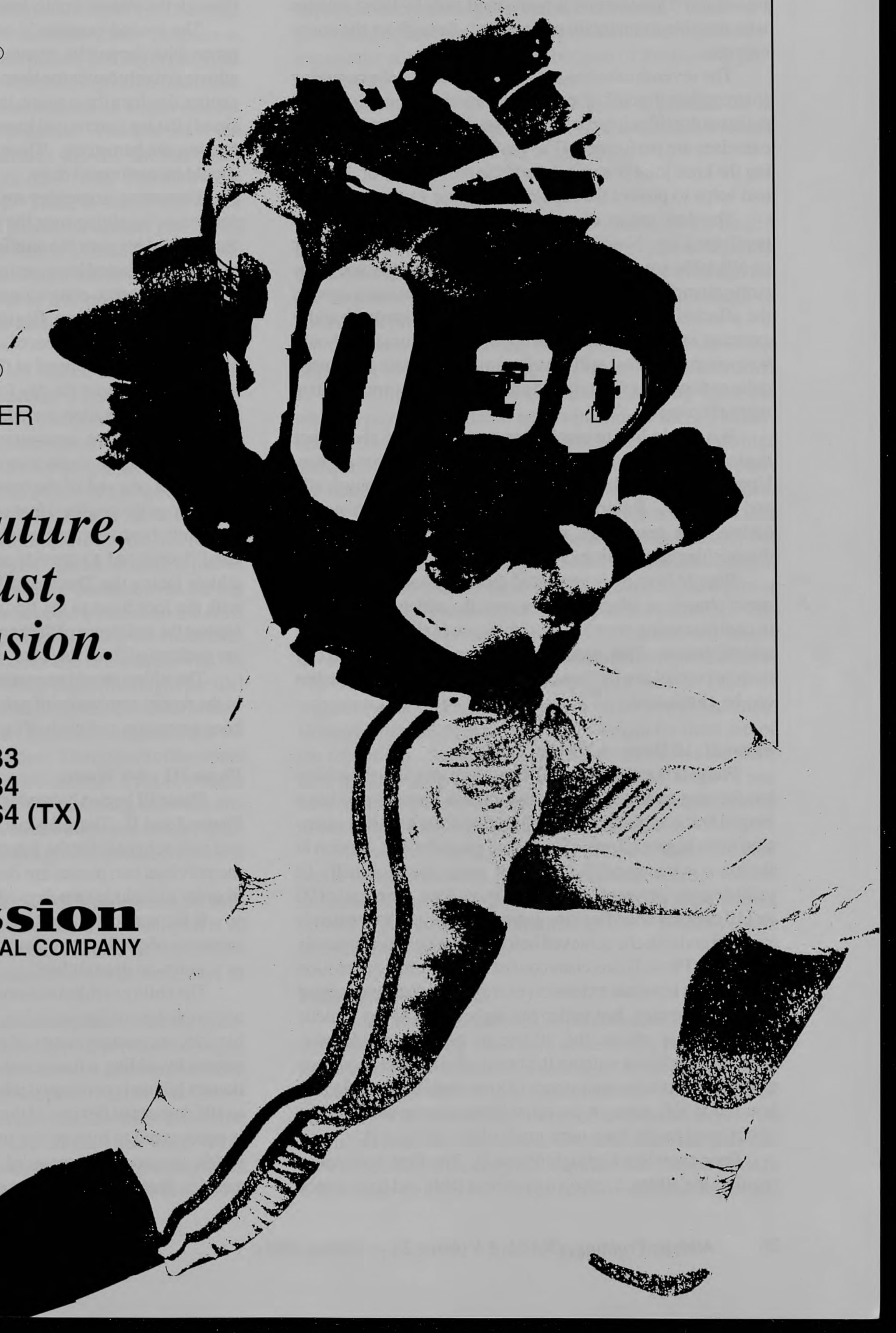
The second exercise is straight leg raises without weights. These are performed lying supine, keeping the affected leg locked in terminal extension by performing a quadriceps set. Fifty repetitions are performed in the morning and fifty at night. These also can be broken down to sets and repetitions (i.e. five sets of ten repetitions or two sets of 25 repetitions).

Table 1. ACL rehabilitation time table

PHASE	TIME	EXERCISE	SETS	REPS
I	0 - 10 days	Quad sets (prone/supine)		100+
		SLR	2	50
		Hip extension	2	50
		Hip abduction	2	50
		Hip adduction	2	50
		Straight legged deadlifts (hams)	3	10
		Ankle exercises with Theraband	4	10
		Unaffected leg exercises		
		Upper body strength and conditioning		
		Aerobic exercise		
II	10 days - 4 weeks	Heel drags (sitting or wall)	3-5	10
		Active knee flex (prone)	3-5	10
		Hamstring isometrics	4	25
		Terminal knee extensions (Theraband)	3	10
III	4 - 8 weeks	Bike		
		Hamstring isotonics	4	10
		Squat motion	3	10
		Side step-ups (3 min.)		90
		Leg press	4	10
IV	8 - 12 weeks	Swimming (time or distance)		
		Power squats (with weight)	3	10
		Toe raises	4	20
V	12 - 16 weeks	Hamstring isokinetics	4	10
VI	16 - 22 weeks	Nautilus leg curls	4	10
VII	22 - 28 weeks	Isotonic knee extensions	4	10
		Jogging (distance)		
		Rope jumping (time)		
VIII	28 - 34 weeks	Isokinetic knee extensions	4	10
		Sprinting (distance/reps)	4	
IX	34 - 40 weeks	Agility drills (distance/reps)	4	
		Plyometrics		
		Sport specific drills		
X	40 weeks-	Maintenance program (pre-exhaust)		

The third, fourth, and fifth exercises consist of hip extension while lying prone, hip abduction while lying on the unaffected side, and hip adduction while lying on the affected side. All of these exercises are performed with the knee in terminal extension. These exercises also help in regaining total leg control. They are performed as straight leg raises with fifty repetitions twice daily.

The sixth exercise in Phase I is a hamstring strengthening exercise performed in a closed chain fashion. Strengthening of the hamstring muscles is performed with straight legged deadlifts without weight. These exercises are also referred to as "good mornings." Keeping the knees locked in terminal extension, the athlete rotates at the hips (not at the waist) and bends forward to approximately 90 degrees while



30

emphasizing and maintaining a "normal" lordotic lumbar curve. The hamstring muscle group is used to extend the hips, contracting in a reverse manner until the athlete is upright. This exercise allows early hamstring strengthening without knee joint involvement. Working the hamstrings in this manner will increase the strength of the hamstrings and allow the athlete to exercise while weight bearing in a closed chain manner. Three sets of ten repetitions are performed daily with no weight. This exercise is performed only by those athletes who are able to maintain perfect form throughout the entire exercise.

The seventh exercise uses Theraband™ or elastic tubing to strengthen the calf. Four sets, ten repetitions each, of active resistive dorsiflexion, plantar flexion, inversion, and eversion exercises are performed. The gastrocnemius muscle, crossing the knee joint posteriorly, adds to the stability of the knee and helps to protect the repaired ACL.

The last group of exercises in Phase I involves the unaffected leg. Nautilus, Orthotron, Universal Gym, and/or an NK table are used to maintain good quadriceps and hamstring strength and power. There may also be a carry-over to the affected leg. If available, an alternative cardiovascular exercise, such as the use of an upper body ergometer, should be encouraged. This will develop and/or maintain cardiovascular endurance, which should allow the athlete to rehabilitate more efficiently.

We would like to emphasize that the athlete should not neglect other areas of the body because of the injured knee. Upper body strengthening may be beneficial both physically and mentally. Returning to the weight room reunites the athlete with teammates in an athletic setting, potentially diminishing any feeling of alienation from the team (12).

Weight bearing is permitted through Phase I and subsequent phases, as tolerated. However, the athlete is instructed to continue using crutches until their use is eliminated by the athletic trainer. Pain, gait mechanics, and hamstring and calf muscle control are factors in determining when the crutches can be eliminated.

Phase II, 10 Days - 4 Weeks

Phase II begins 10 days after surgery, or when the athlete has the cast removed (if one was used in Phase I) and has a hinged brace applied. Range of motion from terminal extension to 30 degrees flexion is allowed immediately. Motion in the brace is increased as the athlete gains flexion usually 10 to 30 degrees per week, with a four week long-term goal of 90 to 110 degrees knee flexion. Isometric terminal extension is stressed and must be achieved before the brace is permanently unlocked. Phase II exercises consist of active range of motion and passive terminal extension exercises. All are performed without the brace, but under the supervision of the athletic trainer. This allows the athlete to become comfortable exercising the knee without the brace. It is critical to educate the athlete about the importance of knee mobilization. Apprehension at this point in the rehabilitation program could be detrimental to the long-term goals of the athlete (18).

Four exercises highlight Phase II. The first, heel drags, requires the athlete to sit on a treatment table and have a sock on the affected leg. The athlete is instructed to actively drag the heel towards the buttocks. This also can be performed lying supine with the foot up on a wall in a gravity assisted position. With the help of the athletic trainer, or using the unaffected leg, the athlete then lets the knee straighten out passively, attaining terminal extension as a goal after each repetition. Three to five sets of ten repetitions are performed daily. We emphasize that this exercise is performed only through the athlete's pain-free range of motion.

The second exercise is active knee flexion while lying prone with the patella situated over the end of a table. The athlete actively bends the knee as far as possible and holds the contraction for a three count, then slowly extends (gravity assisted) the leg to terminal knee extension, eccentrically contracting the hamstring. Three to five sets of ten repetitions should be performed daily.

Hamstring isometrics are the third exercise. These are performed by sitting over the edge of the table and hooking the affected leg over the unaffected leg. The athlete is asked to bend the affected knee, resisting with the unaffected leg. A maximal isometric contraction of six to ten seconds is held at the athlete's maximum flexion and extension. When the athlete achieves 90 degrees of knee flexion, the isometric contraction is also performed at the mid-range. The exercise is repeated throughout the day for at least 100 repetitions, with five-second relaxation periods.

Terminal knee extensions are also performed in this phase in a closed chain manner using Theraband™. The athlete ties one end of the band to a table leg and hooks the other above the popliteal fossa of the affected knee. The knee is slightly bent, approximately 30 degrees, with the Theraband™ stretched to provide adequate resistance. With the athlete facing the Theraband™ attachment to the table and with the foot fixed to the floor, the athlete extends the knee against the resistance of the band. Three sets of ten repetitions are performed three days per week.

The athlete should be continuously monitored and coached in the proper mechanics of gait, emphasizing heel strike with knee extension and push-off with knee flexion.

Phase III - 4-8 Weeks

Phase III begins by reeducating the student athlete about Phases I and II. The subgoals for these phases are reviewed and new subgoals for the future are created. Exercises from the previous two phases are decreased to five days per week in order to include two days of rest.

If the surgical wound has completely healed, whirlpool exercises of gentle active flexion and extension may be added as a warm-up to exercise.

The ability to ride a stationary bicycle is typically a major accomplishment for an athlete. A specific goal, to ride the bicycle, encourages range of motion and builds some self-esteem by adding a functional activity to the program. Stationary biking is performed when the athlete has achieved 95 to 105 degrees of flexion. If this occurs in Phase II, the athlete is encouraged to bike at that time. To help the athlete work within the available range of motion, a high seat with an anterior foot position is recommended (13). The athlete begins riding for ten minutes three days per week, gradually working towards 30 minutes three days per week. At the beginning, no resistance is permitted.

Hamstring isotonic exercise, preferably using an NK table, is performed. Hamstring exercises performed while seated place the hamstring in an elongated position (pre-stretched over the hip joint), thereby allowing maximal force production and efficiency at the knee joint and throughout the athlete's available range of motion. A modified DeLorme (9,11) Progressive Resistance Exercise (PRE) program is used to objectively document the patient's strength progress. This is done by finding the athlete's ten repetition maximum (10 RM), which is the maximum amount of weight that the athlete can produce for ten repetitions. The first set is ten repetitions at one-half of the athlete's 10 RM. The second set is ten repetitions at three-fourths the 10 RM. The third set is ten repetitions at the 10 RM. Then, a fourth set, which consists of the 10 RM plus five pounds for as many repetitions as the athlete can produce pain free, is added. As soon as the athlete can produce ten repetitions on the fourth set, the 10 RM increases by two and a half to five pounds. Hamstring isotonics are performed in this fashion three days per week, preferably every other day.

At approximately four to six weeks, under the supervision of the athletic trainer, the patient is instructed in the mechanics of the power squat (closed chain compound task). No weight is added to the bar at this time. This exercise is performed to prepare the athlete for power squatting in the muscle building phases, and also is used as a range of motion and proprioception exercise. The athlete takes a stance slightly wider than shoulder width apart with the feet rotated outward at a 30 to 45 degree angle. The bar, if used, is placed on the upper back in a low posterior position over the hip joints (11,19). The athlete is instructed to maintain a normal lordotic curve in the lumbar spine and to keep the knees over the forefoot. The athlete then descends into a squat with the knee angle no lower than that which places the thighs parallel to the floor. At the completion of the descent, without bouncing, the hips are extended and the knees are straightened as the athlete returns to a standing position. The posture of the upper body should not change during the exercise. This exercise is performed on the same days as the hamstring isotonics are. The athlete should begin with one to three sets of ten repetitions, gradually working towards a goal of three to five sets of ten repetitions.

At six to eight weeks, lateral side step-ups at a six inch step height are performed in Phase III . The initial goal is 90 repetitions in three minutes, working towards 120 repetitions in five minutes. These are performed on the same days as biking.

The other exercise started in this phase is the leg press. This exercise can be accomplished on either Nautilus, Eagle, or Universal equipment, or on a sled. In our rehabilitation program, the leg press is performed prior to active knee extensions. The decreased lever arm decreases the force at the knee joint, thus decreasing the torque on the knee joint. While using the leg press, the forces on the knee are pushing down through the shaft of the tibia to the foot. While active extensions are performed, the forces push the tibia forward on the femur. Leg press exercises are performed twice weekly, on two of the same days that the hamstring isotonics and the squats are done.

By Phase III the athlete is expected to advance in proficiency to normal ambulation/gait without crutches. It is advised that the athlete begin crutch-free walking with the use of the brace if this was not achieved earlier. However, as gait improves, discontinuing the brace is considered. The athlete's gait should be functional, and he or she should have good neuromuscular control by Phase III because of the training provided by the closed chain exercises.

If post-exercise swelling or effusion is present, ice is applied for 15 to 20 minutes at the conclusion of each workout throughout the remainder of the phases.

Phase IV, 8 - 12 Weeks

Phase IV begins with the total elimination of the hinged brace. We feel the athlete can become psychologically dependent upon the brace. At this point it is believed that the calf and hamstring muscle groups are developed enough to control and protect the knee.

Swimming is performed in this phase on the off-lifting days along with biking and step-ups. The athlete is instructed in swimming for time and distance, depending upon the athlete's physical condition and swimming ability. The athlete is shown how to stabilize the knee using the hamstrings and quadriceps. To prevent forces from water resistance placing stress on the ACL repair, forced kicking is not permitted.

At this point in the rehabilitation program we feel that there is a need for further development of the quadriceps, but not at the expense of stressing the ACL repair/reconstruction. To accomplish this, we have used the (closed chain) power squat with weight successfully for the past six years (11). The free weight squat promotes free weight control and neural development, and it restores confidence to the injured athlete. The same technique employed for squat motion (with or without the bar) in Phase III is again used for power squatting. However, the athlete now squats with weight for three sets of ten repetitions. Squatting is performed on two of the same days as hamstring isotonics, with at least 48 hours of rest between lifts. Every two weeks weight is added to the bar, up to the weight load that the athlete can handle.

Toe raises off a step are also performed in Phase IV. Four sets of twenty repetitions are performed three times a week on the same days as hamstring isotonics, squat motions, and leg presses. The athlete is permitted to use a proprioception balance board at this time.

Phase V, 12-16 Weeks

The orthotron (isokinetics) is performed in Phase V three days per week, on the same days as hamstring isotonics. The unaffected leg is worked at a setting of seven up and seven down for four sets of ten repetitions (or your preferred protocol). The affected leg is worked at speed settings of ten up and three down. The athlete is instructed to bring the bar up without forced kicking, and explode into flexion through a full range of motion. Active resistive extensions are not added until Phase VII.

Phase VI, 16-22 Weeks

By this time the emphasis in the rehabilitation program is to regain strength. New repetition maximums are determined for the NK table, leg press, and squat.

As the hamstrings become stronger, the Nautilus leg curl is added to the program during Phase VI. Using the Nautilus and the NK table, the athlete is able to exercise all components of the hamstring. In addition, the Nautilus hip and lowback machine is added in order to exercise the upper hamstring and gluteal muscles. If available, the hip abduction and adduction machine is used to exercise the abductor and adductor muscle groups. The athlete completes four sets of ten repetitions at a challenging weight. As the athlete gains strength, additional weight is added. The Nautilus exercises are performed three days per week, on lifting days.

Phase VII, 22-28 Weeks

At six months, the athlete is permitted to begin isotonic knee extensions. The athlete is re-instructed in the use of the modified DeLorme (11) Progressive Resistance Exercise program described in Phase III. Because of the strength level in the quadriceps muscle group from performing the leg press, power squat, side step-ups, and biking, the athlete should be able to progress in weight quickly. It should be emphasized to the athlete that he or she must avoid "too much too soon," and should report any signs or symptoms of patello-femoral discomfort. Isotonic knee extensions are performed three days per week on lifting days.

A jogging program begins on the off-lifting days. If it can be accomplished without pain, a normal running gait pattern is reviewed. The athlete begins with one-half mile twice a week, then adds one-half mile every week. The eventual goal is three to five miles dependent upon the athlete's long-term goals and sport.

To improve agility, jumping rope is performed on the off lifting days. Two days per week the athlete jumps rope for two minutes. If no symptoms occur, the time is increased to five minutes. As the athlete becomes more proficient in jumping, alternative exercises requiring increased skill are added. Alternating feet, straddling the rope, and speed jumping are examples of alternative exercises. These also will serve to maintain the athlete's interest.

Phase VIII, 28 - 34 Weeks

The athlete is permitted to adjust the orthotron settings for the affected knee to speeds of seven for flexion and seven for extension (or your preferred protocol). These are performed on the lifting days with the other strengthening exercises.

A sprinting program is also started in Phase VIII. The athlete begins at half speed for fifty yards using straight-ahead strides three days per week, for two weeks. If the athlete is symptom-free then he or she may progress to three-fourths speed and eventually to full speed sprints. Proper upper and lower body form is emphasized. Distance is also gradually increased to one hundred yards. It is important not to compromise form for speed or distance. Full speed sprints, meeting the demands of the particular sport of the athlete, are the goals of this program; however, it is important to have the athlete in good physical condition in order to avoid other injuries.

Phase IX, 34 - 40 Weeks

At nine months, the athlete adds agility and plyometric drills to prepare for return to competition. Included in these exercises are sport-specific drills which may vary from sport to sport, and can be used as functional tests. For example, a soccer player may begin footwork drills, starting at half speed and progressing to full speed. The athlete should also begin some movements that will specifically (but mildly) stress the injured knee.

The following drills/tests are performed on the same days as the sprinting program. Three sets of five repetitions are performed three days per week. All are performed at one-half speed while wearing a brace. If the athlete remains pain-free, then speed can be increased. It is advisable for the athlete to begin the functional agility drills/tests on a soft natural surface. However, the athlete should advance to the playing surface of his or her specific sport, i.e., artificial turf, hardwood floor, etc.

Twenty yard zigzag patterns are instituted. The athlete cuts from the outside leg every five yards. As the athlete progresses, the distance is extended. "Figure eight" patterns are run over a fifty-yard distance. The athlete starts and stops at the bottom of the eight. As the athlete progresses, the "figure eight" pattern decreases in size. If the athlete remains asymptomatic, additional maneuvers are added such as back pedaling and side shuffles. Side shuffles are performed with the athlete shuffling from side to side without crossing the feet. Cross-overs, or "carioca," are used in the same manner. All exercises are initially performed at fifty yards until the athlete progresses. For the functional drills, the final progression is to the cutting maneuvers. Two types of maneuvers are performed, the straight cut and the cross-over cut. A straight cut involves the athlete planting the affected foot and cutting to the opposite direction. In the cross-over cut, the athlete brings the affected leg across the body and cuts to the same side as the leg was planted (1). These exercises are started at one-half speed at a distance of twenty yards, gradually increasing speed and distance as the athlete improves.

Phase X, 40 Weeks

Depending on the athlete's goals and time frame, a maintenance regimen, using our program's concepts as a foundation, is prepared so the athlete can return to competition. This may involve a summer program designed for the athlete's team or easing him or her into team practice. More recently, we have used the pre-exhaust strengthening principle at this time. When using squats, we will pre-exhaust the knee with knee extensions. The athlete performs a set of ten repetitions of knee extensions followed immediately by ten repetitions of squats. The athlete then takes a two-minute rest and repeats this sequence for four sets. We feel that when you use an open chain single joint exercise followed immediately

by a closed chain compound movement, you are pre-exhausting the joint and allowing for strengthening, endurance, and power of both the joint stabilizers and dynamic movers.

We then follow this principle for the hamstrings. We pre-exhaust with open chain single joint movement hamstring curls, followed immediately by closed chain straight legged deadlifts, as described in Phase I but with the use of weight.

DISCUSSION

Traditionally, most rehabilitation programs have taken a slow, conservative approach to returning the athlete to competition. Most of those researchers were acting on existing information and concentrating on protecting the repair rather than returning the athlete to full function (7,10,16,20,26). Through advances in surgical techniques and increased research in rehabilitation, accelerated rehabilitation programs are being developed and used (4,11,18,24,25).

Probably the most significant advance is early terminal extension exercises. Previous research cited the need to limit extension to 30 degrees flexion to prevent compromising the ACL repair (2,20,21). However, this practice led to post-surgical complications such as quadriceps weakness, flexion contracture, and patello-femoral irritation (18,22). New data emphasizes the need for early quadriceps work to prevent post-surgical complications (22,23,24,25). In support of this research, our program emphasizes early quadriceps strengthening and the need to maintain terminal knee extension. We also concur with Shelbourne (24) who recognizes that terminal extension should be equal to the contralateral leg, not to zero degrees of flexion.

Other rehabilitation programs use isokinetic testing at six months or earlier in their rehabilitation programs (7,24,26). In our program, isokinetic testing is delayed to Phase VIII or IX. The athlete has not been permitted to isokinetically strengthen the quadriceps; therefore, a predictable slight weakness will be found. This could present negative feedback to the athlete, which should be avoided at all times. This weakness should considerably decrease after four to six weeks of isokinetic strength training. We prefer to employ subjective functional testing to evaluate the athlete's progress. We agree with Voight's (28) use of the three Cs (carriage, control, and confidence) as functional parameters. Carriage is the athlete's ability to perform smooth, symmetrical movement. Control is the athlete's ability to decelerate without placing undue stress on the joint. Confidence is the athlete's overall approach to using the injured knee (28). Our primary task is to prepare the athlete to return functionally. Functional training will lead to increased isokinetic scores; however, isokinetic training will not always lead to increased functional scores (28).

When evaluating a rehabilitation program, one important variable to consider is the patient population. Our program is a direct reflection of our patient population, and is directed to meet the particular goals of college student athletes. These athletes' goals are much different from other population's goals, and their academic schedules do not allow much time out of classes.

A second variable of utmost importance is the time parameter required for safe return to competition. Although precise time parameters remain largely undetermined, many accelerated rehabilitation programs are using six months (4,23,24,25). We prefer using up to ten months when returning athletes to high contact and cutting sports in order to allow graft and soft tissue healing, maturation, psychological conditioning, and regaining confidence in the injured knee. Steadman et al. (25) suggest that a minimum rehabilitation period for competitive athletes is ten months, especially for high impact pivoting sports such as football, volleyball, and basketball. Shelbourne (24) further suggests that athletes need to begin participating in their particular sport for at least two months prior to returning to full competition. Our program is generally designed for ten months, but can be varied to accommodate the individual needs of our athletes. Some athletes progress more rapidly and may resume functional activities in six to eight months; however, we feel additional time is necessary to return the athlete to full athletic competition.

SUMMARY

Although many protocols for knee rehabilitation following primary repair/reconstruction of the ACL have been described over the past 10 years, we feel that our program has allowed our student athlete population to fully attain their short-term and long-term goals in an academic setting with minimal time lost from classes, rapid return to activities of daily living, and a reasonably rapid return to their specific sport. The initial short immobilization period and lack of CPM has not been detrimental to knee motion. In fact, in some cases, motion has been achieved earlier because of better pain relief in the immediate post-operative period and maintenance of full extension.

ACKNOWLEDGEMENT

We would like to thank Dr. Mary Turner DePalma, Assistant Professor, Department of Psychology, Ithaca College, Ithaca, New York, for her contributions to this manuscript.

REFERENCES

1. Antich TJ, Brewster CE: Rehabilitation of the nonreconstructed anterior cruciate ligament-deficient knee. In Indelicato PA (ed): *Clinics in Sports Medicine*. Philadelphia, PA: W.B. Saunders, 1988, pp. 813-826.
2. Arms SW, Pope MH, Johnson RJ, Fischer RA, Arvidsson I, Eriksson E: The biomechanics of anterior cruciate ligament rehabilitation and reconstruction. *Am J Sports Med* 14:285-290, 1986.
3. Barata R, Solomonow M, Zhou BH, Letson D, Chuinard R, D'Ambrosia R: Muscular coactivation. *Am J Sports Med* 16: 113-122, 1988.
4. Calliouet H: Knee rehabilitation following anterior cruciate ligament injury. *Sports Medicine Update* 4: 15-18, 1989.
5. Coaches Roundtable: The squat and its application to athletic performance. *The National Strength and*

Conditioning Association Journal 6: 10-22, 1984.

6. Coutts RD, Craig EV, Mooney V, Osterman AL, Salter RB: The use of continuous passive motion in the rehabilitation of orthopaedic problems. *Contemporary Orthopaedics* 16: 75-111, 1988.
7. Crochet DJ: Anterior cruciate ligament rehabilitation: Conceptual approach. *Sports Medicine Update* 4(1): 11-14, 1989.
8. DeCarlo MS, Shelbourne KD, McCarrol JR, Rettig AC: Rehabilitation following anterior cruciate ligament reconstruction. Presented at the 41st Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association. Indianapolis,IN, June 12, 1990.
9. DeLorme TL, Watkins AL: *Progressive Resistance Exercise: Techniques and Medical Application*. New York, NY: Appleton-Century-Crofts, Inc., 1952.
10. Delitto A, Lehman RC: Rehabilitation of the athlete with a knee injury. In Lehman RC, Delitto A (eds): *Clinics in Sports Medicine*. Philadelphia, PA: W.B. Saunder, 1989, pp. 805-840.
11. DePalma BF, Zelko RR: Knee rehabilitation following anterior cruciate ligament injury or surgery. *Athletic Training, JNATA* 21: 200-206, 1986.
12. DePalma MT, DePalma B: The use of instruction and the behavioral approach to facilitate injury rehabilitation. *Athletic Training, JNATA* 24: 217-219, 1989.
13. Ericson MO, Nissel R: Tibiofemoral joint forces during ergometer cycling. *Am J Sports Med* 14: 285-290, 1986.
14. Gieck J: Psychological considerations of rehabilitation. In Prentice W (ed): *Rehabilitation Techniques in Sports Medicine*. St Louis: Times Mirror/Mosby, 1990, pp. 24-33.
15. Henning SE, Lench MA, Glick KR: An in-vivo strain gauge study of elongation of the anterior cruciate ligament. *Am J Sports Med* 13: 22-26, 1985.
16. King S, Butterwick DJ, Cuerrier JP: The anterior cruciate ligament: A review of recent concepts. *J Orthop Sports Phys Ther* 8: 110-122, 1986.
17. Moyer JA: Rehabilitation goals in sports medicine. In Prentice W (ed): *Rehabilitation Techniques in Sports Medicine*.St Louis: Times Mirror/Mosby, 1990, pp. 24-33.
18. Noyes FR, Mangine RE, Barber S: Early knee motion after open and arthoscopic anterior cruciate ligament reconstruction. *Am J Sports Med* 15: 149-160, 1987.
19. O'Shea P: The parallel squat. *The National Strength and Conditioning Association Journal* 7: 4-6, 1985.
20. Paulos L, Noyes FR, Grood E, Butler DL: Knee rehabilitation after anterior cruciate ligament reconstruction and repair: *Am J Sports Med* 9: 140-149, 1981.
21. Renstrom P, Arms SW, Stanwyck TS, Johnson RJ, Pope MH: Strain within the anterior cruciate ligament during hamstring and quadriceps activity. *Am J Sports Med* 14: 83-87, 1986.
22. Sachs RA, Daniel DM, Stone ML, Galfein RF: Patellofemoral problems after anterior cruciate ligament reconstruction. *Am J Sports Med* 17: 760-765, 1989.
23. Seto JL, Brewster CE, Lombardo SJ, Tibone JE: Rehabilitation of the knee after anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther* 11: 8-18,1989.
24. Shelbourne DK: ACL's, researching repairs and rehabilitation. Presented at the 41st Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association. Indianapolis, IN, June 13, 1990.
25. Steadman JR, Forster RS, Silferskiold JP: Rehabilitation of the knee. In H. Royer Collins (ed): *Clinics in Sports Medicine*. Philadelphia, PA: W.B.Saunders, 1989, pp. 605-627.
26. Steadman JR, Higgins RW: ACL injuries in the elite skier. In Feagin JA (ed): *The Crucial Ligaments*. New York, NY: Churchill-Livingstone, 1989, pp. 471-482.
27. Solomonow M, Barata R, Zhou BH, Shoji H, Bose W, Beck C, D'Ambrosia R: The synergistic action of the anterior cruciate ligament and thigh muscles in maintaining joint stability. *Am J Sports Med* 15: 207-213, 1987.
28. Voight M, Tippet S: Closed kinetic chain. Presented at the 41st Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association. Indianapolis, IN, June 12, 1990.
29. Walla DJ, Albright JP, McAuley E, Martin RK, Eldridge V, El-Khoury G: Hamstring control and the unstable anterior cruciate ligament deficient knee. *Am J Sports Med* 13: 34-39, 1985.
30. Whieldon T, Yack J, Collins C: Anterior tibial displacement during weight bearing and non-weight bearing rehabilitation exercises in the anterior cruciate deficient knee. Presented at the 40th Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association. Dallas, TX, June 13, 1989.

Rapid Rehabilitation Following Anterior Cruciate Ligament Reconstruction

Dale F. Blair, MS, ATC, CSCS
Robert P. Wills, MD

ABSTRACT: An aggressive rapid rehabilitation program can return athletes quickly and safely to their previous levels of activity following anterior cruciate ligament reconstruction (ACLR). An intra-articular, bone-patellar tendon-bone procedure without extra-articular reconstruction provides a solid fixation and, when isometrically placed, allows an aggressive rehabilitation program. The early results of the program are very encouraging. Athletes have returned to competitive athletics at 4 to 6 months postoperatively, depending upon strength, functional ability, and sport activity. Early motion and weight bearing are the cornerstones of the program. It has been documented in a study by one of the authors that there was no significant difference in anterior-posterior laxity between early motion/early weight bearing patients versus braced or casted/delayed weight bearing patients in a follow-up of 137 ACLR cases. Continuous passive motion (CPM) begins immediately following surgery while the patient remains under the effect of a long-lasting regional anesthetic. The formal rehabilitation program begins at 5 to 7 days postoperatively. Passive extension/flexion, stationary bicycling, muscle stimulation, and a series of heavy rubber tubing exercises are started at this time. Patients progress from partial to full weight bearing within two weeks post-operatively. Emphasis is placed on closed kinetic chain activities (leg press, quarter squat, etc.) and proprioceptive exercises as the rehabilitation progresses. Light agility activities and jogging may be started at six weeks when the involved extremity reaches 70% of the uninvolved extremity on high speed isokinetic testing. Sports specific drills and a more intensive strengthening program follow in a progressive manner. Although our preliminary observations are very positive, a larger patient base and longer period of follow-up is needed to determine the long-term success of the "rapid rehabilitation" protocol.

Dale Blair is Head Athletic Trainer at the Wenatchee Valley Clinic Sports Medicine Center and Head Athletic Trainer/Director of Sports Medicine at Wenatchee Valley College, Wenatchee, Washington, 98801.

Robert Wills is an orthopedic surgeon at the Wenatchee Valley Clinic Sports Medicine Center and Team Physician at Wenatchee Valley College and Wenatchee High School.

One of the most controversial areas in the field of sports medicine involves the rehabilitation following anterior cruciate ligament (ACL) reconstruction. The literature has described numerous programs used to rehabilitate the knee and return the patient to the previous level of activity (3,5,8,10,12,14,15,16,17,18,22,31,36,37,38,44,45,46,47,51). However, as more studies are performed involving the ACL, a higher level of knowledge can be acquired regarding the ACL rehabilitation process. This paper describes a rapid rehabilitation protocol that uses early motion and weight bearing. Athletes may return to sports at four to six months following surgery if certain functional criteria are met.

ANATOMY

The anterior cruciate ligament (ACL) is an intra-articular structure that has its origin anteriorly and laterally to the anterior tibial spine, and its insertion on the posteromedial aspect of the lateral femoral condyle (42). The ACL's primary function is to prevent anterior translation of the tibia on the femur. The ACL also functions as a second rotatory stabilizer of the knee.

The ACL is comprised of three main bundles of fibers (the anteromedial, the intermediate, and the posterolateral). Each bundle has a specific function in regard to the stability of the knee (42). The anteromedial bundle is taut in both flexion and extension, and contributes to the anterolateral stability. The intermediate bundle provides stabilization to the knee in straight anterior and anteromedial stresses. The posterolateral bundle is tight in extension and lax in flexion, and provides posterolateral stability. If the anteromedial bundle was sectioned, a positive anterior drawer sign would result (42). The ACL acts as the principle restraint in the anterior drawer test providing about 86% of the total resistive force (42). The remaining 14% is provided by secondary restraints, the surrounding ligaments, and the joint capsule. The three bundles of the ACL comprise a complex structure that is difficult to reproduce. If a graft replacement is incorrectly positioned, additional stress or impingement may occur. An isometrically placed graft will maintain constant length and tension throughout a full range of passive motion (39). It has been shown that the isometric placement of an ACL graft provides a strain pattern similar to the normal ACL (1).

SURGERY

Many types of intra-articular surgical reconstructive procedures for the ACL have been described in the literature (9,23,26,28,29,39,41,42,46,54). Wills et al. (54) and Roth et al. (41) found no significant difference in the stability of combined intra- and extra-articular procedures when compared to the stability after intra-articular procedures alone. A bone-patellar tendon-bone reconstruction provides immediate stability, and allows a more aggressive rehabilitation program as a result of interference screw fixation. There are many effective surgical procedures that use the patellar tendon. We use a modified Rosenberg ("inside-out") procedure, which involves placing the femoral screw transarticularly; it is performed through a single four centimeter incision.

Pre-operative

It is imperative that the ACL problem be properly diagnosed prior to surgery. A complete history, in conjunction with ligament laxity tests and knee arthrometry (11), helps the clinician to confirm an ACL tear. It is very important that our patients be positively identified as ACL reconstruction candidates before surgery, as a long-lasting regional anesthetic needs to be admininstered for early motion protocol. Thus, the decision to perform the reconstruction cannot be made during the arthroscopy.

Shelbourne (46) found that it was not crucial to perform ACL recontructions immediately after an injury. He demonstrated a decreased incidence of postoperative flexion contractures in those patients whose surgery was performed more than one week following their injury. Also important is the delay of surgery to allow patients to plan around their school or work, and to provide them the time they need to mentally and physically prepare for it.

A positive mental attitude is extremely important before surgery. The patient needs to be given positive reinforcement concerning his or her athletic future. Many athletes feel that their competitive careers are over following an ACL injury. It is important to allay their fears by setting up attainable goals and emphasizing the positive aspects of the rehabilitation. Those patients who go into surgery with a positive mental outlook and realistic goals tend to be best prepared to handle the post-surgical results.

It is also important to make other arrangements before the surgery is performed. For example, many insurance carriers need prior authorization to cover the continuous passive motion apparatus required for home use following an ACL reconstruction.

REHABILITATION

The rehabilitation program plays a major role in the final result of an ACL reconstruction. We have found that an aggressive "rapid rehabilitation" program can return patients to their previous level of activity quickly and safely in four to six months. Shelbourne and Nitz (42) found that the patellar tendon graft remains consistently viable and attains its maximum fibroblast size and number by the sixth postoperative month. None of the biopsy samples demonstrated more than a partial central necrosis. These findings support the theory that grafts can match the physical stresses required of an accelerated ACL rehabilitation program.

The program described in this paper outlines some general guidelines for an accelerated ACL rehabilitation program (Table 1). The protocol is patient driven as each is guided through the program. General recommendations are given to the patient regarding sets, repetitions, and rest periods, but the actual intensity of the program is based upon what the patient is functionally able to perform. Only those restrictions that are absolutely contraindicated, e.g., to avoid open kinetic chain quadriceps exercises, etc., are imposed on the athlete. Athletes tend to respond better if they are given a list of things they may do as opposed to a list of things they should not do.

Among patients, there are obvious differences that may account for minor variations in the basic rehabilitation program. These differences may include additional surgical procedures performed with reconstruction, previous pathology or surgeries, patient's motivation and pain tolerance, etc. Throughout the discussion of the rehabilitation program, a rationale will be presented based on recent studies conducted in this area.

Immediate Postoperative Treatment

Immediately following surgery, continuous passive motion (CPM) is used while the patient remains under the effects of a long-lasting regional anesthetic. It has been determined that CPM can be beneficial in decreasing muscle atrophy (35), reducing adhesions and scar tissue, promoting articular cartilage nourishment, reducing pain, and increasing range of motion (19,36). Arms et al. (1) stated that there is only minimal stress placed on the ACL during passive extension and flexion. Disuse was also found to weaken bone-ligament-bone preparations in animal models (35,36). Noyes (35) described no deleterious effects in regard to increased ligamentous laxity as a consequence of early motion. Wills et al. (54) found no significant difference in anterior-posterior (AP) laxity between casted knees and early motion knees.

The slowest speed of the CPM is used initially. Range of motion is set at 0° extension to 90° flexion immediately following surgery while the patient remains under the effects of the regional anethestic (for approximately 20 hours). The range of motion is set and gradually increased (usually 5° of flexion each day) based upon the patient's pain tolerance. The patient will use the CPM on an at-home basis upon discharge from the hospital for eight hours or longer per day, depending upon patient comfort for the first two weeks.

It is also vital to begin passive extension range of motion immediately following surgery. The foot should rest on pillows to allow full passive extension as the knee sags straight. Prone leg hangs, which involve the patient lying

Table 1. Rapid rehabilitation protocol

Immediately Following Surgery
- Continuous passive motion while under effects of long lasting regional anesthetic

2-3 Days Post Operatively
- Continue CPM; 0-90° ROM goal.
- Prone leg hang, 3-4 times daily for 20-30 minutes
- Partial weight bearing with crutches and knee immobilizer as tolerated

5-7 Days Postoperatively
- Continue CPM; 0-95° ROM goal, continue prone leg hang.
- Wall slides, towel pull, opposition bending, passive stationary biking for flexion
- Electrical muscle stimulation with co-contractions of quadriceps and hamstrings; patellar mobilization
- Heavy rubber tubing exercise: hip flexion, extension, abduction, adduction, (resistance above knee) closed kinetic chain terminal knee extensions; tubing hamstring pull-back; seated toe raises
- Partial weight bearing with progression to full weight bearing

10-14 Days Postoperatively
- Continue prone leg hang and add gentle joint mobilization; soft tissue release, if full extension has not been acheived at this time; continue flexion ROM 0-100° ROM goal.
- Full weight bearing at this time, decrease use of knee immobilizer (depends on amount of walking and outdoor conditions)
- Continue above strengthening; add active cycling on stationary bike, leg press (tubing or weight), 2" step-ups, 1/4 squat with tubing, isotonic hamstring curls.

3-4 Weeks Postoperatively
- Continue ROM as needed, 0-120° ROM goal.
- Continue above strengthening; add toe raises, 4" step-ups, 1/4 squat with tubing on mini-trampoline, scooter drills. [All quadriceps strengthening performed through closed kinetic chain exercises, NO open chain quadriceps exercises (except isokinetic testing, with Anti-Shear) are performed in the first 4 months].
- Isokinetic hamstring exercises (concentric/eccentric)
- Proprioceptive exercises (one foot balancing, unidirectional balance board)

6 Weeks Postoperatively
- Continue as above; ROM should be full at this point.
- Continue strengthening as above.
- Add intensive proprioception [one foot multi-directional balance board (also 1/4 squat with tubing on board), sport-specific drills, proprioceptive toe raises, balance baord walking].
- Add slide board, Fitter, and Pogo Ball.
- Isokinetic evaluation at 180°/sec. with a 20° extension stop with Anti-Shear is performed at this time; if strength is 70% of the uninvolved leg, the athlete may begin light functional drills (light jogging, agilities, jumping rope). ?

2-3 Months Postoperatively
- Continue strengthening as above.
- Begin or add more agilities; important not to slack off at this time as the knee begins to feel more functional (a common occurence).
- Isokinetic testing every two to four weeks; important to do follow-up testing to find residual weaknesses

4-6 Months Postoperatively
- Athlete can return to activities at this time depending upon:
  - Level of strength
  - Absence of residual swelling
  - Good stability (as measured by knee arthrometry)
  - Functional abilities
  - Amount of cutting required in sport.
- Athlete continues to work intensively on strengthening, proprioceptive, and agility exercises

prone on a table with the knee hanging over the edge,are a key exercise for regaining terminal extension (Figure 1). Those patients who do not achieve full extension in the first six weeks have more difficulty attaining a straight knee which may ultimately result in a flexion contracture (46). Sachs et al. (43) found flexion contractures greater than five degrees strongly correlated with anterior pain, crepitus, and a poor postoperative functional result. A quick estimate of knee extension can be measured with the patient prone, with both lower limbs hanging off the end of a table. One centimeter of heel height difference equals approximately one degree of flexion contracture (43).

Patients usually weight-bear to comfort on the affected knee two to three days postoperatively. A knee immobilizer allows the patient to maintain full knee extension and prevents hyperextension as well as varus and valgus forces. The immobilizer is used regularly in the first week postoperatively and is gradually removed by the end of the second week in most cases. The amount of use may also depend upon the patient's comfort, the amount of walking, and the outdoor conditions (snow/ice).

Shoemaker and Markolf (48) concluded that AP laxity as

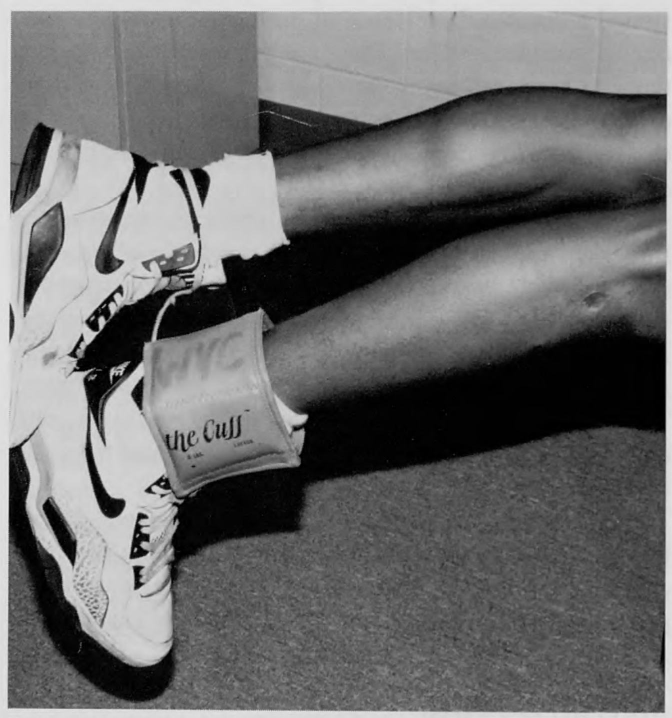
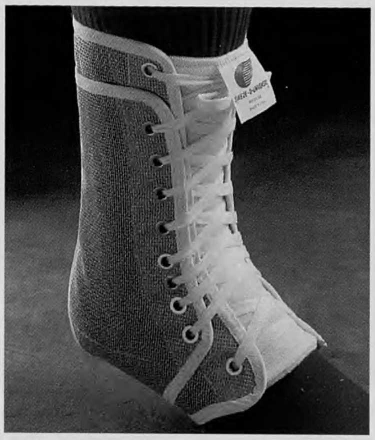
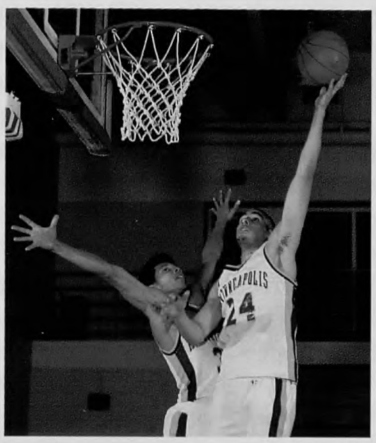
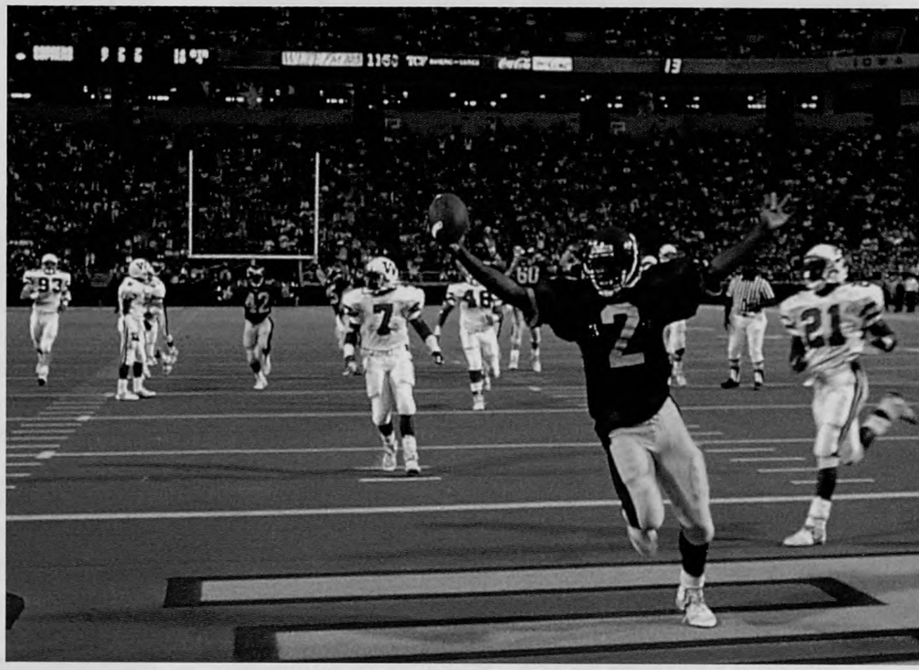


Figure 1. Prone leg hang







a result of sectioning of the ACL was significantly reduced when a joint load of 925 Newtons was applied to the knee. These findings are likely a consequence of an increase in the tibiofemoral congruency and compression of the menisci, which would indicate that early weight bearing applies only minimal stress to the ACL graft.

FIVE TO SEVEN DAYS POSTOPERATIVELY

At approximately five to seven days postoperatively, a formal rehabilitation program is initiated. The patient will continue to use the CPM until the maximal range of motion available in the apparatus is reached. A home rehabilitation program is implemented in addition to the supervised program. The program consists of gentle passive extension, active/passive flexion range of motion exercises, isometric exercises, and selected rubber tubing exercises.

Range of Motion

Wall Slide. While wearing a stocking on the involved foot and lying on the back, the patient slides the foot down a wall. The uninvolved leg can be used to assist in sliding the involved leg down the wall.

Assisted Flexion/Extension. The uninvolved leg passively extends and flexes the knee as the patient is in a sitting position. At no time are the quadriceps contracted.

Prone Leg Hang. Passive leg hangs are continued at this time. Additional passive resistance can be added using the uninvolved leg and/or a sandbag weight. Gentle passive stretching and joint mobilization can also be implemented while the athlete is in this position.

Stationary Exercise Bicycle. Stationary bicycling can be started with the uninvolved leg pedaling actively and the involved leg moving passivly. Because complete revolutions may not be accomplished initially, partial revolutions can be performed until the range of motion allows a full revolution. Henning et al. (21) found extremely low amounts of stress applied to the ACL in their *in vivo* study (only 7 percent of an 80 pound Lachman test). Adjusting the height of the bicycle seat is an important factor in regaining range of motion. The seat can be raised to emphasize extension and lowered to stress flexion.

Patellar Mobilization. Patellar mobilization is important to prevent patellofemoral compression syndrome. The patella is often very immobile following ACL reconstruction (43). The adhesions and scar tissue can be minimized by mobilizing the patella in multi-directional planes.

Quadriceps/Hamstring Co-Contractions. Isolated quadriceps contractions can exert loads near the deforming range. Thus, isolated quadriceps contractions should be avoided for the purpose of strengthening. However, simultaneous isometric contractions of the quadriceps and hamstring muscles (co-contractions) are effective in regaining muscular strength and reducing muscle atrophy without producing the same anterior tibial excursion as an isolated quadriceps contraction. The contractions should be held for six seconds and performed 20 to 40 times each waking hour.

The co-contractions are also used in conjunction with electrical muscle stimulation (EMS). Several authors have described the use of EMS in the rehabilitation of the ACL reconstruction (1,13,34,49). EMS can aid in the re-education of the quadriceps and/or the hamstrings and can help improve muscle tone early in the rehabilitation process, because it may be difficult to regain thigh muscle girth and strength postoperatively.

Biofeedback units also may be beneficial in providing feedback for muscular contractions. These units are mini-electromyography devices that measure the electrical activity in the muscles, and provide the patient with information pertaining to the effectiveness of his or her muscle contraction.

Pillow Squeeze. A pillow or pad is placed between the thighs with the patient in a long sitting position; the knees and hips are flexed up to approximately 45°. The hip adductors are isometrically contracted against the pillow. It has been suggested that some fibers of the vastus medialis obliquus (VMO) attach to the adductor tendons (42) and that adductor strengthening may improve patellar tracking (45).

Hip Flexion, Extension, Abduction, and Adduction. Strengthening exercises with resistance provided against hip flexion, extension, abduction, and adduction can be performed with heavy rubber tubing. The end of the tubing is attached above the knee so that minimal or no stress is imposed on the ACL graft. These exercises are performed while standing on the uninvolved leg and holding onto a chair or stool. It is important to concentrate on both concentric and eccentric phases of the exercises. As the rehabilitation progresses, the tubing may be looped around the ankle on all exercises except hip flexion.

Seated/Standing Toe Raise. Starting from a sitting position with the knees flexed to 90°, the patient performs toe raises. Weight is progressively added to the top of the knee. When full weight-bearing is permitted, standing toe raises can be performed with resistance (e.g., a weighted backpack). The standing toe raise and seated toe raise are effective in strengthening the triceps surae, which helps to control tibial motion.

Seated Hamstring Pull. This exercise is performed while the patient is in a seated position with rubber tubing attached in front of the patient and around the ankle. The involved foot slides posteriorly along the floor and then is slowly returned to the starting point for eccentric hamstring strengthening. Hamstring strength is of vital importance in controlling anterior tibial excursion.

Hamstring curls performed on traditional isotonic equipment can be added to the hamstring strengthening program as permitted by range of motion and pain.

Chair Scoot. A chair with wheels can function as an effective strengthening modality (Figure 2). "Walking" the chair forward while in a sitting position strengthens the hamstrings and, if done for extended periods, can enhance hamstring endurance. A carpeted floor provides additional resistance.

TEN DAYS TO TWO WEEKS POSTOPERATIVELY

Closed Kinetic Chain Exercises

Closed kinetic chain exercise (with the distal body segment stabilized) increases joint stability through greater joint

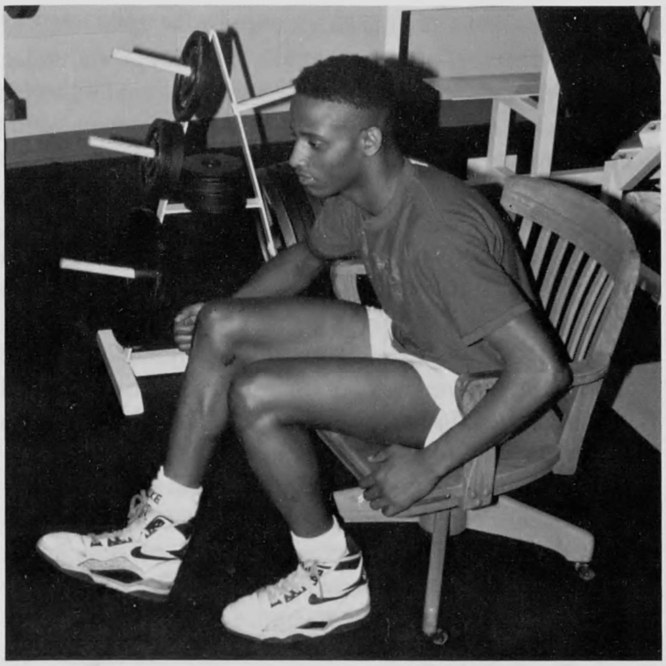


Figure 2. Chair scoot

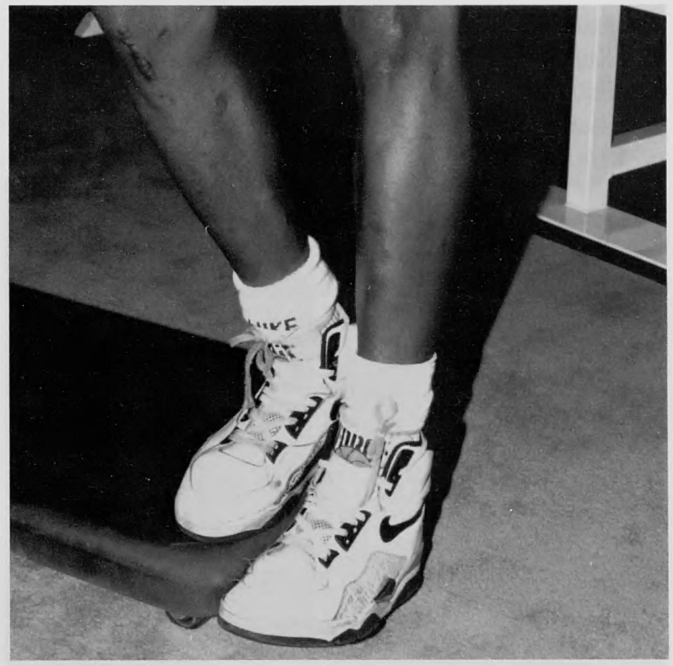


Figure 3. Step-ups

congruency (48) and through active contraction of the muscles that help to control the stability of the knee. In the work of Henning et al. (21), "closed chain" exercises produced considerably less anterior posterior translation than "open chain" (distal body segment not stabilized) activities. They found that the half squat produced 21 percent ACL elongation as compared to an 80 pound Lachman test, while open chain contractions at full extension resulted in 107 percent elongation (21). Washco et al. (53) discovered that significantly less anterior tibial translation occurred with tibiofemoral joint compression (closed chain) when compared to a no compression condition (open chain). Solomonow et al. (50) found that direct stress to the ACL also may have an inhibitory effect on the quadriceps musculature which would further contraindicate "open chain" exercises.

Step-ups. Step-ups can be started as soon as full body weight can be supported by the involved leg. The patient stands on a two-inch high block of wood. The patient may hold on to a chair back for balance in the early stages of rehabilitation. The heel of the uninvolved leg touches the floor as the body is lowered in a slow, controlled fashion (Figure 3). The body is then raised to the starting position. Block height is set at two inches initially, then gradually raised to six inches over the course of the rehabilitation program. The step-ups help to promote muscle control through the improvement of proprioception and eccentric strengthening.

Leg Press. The leg press, also classified as a closed kinetic chain activity because the distal segment is stabilized, effectively strengthens the quadriceps with minimal stress. The leg press (or hip sled) can be performed with either an isotonic machine or with heavy rubber tubing. The range of motion should be limited to the final 30° of motion. Increased knee flexion tends to apply greater compressive forces to the patellofemoral joint.

Closed Kinetic Chain Terminal Knee Extensions. Closed kinetic chain terminal knee extensions provide functional strengthening of the quadriceps by placing rubber tubing above the knee (Figure 4). With the foot fixed, the patient moves from 30° of flexion to full extension against the resistance of the tubing. Special attention is given to avoid hyperextension of the knee.

Quarter Squats with Tubing. While standing on a piece of heavy rubber tubing, the patient performs a quarter squat from full available extension to approximately 30° of flexion (Figure 5). The key to this exercise is the eccentric (down) phase of the squat. It is felt that these functional eccentric exercises are of paramount importance in returning

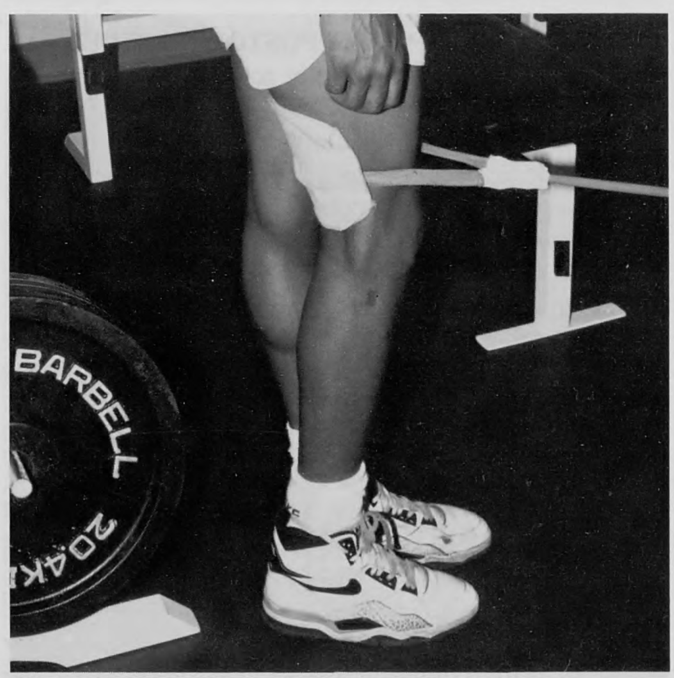


Figure 4. Closed kinetic chain terminal extensions

the quadriceps to a competitive level of strength.

Stair Machine. A stair machine (such as the StairMaster 4000) provides effective closed chain resistance in order to enhance quadriceps strength and endurance. Range of motion can also be controlled by the athlete.

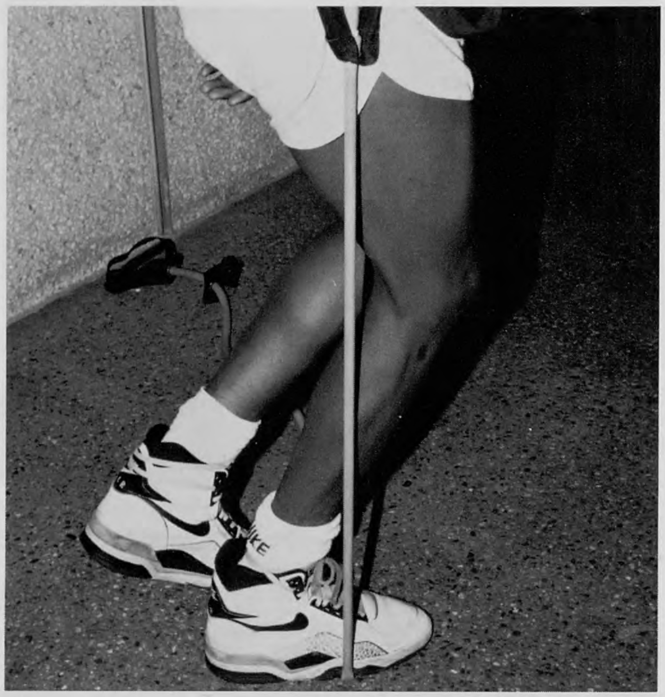


Figure 5. Quarter squat with tubing

Full weight bearing is permitted as soon as the patient is comfortable bearing weight, the knee can be extended fully, and the patient can walk with only a minimal limp. Patients need to be nondependent of crutches within two weeks postoperatively.

THREE TO FOUR WEEKS POSTOPERATIVELY

If full knee extension is not achieved at this time, a spring-loaded extension apparatus, Dyna-Splint (Landmark Medical, Baltimore, MD), is utilized. This spring-loaded splint can be worn at night and/or during the day, according to the manufacturer's protocol. This device is rarely needed if prone leg hang exercises are started early and performed diligently. All previously described range of motion and strengthening exercises are continued during this stage. Gradual increases in resistance and repetitions are added as the rehabilitation program progresses. The following exercises are added to the program as tolerated by the patient.

Scooter. Use of a large child's scooter provides muscular endurance and strengthening for the quadriceps musculature (27). The pushing motion is similar to the quarter squat and can be done over longer distances to improve muscular endurance. The scooter is also beneficial in proprioceptive reeducation.

Swimming and Pool Activities. Pool activities are beneficial as the dynamic resistance of the water aids in the strengthening of the supportive musculature. The buoyancy of the water allows the patient to continue the early range of motion and strengthening exercises without placing undue stress on the knee. Flotation vests are useful modalities for treading water in a pool. Swimming is also recommended for general strengthening and cardiovascular conditioning. The intensity and duration of pool activities is dependent upon the patient's rehabilitative progress.

One Legged Cycling. Single leg cycling isolates the involved leg and forces the hamstrings to pull the leg through the upswing of the cycling motion.

Tibial Internal/External Rotations. Strengthening the tibial internal and external rotators can be accomplished through the use of surgical tubing or the multi-axial ankle exerciser (Multi-Axial Inc., Lincoln, RI).

Proprioceptive Exercises. Proprioception has been described by many authors in relation to ACL rehabilitation (4,8,10,18,20,27,37,38,45). Barrack et al. (4) found that patients with instability following complete ACL tears may experience a decrease in proprioceptive function of the knee. Our program employs a series of activities to regain lost proprioception. Many of these exercises include components of strengthening as well. This progression includes the following proprioceptive/strengthening exercises, some of which may be started at this time while others are begun later in the program:

- One foot balancing with eyes closed
- One foot balancing with eyes closed while performing a quarter squat (progressing to tubing)
- One foot balancing on a mini-trampoline
- One foot balancing on a mini-trampoline while performing a quarter squat (progressing to tubing)
- Two foot unidirectional balance board
- One foot multidirectional balance board
- One or two foot multidirectional balance board (Figure 6) (Sport specific drills can be performed on the balance board; e.g., the patient can dribble or shoot a basketball while balancing.)

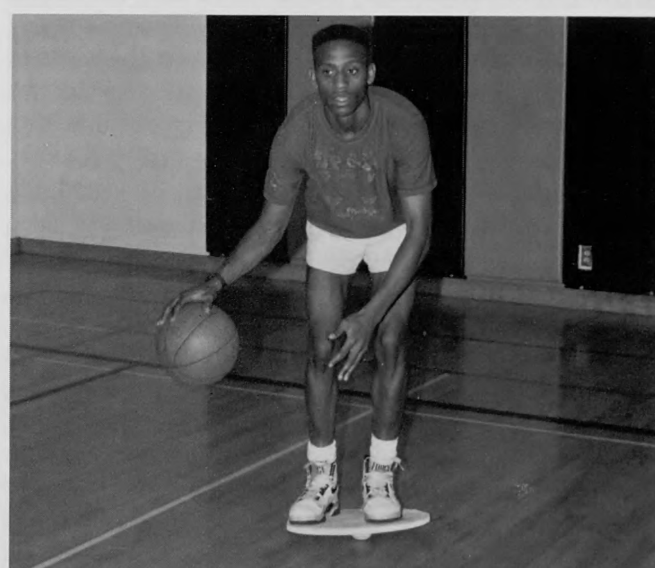


Figure 6. Sport - specific proprioception on balance board

SIX WEEKS POSTOPERATIVELY

At six weeks postoperatively, the rehabilitation program continues with the intensity of the exercises gradually increasing. Additional functional exercises may be used at this time in the rehabilitation program. However, before the functional agility drills can be started, muscular strength/power needs to be objectively assessed. High speed isokinetic (180 degrees per second or greater) testing with a 20° extension block is conducted at this time to determine the level of recovery. When the involved thigh strength reaches 70 percent of the uninvolved thigh strength (both quadriceps and hamstrings), the functional agility program can be started.

- **Balance Board Walk** - Walking across a series of different balance boards prepares the athlete for a variety of terrains and surfaces.
- **Slide Board** - Side to side movements, similar to speed skating, aid in eccentric control, lateral strengthening, and proprioceptive balance (Figure 7).
- **Fitter** - (Fitter International, Calgary, Canada) This exerciser is also beneficial for improving lateral strength and proprioceptive balance.
- **Pogo Ball** - (available at most toy stores) (Figure 8) Early in the protocol, controlled patterns (alphabet and multidirectional) are performed while holding on to an object. Later, more advanced hopping drills can be instituted.
- **Backward Running with Tubing** - Retrorunning is performed while heavy rubber tubing is attached around the patient's waist.
- **Lateral Agilities with Tubing** - Controlled side to side hops are performed while maintaining balance against the resistance of heavy tubing. The eccentric (return) phase of the exercise is critical in the execution of this drill.
- **Trampoline Jogging** - Forward and backward controlled jogging is done.
- **Trampoline Hops** - The patient hops side to side, using two mini-trampolines.
- **Jumping Rope** - The patient progresses from two foot jumping to one foot jumping.
- **Progressive Cutting on Mini-trampoline** (27) (Figure 9)
  - √ Jog straight ahead
  - √ Jog with 45° cut away from involved leg
  - √ Jog with 90° cut away from involved leg
  - √ Jog with 45° cut across involved leg
  - √ Jog with 90° cut across involved leg

  (The involved leg cuts off the mini-trampoline during each run through; the pattern for this drill looks like a star if viewed from above.)
- **Carioca** - Crossover steps alternating front and back are performed.
- **Figure Eight Patterns** - The patient starts with large circles then progresses to small circles.
- **Zig Zag Running**
- **Sport Specific Drills and Patterns**

Figure 8. Pogo ball

Figure 7. Slide board

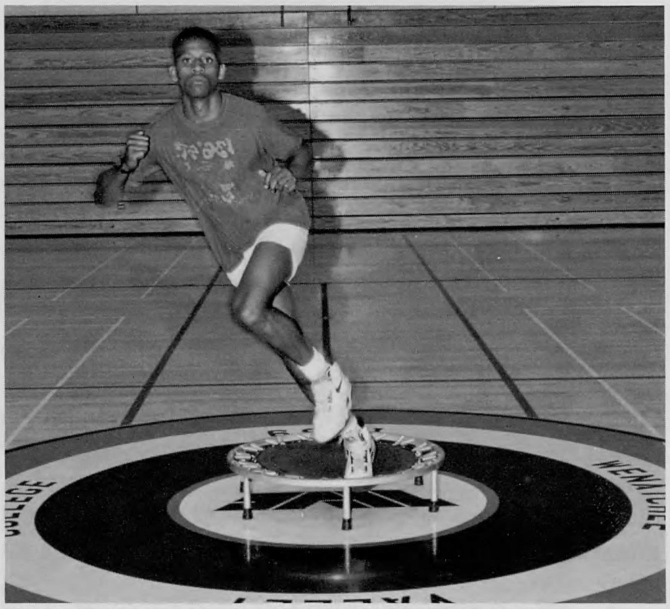


Figure 9. Progressive cutting off of mini-trampoline

This agility program starts slowly and gradually intensifies over several weeks. Some patients may be able to start agility exercises at six weeks. However, others may need to wait longer until minimal isokinetic percentages are attained, and an acceptable level of functional ability can be demonstrated.

TWO TO THREE MONTHS POSTOPERATIVELY

It is very important for the patient to continue to work faithfully on the outlined rehabilitation program. The "slack off syndrome" may occur at two to four months (or longer) following surgery for some athletes. During this time, an athlete may be less diligent in performing the prescribed activities as the knee begins to feel more functional. Intense motivational techniques may be required to encourage the athlete to strive for continued improvement. The athlete's functional abilities may be sufficient to play pick-up games; however, exceptional levels of strength and function are required to provide adequate protection against reinjury and to allow the athlete to be able to compete at an elite level of competition.

Follow-up isokinetic testing is needed every two to four weeks to assess muscular strength and endurance. Numerous authors (20,25,30,33,44) have documented long-term strength deficits (particularly in the quadriceps) in their ACL reconstruction patients. This reinforces the need for follow-up strength testing to identify those patients with deficits and determine ways to remedy those weaknesses. These deficits often are not perceived by the patient. Harter et al. (20) stated that postoperative deficits of up to 30 percent between the surgically reconstructed knee and the uninvolved knee on specific measures of stability and function (including isokinetic evaluation) did not greatly influence the patient's perceptions of knee function. We have found that patients who return for follow-up isokinetic/functional testing typically have better long-term results because their programs can be modified to rectify any demonstrated deficits.

Controlled competitive activities should commence at this time. If an athlete expects to be playing competitively at four to six months following surgery, sport specific drills and activities must be instituted during this period.

RETURN TO COMPETITION

The timing of the return to competition following an ACL reconstruction has elicited numerous opinions by various authors (3,5,8,10,12,14,17,18,22,36,37,38,45,46,47,54). Traditionally, a nine to twelve month rehabilitation preceeded a return to sporting activities. However, we have had excellent results with our accelerated return to activity protocol. Our preliminary data has shown excellent follow-up results with no significant increase in laxity or early failures. Shelbourne and Nitz (47) and DeCarlo et al. (12), using a similar accelerated rehabilitation protocol in 450 ACL reconstruction patients, have also demonstrated excellent results. Stability was found to be better in the accelerated protocol group than in the traditional protocol group (12,47). The accelerated group was also able to regain extension significantly earlier (12,47).

The exact time of return to action is highly variable among patients and is dependent on the sport to which the athlete is returning. Typically, the patient can return to full activity at four to six months following surgery if the following can be demonstrated.

1. Better than 90 percent side to side strength on isokinetic testing
2. Better than 70 percent quadriceps/hamstring ratio
3. Adequate proprioceptive awareness
4. Adequate sport specific agility
5. Functionality in a specific sports activity

The question of bracing the post-surgical ACL patient has been discussed in the literature (6,7,32,40). Branch et al. (6) concluded that bracing did not alter electromyographic activity or change firing patterns, suggesting that braces do not have a proprioceptive influence. Rink et al. (40) and Branch et al. (7) found no reduction in anterior tibial displacement when measured by joint arthrometry as forces increased. We feel that functional ACL bracing is not necessary for our patients when returning to activities, if strength and functional ability criteria are met. However, a brace may be used by those athletes who feel they need a boost in their "confidence factor."

Based on the new data that is becoming available, we have accelerated our ACL rehabilitation program which emphasizes early motion, early weight bearing, closed kinetic chain exercises with heavy rubber tubing, functional proprioceptive exercises, and sport specific agility drills. As with any rehabilitation program, one cannot use a "cookbook" formula. This paper serves only as a general outline of a sample rapid rehabilitation program and may vary greatly from patient to patient. Our protocol is patient driven and is designed to improve outcomes and, consequently, to enhance patient satisfaction. We will continue to collect data on our "rapid rehabilitation" protocol in order to return athletes to the field of competition as quickly as possible, without increasing their risk of ACL graft failure.

ACKNOWLEDGEMENT

The authors would like to thank Greg Whitmore, ATC for his review of this manuscript.

REFERENCES

1. Arms SW, Pope MH, Johnson RJ, Fischer RA, Arvidsson I, Eriksson E: The biomechanics of anterior cruciate ligament rehabilitation and reconstruction. *Am J Sports Med* 12: 8-18, 1984.
2. Arvidsson I, Arvidsson H, Eriksson E, Jansson E: Prevention of quadriceps wasting after immobilization: An evaluation of the effect of electrical stimulation. *Orthopedics* 9: 1519-28, 1986.
3. Arvidsson I, Eriksson E: Counteracting muscle atrophy after ACL injury: Scientific bases for a rehabilitation program, in Feagin JA, Jr (ed): *The Crucial Ligaments.* New York, Churchill-Livingstone, 1988, pp. 451-460.
4. Barrack RL, Skinner HB, Buckley SL: Proprioception in the anterior cruciate deficient knee. *Am J*

Sports Med 17:1-6, 1989.

5. Blackburn TA: Rehabilitation of anterior cruciate ligament injuries. *Orthop Clin North Am* 16: 241-269, 1985.
6. Branch TP, Hunter R, Donath M: Dynamic EMG analysis of anterior cruciate deficient legs with and without bracing during cutting. *Am J Sports Med* 17: 35-41, 1989.
7. Branch TP, Hunter R, Reynolds P: Controlling anterior tibial displacement under static load: A comparison of two braces. *Orthopedics* 11:1249-52, 1988.
8. Caillouet H: Knee rehabilitation following anterior cruciate ligament injury. *Sports Medicine Update* 4(1): 15-18, 1989.
9. Clancy WG: Intrarticular reconstruction of the anterior cruciate ligament. *Orthop Clin North Am* 16: 183, 1985.
10. Crochet DJ: Anterior cruciate ligament rehabilitation conceptual approach. *Sports Medicine Update* 4(1): 11-14, 1989.
11. Daniel DM, Malcolm LL, Losee G, Sonte ML, Sachs R, Burks R: Instrumented measurement of anterior knee laxity after ACL reconstructive surgery. *J Bone Joint Surg* 67A: 720-725, 1985.
12. DeCarlo MS, Shelbourne KD, McCarroll JR, Rettig AC: Rehabilitation following ACL reconstruction. Presented at the 41st Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association, Indianapolis, IN, June 1990.
13. Delitto A, Rose SJ, McKowen JM, Lehman RC, Thomas JA, Shively RA: Electrical stimulation *versus* voluntary exercise in strengthening thigh musculature after anterior cruciate ligament surgery. *Phys Ther* 68: 660-663, 1988.
14. DePalma BF, Zelko RR: Knee rehabilitation following anterior cruciate ligament injury or surgery. *Athletic Training, JNATA* 21: 200-204, 1986.
15. Elmqvist L-G, Lorentzon R, Langstrom M, Fugl-Meyer A: Reconstruction of the anterior cruciate ligament. Long-term effects of different knee angle at primary immobilization and different modes of early training. *Am J Sports Med* 16: 455-462, 1988.
16. Engle RP, Canner GC: Rehabilitation of symptomatic anterolateral knee instability. *J Orthop Sports Ther* 11: 237-244, 1989.
17. Eriksson E, Arvidsson I: Knee rehabilitation. *Orthopedic Review* 18: Supplement, 61-66, 1989.
18. Fanton GS: Rehabilitation of the knee after anterior cruciate ligament surgery. *Physical Medicine and Rehabilitation* 1: 639-646, 1987.
19. Hamilton HW, Hoffman DV, Morris JS, Porter JS: Continuous passive motion in postoperative knee rehabilitation. In Feagin JA Jr. (ed): *The Crucial Ligaments*. New York, Churchill-Livingstone, 1988, pp. 465-470.
20. Harter RA, Osternig LR, Singer KM, James SL, Larson RL, Jones DC: Long-term evaluation of knee stability and function following surgical reconstruction for anterior cruciate ligament insufficiency. *Am J Sports Med* 16: 434-442, 1988.
21. Henning CE, Lynch MA, Glick KR: An *in vivo* strain gage study of elongation of the anterior cruciate ligament. *Am J Sports Med* 13: 22-26, 1985.
22. Huegel M, Indelicato PA: Trends in rehabilitation following anterior cruciate ligament reconstruction. *Clinics in Sports Med* 7: 801-811, 1988.
23. Johnson RJ, Eriksson E, Haggmark T, Pope MH: Five to ten-year follow-up after reconstruction of the anterior cruciate ligament. *Clin Orthop* 183: 122-140, 1984.
24. Kain CC, McCarthy JA, Arms S, Pope MH, Steadman JR, Manske PR, Shively RA: An *in vivo* analysis of the effect of transcutaneous electrical stimulation of the quadriceps and hamstrings on anterior cruciate ligament deformation. *Am J Sports Med* 16: 147-152, 1988.
25. Kannus P, Latla K, Jarvinen M: Thigh muscle strengths in the anterior cruciate ligament deficient knee: Isokinetic and isosymetric long-term results. *J Orthop Sports Phys Ther* 9: 223-226, 1987.
26. Kochan A, Markolf KL, More RC: Anterior-posterior stiffness and laxity of the knee after major ligament reconstruction. *J Bone Joint Surg* 66: 1460-65, 1984.
27. Kola B: Personal Communication, 1988.
28. Kurosaka M, Yoshiya S, Andrish JT: A biomechanical comparison of different surgical techniques of graft fixation in anterior cruciate ligament reconstruction. *Am J Sports Med* 15: 225-229, 1987.
29. Lambert KL: Vascularized patellar tendon graft with rigid internal fixation for anterior cruciate ligament insufficiency. *Clin Orthop* 172: 85-89, 1983.
30. LoPresti C, Kirkendall DT, Street GM, Dudley AW: Quadriceps insufficiency following repair of the anterior cruciate ligament. *J Orthop Phys Ther* 9: 245-249, 1988.
31. McLeod WD, Blackburn TA: Biomechanics of knee rehabilitation with cycling. *Am J Sports Med* 8: 175-180, 1980.
32. Millet CW, Drez DJ: Principles of bracing for the anterior cruciate ligament-deficient knee. *Clinics in Sports Medicine* 7: 823-833, 1988.
33. Morrissey MC, Brewster CE: Hamstring weakness after surgery for anterior cruciate ligament. *J Orthop Sports Phys Ther* 7: 310-313, 1986.
34. Morrissey MC, Brewster CE, Shields CL, Brown M: The effects of electrical stimulation on the quadriceps during postoperative knee immobilization. *Am J Sports Med* 13: 40-45, 1985.
35. Noyes FR, Butler DL, Grood ES, Zernicke RF, Hefzy MS: Biomechanical analysis of human ligament grafts used in knee ligament repairs and reconstructions. *J Bone Joint Surg* 66A: 344-352, 1984.

36. Noyes FR, Mangine RE, Barber S: Early knee motion after open and arthroscopic anterior cruciate ligament reconstruction. *Am J Sports Med* 15: 149-160, 1987.
37. Paulos LE, Noyes FR, Grood E, Butler DL: Knee rehabilitation after anterior cruciate ligament reconstruction and repair. *Am J Sports Med* 9: 140-149, 1981.
38. Paulos LE, Payne FC, Rosenberg TD: Rehabilitation after anterior cruciate ligament surgery, in Jackson DW, Drez D (eds): *The Anterior Cruciate Deficient Knee*. St. Louis, C.V. Mosby, 1987, pp. 290-314.
39. Penner DA, Daniel DM, Wood P, Mira D: An *in vivo* study of anterior cruciate ligament graft placement and isometry. *Am J Sports Med* 16: 238-243, 1988.
40. Rink PC, Scott RA, Lupo RL, Guest SJ: A comparative study of functional bracing in the anterior cruciate deficient knee. *Orthopedic Review* 18: 719-727, 1989.
41. Roth JH, Kennedy JC, Lockstadt H, McCallum CL, Cunning LA: Intra-articular reconstruction of the anterior cruciate ligament with and without extra-articular supplementation by transfer of the biceps femoris tendon. *J Bone Joint Surg* 69: 275-278, 1987.
42. Rovere GD, Adair DM: Anterior cruciate-deficient knees: A review of the literature. *Am J Sports Med* 11: 412-417, 1983.
43. Sachs RA, Daniel DM, Stone ML, Garfein RF: Patellofemoral problems after anterior cruciate ligament reconstruction. *Am J Sports Med* 17: 760-765, 1989.
44. Seto JL, Orofino AS, Morrissey MC, Medeiros JM, Mason WJ: Asessment of quadriceps/hamstring strength, knee ligament stability, functional sports activity levels five years after anterior cruciate ligament reconstruction. *Am J Sports Med* 16: 170-180, 1988.
45. Seto JL, Brewster CE, Lombardo SJ, Tibone JE: Rehabilitation of the knee after anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther* 11: 7, 8-18, 1989.
46. Shelbourne DK: ACLs: Researching repairs and rehabilitation. Presented at the 41st Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association, Indianapolis, IN, June 1990.
47. Shelbourne DK, Nitz P: Accelerated rehabilitation after anterior cruciate ligament reconstruction. *Am J Sports Med* 18: 292-299, 1990.
48. Shoemaker SC, Markolf KL: Effects of joint load on the stiffness and laxity of ligament-deficient knees. *J Bone Joint Surg* 67A: 136-146, 1985.
49. Sisk TD, Stralka SW, Deering MB, Griffin JW: Effect of electrical stimulation on quadriceps strength after reconstruction surgery of the anterior cruciate ligament. *Am J Sports Med* 15: 215-219, 1987.
50. Solomonow M, Baratta R, Zhou BH, Shoji EE,H, Bose W, Beck C, D'Ambrosia R: The synergetic action of the anterior cruciate ligament and thigh muscles in maintaining joint stability. *Am J Sports Med* 15: 207-213, 1987.
51. Tibone JE, Antich TJ: A biomechanical analysis of anterior cruciate ligament reconstruction with the patellar tendon. A two-year follow-up. *Am J Sports Med* 16: 332-343, 1988.
52. Walla DJ, Albright JP, McAuley E, Martin RK, Eldridge V, El Khoury G: Hamstring control and the unstable anterior cruiciate ligament-deficient knee. *Am J Sports Med* 13: 34-39, 1985.
53. Washco LA, Yack HJ, Whieldon T: The role of joint load in limiting anterior tibial translation in ACL deficient knees. Presented at the 41st Annual Meeting & Clinical Symposium of the National Athletic Trainers' Association. Indianapolis, IN, June 1990.
54. Wills RP, Feagin JA, Lambert KL, Cunningham RR, Ruttle PE, Van Meter CD: Intraarticular anterior cruciate ligament reconstruction without extraarticular augmentation: A follow-up of 137 knees. Submitted to *Clin Orthop*, 1990.

Functional Performance Tests for the Anterior Cruciate Ligament Insufficient Athlete

Scott M. Lephart, PhD, ATC
David H. Perrin, PhD, ATC
Freddie H. Fu, MD
Kimberly Minger, ATC

ABSTRACT: Considerable controversy exists regarding the functional assessment of the anterior cruciate ligament (ACL) insufficient athlete. Traditionally, clinicians have speculated that certain physical characteristics, such as muscular strength and power and joint laxity, should be assessed and used to predict functional capacity. Recent research has refuted the relationship between these physical characteristics and functional capacity, and has suggested the best assessment of functional capacity is acheived through the use of three functional performance tests. This paper describes three objective functional performance tests (FPTs) that have been shown to be accurate assessments of functional capacity in the ACL insufficient athlete. To assist the clinician with the assessment of the ACL insufficient athlete's readiness to return to pre-injury levels of activity, mean values on three FPTs were established for healthy Division I intercollegiate athletes (n = 30 males, n = 15 females). Collectively, these FPTs provide the clinician with new objective parameters by which to dynamically assess the functional capabilities of the ACL insufficient athlete. The results of these tests help provide a basis for determining an athlete's readiness to return to sport activity.

Scott Lephart is Director, Sports Medicine/Athletic Training; Assistant Professor, School of Education; and Assistant Professor, School of Medicine, Department of Orthopedics at the University of Pittsburgh, 140 Trees Hall, Pittsburgh, Pennsylvania 15621.

David Perrin is Director, Graduate Athletic Training Program and Assistant Professor, Curry School of Education, University of Virginia, Charlottesville, Virginia.

Freddie Fu is with Blue Cross of Western Pennsylvania Professor of Orthopedic Surgery, and Team Physician at the University of Pittsburgh.

Kimberly Minger is Assistant Athletic Trainer at the University of Texas at Austin.

Assessment of the anterior cruciate ligament (ACL) insufficient athlete's functional capacity and readiness to return to sport activities remains a controversial and misunderstood issue (2,3,5,9,11). Many suggest the use of various physical characteristics, which are believed to be compensatory for the instability, to assess functional capacity (1,4,8,10,12,13,14). Variables such as thigh musculature strength (4,8,10,12,13), reciprocal muscle group strength ratios (13), static laxity (4,13,14), girth, and range of motion (1) have been traditionally used for assessment of functional capacity in the ACL insufficient athlete.

Recently, the use of such physical characteristics for the assessment of functional capacity has been refuted, based on the lack of a strong relationship between these physical characteristics and functional measures (6). Often the athlete's self assessment and the inappropriate use of these physical characteristics has led to speculative clinical decisions and to the athlete's premature return to sport activity.

The lack of an objective assessment of maneuvers similar to those used in sports participation prompted a recent study that assessed the ACL insufficient athlete's functional level with three functional performance tests (6). These tests included a co-contraction semicircular test, a carioca test, and a shuttle run test. Those ACL insufficient subjects who were able to return to pre-injury levels of sport activity performed significantly better on the functional performance tests than those athletes who were unable to return to pre-injury activities. Based on these findings, Lephart et al. suggested that the FPT be included in the battery of assessments used to determine the athlete's readiness to return to functional activity. Furthermore, it was suggested that FPTs may be integrated into the functional rehabilitation phase of the ACL insufficient athlete (6,7).

If the FPTs are to be included in the battery of assessments for returning an ACL insufficient athlete to activity, the clinician must have comparative data available specific to athletes participating in various sports, and in some cases, to positions within sports. The eventual establishment of normative values on the FPTs will provide the injured athlete with the objective goals and more accurate feedback regarding his/her functional status compared to healthy athletes within the same sport. Therefore, this paper describes the functional status of the ACL insufficient athlete, and reports mean values on these tests for healthy athletes specific to gender, sport, and in some instances, positions within sports.

METHODS

Healthy athletes from five intercollegiate men's teams (n = 30, age = 20.3 ± 8 yrs, ht = 6' 1.7" ± 3.3", wt = 179.2 ± 18.3 lbs) and three intercollegiate women's teams (n = 15, age = 19.2 ± 1.2 yr, ht = 5' 4.5" ± 1.0", wt = 136.7 ± 9.9 lbs) at the University of Pittsburgh participated in the study. Male athletes were selected from the football, basketball, baseball, soccer, and gymnastics teams while female athletes were selected from the basketball, volleyball, and gymnastics teams. Football players were divided into two categories: line positions and back positions. The athletes signed an informed consent document, consistent with University policy, to voluntarily participate in the study. The subjects were all familiarized with the test maneuvers and they returned the subsequent day for testing.

FUNCTIONAL PERFORMANCE TESTS

The functional performance tests employed in this study were established to assess functional levels of ACL insufficient athletes. Similar maneuvers are frequently used by clinicians to observe an athlete's functional level. A previous study by Lephart et al. revealed that athletes who returned to pre-injury levels of sport activity performed these tests significantly faster than those athletes who were unable to return to pre-injury levels of sports activity following ACL injury (6).

The functional performance tests attempt to recreate in a controlled environment the forces an athlete experiences during common sport skills/activities. When performed at high speeds, these tests may cause tibial subluxation or the dynamic pivot shift phenomenon in unstable knees. These tests provide an objective measurement of function and include a co-contraction semicircular maneuver, a carioca maneuver, and a shuttle run. Test-retest reliability values for these tests range from $r = .92$ to $r = .96$ (6).

The co-contraction test (Figure 1. A, B) was performed by securing a heavy Velcro belt around the athlete's waist, and attaching it to a heavy 48 inch length of rubber tubing with an outer diameter of one inch (Rehab Tubing, Pro Orthopedic Devices, Inc., Tuscon, AZ). The tubing was anchored to a metal loop secured on a wall 60 inches above the floor. A semicircle was painted on the floor which had a radius of 96 inches from the metal loop. The subject stood facing the wall with the toes of his/her feet on the semicircle. This stretched the tubing 48 inches beyond its recoil length. The co-contraction test required each subject to complete five wall-to-wall lengths of the 180° semicircle with the tension applied to the overstretched rubber tubing. The subjects began the test on the right side of the semicircle, moving in a side-step or shuffle fashion, completing the five lengths (three lengths right to left, two lengths left to right) in the minimum amount of time possible.

The carioca test (Figure 2. A, B) required the subjects to move laterally with a crossover step. The test was performed over two lengths of a 40 foot distance. The subjects began moving from left to right, then reversed direction following the first 40 foot length, thus performing the test moving a total of 80 feet in the minimum amount of time possible.

The shuttle run test, running four lengths of 20 feet (Figure 3), also was performed by the athletes. Each subject ran 20 feet, touched a line on the floor with their foot, reversed direction, then returned to the starting point, touched the line, and repeated the process. The complete test covered 80 feet with three changes in direction.

The criterion for all three tests was elapsed time, measured using a hand-held stop watch. Each subject performed three trials of all tests, and the fastest time was recorded as the score for each of the three tests. The sum of the best time on each test was the total functional performance test (TFPT) score.

Treatment of the data included computation of mean and standard deviation values for each sport and gender for the three functional performance tests and the TFPT. To examine statistically significant differences between sports, an analysis of variance (ANOVA) was performed to determine the significance of differences between the five men's sport teams and the three women's sport teams. A post-hoc Scheffe's F-test was employed to determine the significance ($p < 0.05$) of mean differences between sports.

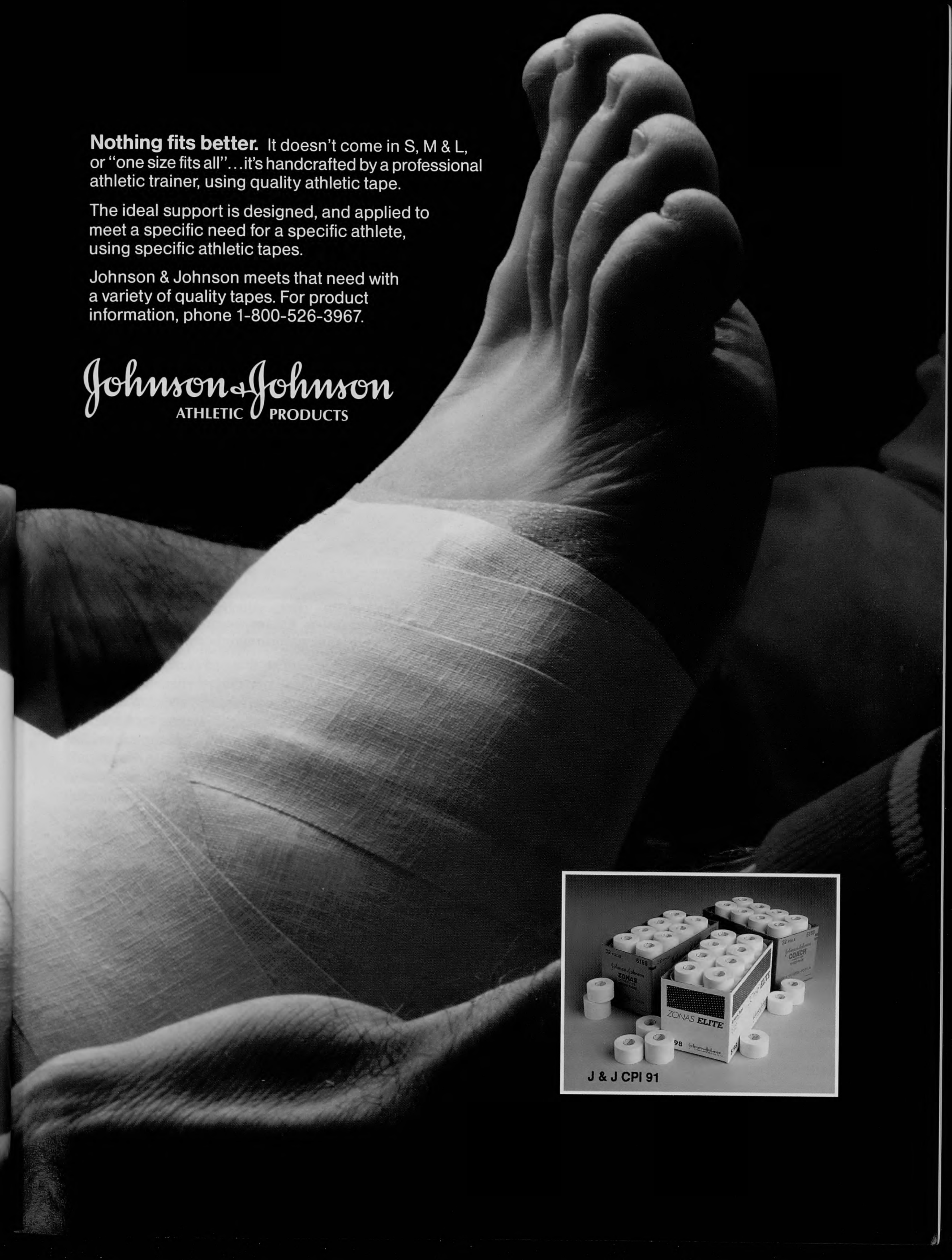
RESULTS

Mean values on the three functional performance tests and the TFPT are presented in Table 1. Significant mean differences [$F(5, 24) = 5.39$, $p = .002$] for male athletes were revealed for the co-contraction test. The football back and line athletes and the baseball players performed this test significantly faster than the male gymnasts. Among women, basketball players and volleyball players performed the co-contraction test significantly faster [$F(2, 12) = 12.97$, $p = .001$] than gymnasts (Table 1).

Significant mean differences [$F(5,24) = 3.35$, $p = .035$] for the male athletes were also revealed for the carioca test. Football back and line athletes performed the test significantly faster than basketball, gymnastic, and soccer athletes. Among the female athletes, volleyball players had significantly lower times on the carioca test [$F(2, 12) = 7.54$, $p = .008$] than did gymnasts (Table 1).

Significant mean differences [$F(5, 24) = 2.45$, $p. = .062$] were revealed between the football back athletes and the male gymnasts on the shuttle run test. Both the female volleyball players and the female basketball players performed significantly faster [$F(2, 12) = 13.10$, $p = .001$] than female gymnasts on the shuttle run test.

The ANOVA revealed that the football back, football line, and baseball athletes performed all three FPTs (TFPT parameter) significantly faster [$F(5, 24) = 8.47$, $p = .0001$]


Nothing fits better. It doesn't come in S, M & L, or "one size fits all"...it's handcrafted by a professional athletic trainer, using quality athletic tape.
The ideal support is designed, and applied to meet a specific need for a specific athlete, using specific athletic tapes.
Johnson & Johnson meets that need with a variety of quality tapes. For product information, phone 1-800-526-3967.
Johnson & Johnson
ATHLETIC PRODUCTS
ZONAS ELITE
J & J CPI 91

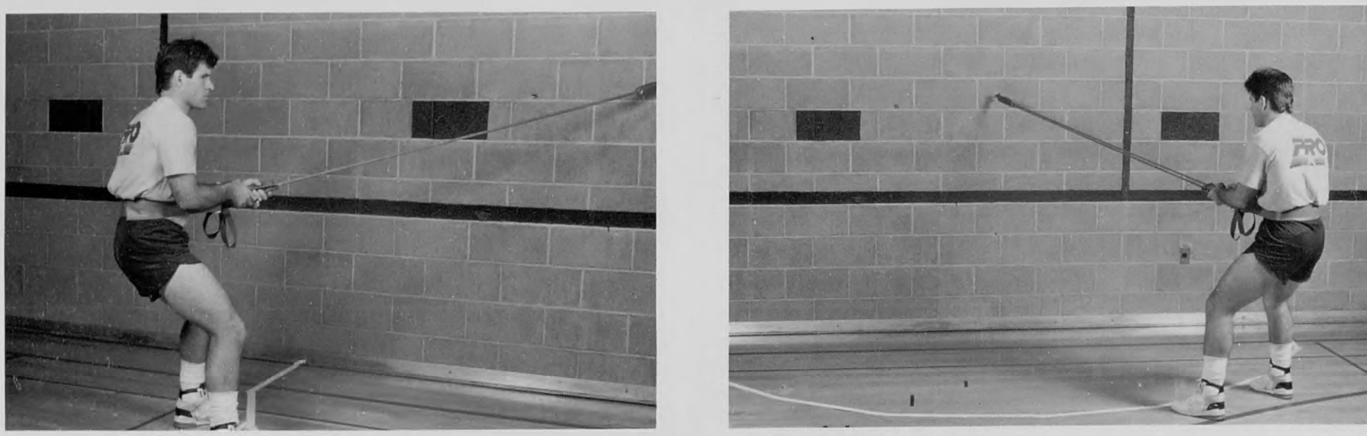


Figure 1. A, B. Co-contraction test. The athlete moves in a side step or shuffle fashion around the periphery of the eight foot radius semicircle. The test is complete when five wall-to-wall lengths are completed.

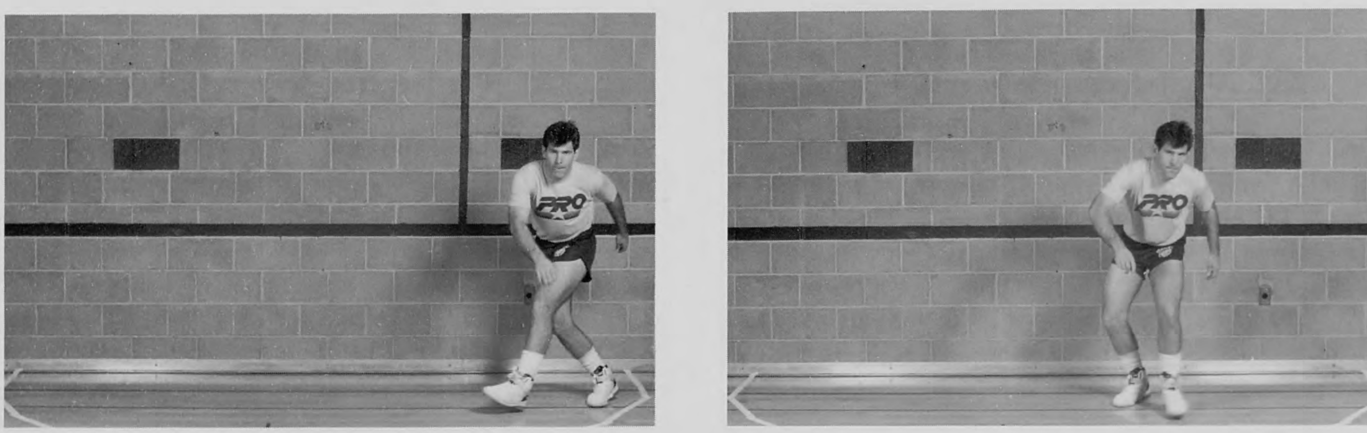


Figure 2. A, B. Carioca test. The athlete moves laterally using an alternating crossover step. The test is completed when the athlete has performed two lengths, beginning by moving laterally to the right 40 feet and reversing direction to move laterally to the left 40 feet.

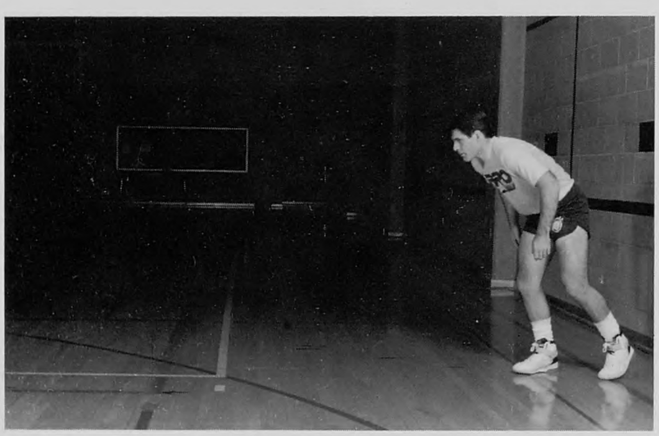


Figure 3. Shuttle run test. The athlete performs four lengths of a 20 foot distance, reversing direction after the completion of each length.

than male gymnasts. The female basketball and volleyball players performed the FPTs in significantly less time [F (2, 12) = 16.43, p = .0004] than did the female gymnasts (Table 1).

DISCUSSION

The functional performance tests (FPTs) described in this study have previously been recommended to assess the ACL insufficient athlete's readiness to return to competitive sport activities (6). The three tests selected place critical stress on the knee, while requiring the athlete to demonstrate dynamic control of his/her ACL insufficient knee in order to perform the FPTs at maximum speed.

The co-contraction test was designed to reproduce the rotational forces at the knee necessitating control of tibial translation by the thigh musculature. The carioca crossover maneuver was employed to reproduce the pivot shift phenomenon in the ACL insufficient knee. The shuttle run test was designed to reproduce acceleration and deceleration forces which are common to athletic activity. Typically, a subject with a dynamically unstable knee will have tibial subluxation, or the sensation of the subluxation, while performing these maneuvers, resulting in apprehension and slower performance of the test.

Our study provided values on the FPTs for 30 healthy collegiate male and 15 healthy collegiate female athletes who participated in various sports. Because of the relatively small number of subjects studied within each sport, the between sport differences are not extremely substantial or meaningful. These preliminary findings suggest that those subjects who participated in sports requiring lateral and running maneuvers

Table 1. Sport specific functional performance test results [Mean (±SD) are in seconds]

SPORT	N	CO-CONTRACTION	CARIOCA	SHUTTLE	TFPT
MEN					
Football Skill	5	9.29 (.64)	5.89 (.35)	6.04 (.31)	21.20 (.94)
Football Line	5	9.63 (.98)	5.54 (.46)	6.29 (.23)	21.47 (1.57)
Basketball	5	10.47 (.35)	6.79 (.54)	6.37 (.11)	23.65 (.87)
Gymnastics	5	11.80 (1.50)	6.70 (1.08)	6.67 (.47)	25.18 (1.61)
Soccer	5	10.21 (.68)	6.44 (.46)	6.28 (.21)	22.94 (1.11)
Baseball	5	9.47 (.76)	5.98 (.43)	6.29 (.29)	21.74 (.64)
TOTAL	30	10.28 (.81)	6.29 (.54)	6.33 (.26)	22.89 (1.19)
WOMEN					
Basketball	5	9.98 (.44)	7.11 (.23)	6.81 (.28)	23.91 (.81)
Volleyball	5	10.08 (.15)	6.52 (.41)	6.61 (.26)	23.20 (.71)
Gymnastics	5	12.58 (1.51)	7.59 (.59)	7.68 (.48)	27.85 (2.13)
TOTAL	15	10.88 (.70)	7.07 (.34)	7.03 (.34)	24.98 (1.22)

as a dominant function of their sport, such as basketball and football, perform better on the FPTs that required such maneuvers. Further research may indicate that athletes such as football players, basketball players, and volleyball players may perform faster on these tests simply because of the training adaptations to their particular sport. We encourage other investigators to develop additional functional performance tests specific to such sports as gymnastics, which seldom requires an athlete to cut or to perform crossover maneuvers. Until a substantially larger athlete population can be tested to create normative values within each sport, we suggest the use of preliminary mean scores established by gender as guideline values for assessing performance on the FPTs.

The study, together with a similar study of ACL insufficient athletes (6), provides the clinician with objective tests to determine the true functional level of the ACL insufficient athlete. With the subsequent testing of a larger sample to establish normative values on these FPTs, the clinician will have an improved ability to evaluate the functional status of the ACL insufficient athlete by referring to compiled normative values for healthy athletes classified by gender, by sport, and by position. The results of our study help the clinician to make more objective decisions regarding the ACL insufficient athlete's readiness to return to functional activities. It should help to avoid making premature decisions to return an athlete to sport activity based on the static or open kinetic chain physical characteristics that the athlete possesses.

REFERENCES

1. Andrews J: Diagnosis and treatment of the ACL deficient knee. Paper presented at Mid-Atlantic National Athletic Trainers' annual meeting. Greensboro, NC, May, 1987.
2. Feagin JA, Curl W: Isolated tear of the anterior cruciate ligament: Five-year follow-up study. *Am J Sports Med* 4: 95-100, 1976.
3. Fetto JA, Marshall D: The natural history and diagnosis of anterior cruciate ligament insufficiency. *Clin Orthop* 147: 29-37, 1980.
4. Giove MA, Miller SJ, Kent MA, Sanford TL, Garrick JG: Non-operative treatment of the torn anterior cruciate ligament. *J Bone Joint Surg* 65A: 184-192, 1983.
5. Katz JW, Fingeroth R: The diagnostic accuracy of ruptures of the anterior cruciate ligament comparing the Lachman test, the anterior drawer sign, and the pivot shift test in acute and chronic knee injuries. *Am J Sports Med* 14: 88-91, 1986.
6. Lephart SM, Perrin DH, Fu F, Gieck JH, Irrgang J, McCue FC, Weltman A: Functional assessment of the anterior cruciate ligament insufficient athlete (abstract). *Med Sci Sports Exerc* 20: 2, 1988 (Supplement).
7. Lephart SM, Perrin DH, Minger K, Fu F, Gieck GH: Sports specific functional performance tests for the ACL insufficient athlete (abstract). *Athletic Training, JNATA* 24: 119, 1989.
8. McDaniel W, Dameron T: Untreated ruptures of the anterior cruciate ligament. *J Bone Joint Surg* 62A: 696-704, 1980.
9. Noyes FR, Butler D, Grood E: Clinical paradoxes of anterior cruciate instability and a new test to detect its instability. *Orthop Trans* 2: 78, 1978.
10. Noyes FR, Matthews DS, Mooar PA, Grood E: The symptomatic anterior cruciate-deficient knee. Part II. *J Bone Joint Surg* 65A: 163-174, 1983.
11. Slocum DB, Larson RL: Rotary instability of the knee. *J Bone Joint Surg* 50A: 211-225, 1978.

12. Tibone JM, Antich MS, Fanton GS, Moynes DR, Perry J: Functional analysis of anterior cruciate ligament instability. *Am J Sports Med* 14: 276-283, 1986.
13. Walla D, Albright J, McAuley E, Martin R, Eldridge V, El-Khoury G: Hamstring control and the unstable anterior cruciate ligament-deficient knee. *Am J Sports Med* 13: 34-39, 1985.
14. Youmans W: The so-called "isolated" anterior cruciate ligament syndrome: a report of 32 cases with some observation on treatment and its effect on result. *Am J Sports Med* 6: 26-30, 1978.

A Physiologic Evaluation of the Sports Massage

Tommy Boone, PhD
Rae Cooper, MS
Walter R. Thompson, PhD

ABSTRACT: This study determines the physiological responses of 10 healthy college-age subjects during submaximal exercise on the treadmill with and without a prior 30-minute sports massage. The Beckman Metabolic Measurement Cart was used to determine the subjects' steady-state responses. Cardiac output was determined by the indirect CO_2 Fick method; mixed venous PCO_2 was calculated using the equilibrium CO_2 rebreathing method. No significant differences in central (HR, SV, Q) or peripheral (a-$\bar{v}O_2$ diff) responses were found between the two submaximal exercise tests. Also, there were no significant differences in lactic acid (LA) and blood pressure responses. The results indicate that massage immediately prior to submaximal exercise at 80% intensity had no effect on the subjects' cardiovascular systems.

One of the unresolved questions in athletics is the physiological benefits of massage, yet it is well accepted as an integral part of coaching and athletic conditioning. Athletes have come to accept massage as a way to improve performance. Physical therapists, orthopedists, and osteopaths use massage for rehabilitation (19) and to promote relaxation (9).

Many claims have been made for the use of massage, but few are based on controlled and carefully designed laboratory studies (4,5,16,21). For example, there seems to be some agreement that massage does not hasten nerve growth, remove subcutaneous fat, or increase muscle strength (6). Not surprisingly however, many athletes use massage to alleviate muscle cramps and remove lactic acid (14); increase pain threshold, flexibility, and coordination (11); stimulate circulation and improve the transport of energy to muscles (15,17); and speed up healing and restoration of joint mobility (11). Unfortunately, the basis for prescribing massage relies solely on practical experience rather than scientific principles (2). The recuperative benefits may be more psychological than physiological.

Part of the difficulty in distinguishing psychological and physiological benefits lies with the lack of adequate scientific research to test various hypotheses. Therefore, athletes should probably be cautious of the various massage programs purportedly designed to enhance physical performance, and restore and/or maintain normal muscle function.

The purpose of this study was to determine whether the sports massage results in positive physiological responses during submaximal exercise, and whether the responses were caused by the central or peripheral adjustments.

METHODS

Ten healthy male volunteers (age = 28 ± 2.6 yrs, wt = 65.2 ± 9.2 kg) were studied. The procedure was fully explained, and informed consent was obtained prior to the study. This investigation was approved by the institution's Human Subjects Review Committee.

The subjects participated in both the Control Session (exercise without prior massage) and the Treatment Session (exercise with prior massage). The order of the sessions per subject was determined by a table of random numbers.

The submaximal exercise on the treadmill was designed to elicit 80% of the subjects' maximal heart rates. The following formula was used to determine the desired heart rate intensity: Exercise HR (bpm) = 220 - age (years). At "0" grade, the treadmill speed was increased per subject to approximate the desired heart rate response. The same exercise conditions were repeated during the second exercise test.

The sports massage therapist used alternating deep strokes and broad cross-fiber strokes of the lower extremities (i.e., the muscles were squeezed, compressed, and rolled) for a duration of 30 minutes. The therapist, an Australian trained masseur, worked with athletes who considered massage critical to their performance.

Oxygen consumption was determined every minute by

Tommy Boone is Professor of Exercise Physiology and Director, Anatomy Laboratory, with the School of Human Performance and Recreation at the University of Southern Mississippi, Hattiesburg, Mississippi, 39406-5142

Rae Cooper is an Exercise Physiologist and Massage Therapist in Hattiesburg.

Walter Thompson is Associate Professor of Exercise Physiology and Director of Laboratory of Applied Physiology with the School of Human Performance and Recreation at the University of Southern Mississippi, in Hattiesburg.

the Beckman Metabolic Measurement Cart (MMC), which was calibrated by certified gas prior to exercise. Blood pressure was monitored by auscultation of the left brachial artery using a standard mercury manometer. Heart rate was derived from the electrocardiograph during the last 15 seconds of each minute of exercise. Cardiac output was estimated during the last minute of exercise using the MMC Clinical Exercise Testing Program. Arterial CO_2 ($PaCO_2$) was derived from the end-tidal PCO_2 ($PETCO_2$). Mixed venous PCO_2 ($P\bar{v}CO_2$) was derived from the rebreathing procedure during which the subjects were disconnected from the non-breathing valve and connected to a bag filled with 11.75% CO_2 in oxygen. A Beckman MMC recorder was used to graphically examine the CO_2 signal generated during the rebreathing to ensure that a satisfactory PCO_2 equilibrium was achieved. Stroke volume was calculated by dividing cardiac output by heart rate. Arteriovenous oxygen difference was calculated by dividing oxygen consumption by cardiac output. Lactic acid was determined upon cessation of exercise using the spectrophotometric (Gilford Stasar III) technique (18).

RESULTS

Means and standard deviations were computed for all physiological responses (Table 1). Paired t-test indicated no significant differences ($p > .05$) between the Control Session exercise data (exercise without prior massage) and the Treatment Session exercise data (exercise with prior massage).

DISCUSSION

This study found that the sports massage did not result in an improved exercise performance, and that the subjects' exercise oxygen consumption was derived from similar and peripheral adjustments. Both exercise tests at 80% of maximum heart rate required the same oxygen consumption (i.e., 3 L/min for the Control Session and 3.1 L/min for the Treatment Session). Therefore, the 30-minute massage just prior to exercise did not provide the subjects with increased oxygen flow to the body tissues. This finding is in contradiction to comments made by some sports massage enthusiasts (11). Without the massage, subjects exercised just as efficiently as when they had received the massage.

Oxygen consumption is the product of oxygen transport (i.e., $\dot{Q}$ = HR x SV) and oxygen utilization (i.e., a-$\bar{v}O_2$ difference). Improvement in a steady-state exercise oxygen consumption can be the result of either a change in oxygen transport or a change in oxygen utilization. A change in the transport of oxygen is generally characterized by a decrease in exercise heart rate, an increase in stroke volume, and no change in cardiac output. The decrease in heart rate at the same exercise cardiac output is indicative of a more efficient heart rate (1,7,10,12,13,20). However, this response did not occur. Heart rate was unchanged with massage. Also, there was no change in arteriovenous oxygen difference (which reflects the peripheral adjustment to maintaining exercise oxygen consumption). The subjects' oxygen utilization was the same with sports massage as without it.

The changes just described (but which did not occur in this study) allow for a more efficient physiological performance at the same oxygen consumption value. Therefore, had the changes occurred, the subjects would have been more physiologically efficient at the same energy expenditure.

It was also anticipated that the sports massage might result in a lower oxygen consumption response at the same exercise load. That is, it was thought that the subjects' exercise heart rate might decrease with no change in stroke volume (following the sports massage). The resultant effect would therefore be a smaller exercise cardiac output; the product of which would yield a smaller oxygen consumption, assuming that the extraction of oxygen in the periphery (i.e., oxygen utilization) was unchanged.

In this regard, several researchers (3,8) have shown that oxygen consumption is not constant. Benson et al. (3), for example, found that their subjects were able to lower steady-state exercise oxygen consumption by eliciting the relaxation response. Their results are interesting in that oxygen consumption during a fixed exercise bout was thought to be constant with each performance. One would expect that, had the sports massage helped the subjects in the present study, economically speaking, the metabolic cost of the exercise would have decreased. A finding of this type would be considered a positive influence of massage on performance (given that the subjects would recover faster).

It is also possible that an enhanced running economy is reflected in a decrease in lactic acid. This has led some researchers (14) to expect that massage prior to exercise affects the magnitude of the lactic acid response. It is very tempting to assume that with less lactic acid during exercise, the subjects would be able to exercise longer and recover faster. Again, a finding of this type would be considered a

Table 1. A physiological comparison of the Control (exercise without massage) and Treatment (exercise with massage) responses during 10 minutes of steady-state treadmill exercise (Mean and Standard Deviation)

Variables	Control	Treatment	t-ratio	Prob
$\dot{V}O_2$ (L/min)	3.0 ± .3	3.1 ± .4	.97	.62
$\dot{Q}$ (L/min)	22.1 ± 3.1	22.0 ± 3.2	.05	.96
HR (bpm)	162.7 ± 9.5	159.3 ± 8.3	.96	.64
SV (ml)	135.2 ± 17.5	137.4 ± 21.3	.37	.72
a-$\bar{v}O_2$ diff (ml/100 ml)	13.1 ± 1.6	13.9 ± 1.3	.34	.74
SBP (mmHg)	166.6 ± 26.0	168.4 ± 24.3	.25	.80
DBP (mmHg)	79.2 ± 10.8	74.6 ± 9.0	-1.41	.19
LA (mM/L)	2.2 ± .8	2.0 ± .6	.78	.54

$\dot{V}O_2$ = oxygen consumption; $\dot{Q}$ = cardiac output; HR = heart rate; SV = stroke volume; a-$\bar{v}O_2$ diff = arteriovenous oxygen difference; SBP = systolic blood pressure; DBP = diastolic blood pressure; LA = lactic acid; Non-significant (p>0.05); paired t-test

ADVANCED ANKLE SUPPORT AT 1/10TH THE COST OF TAPE

With the cost of taping one pair of ankles for one football season hovering at a hefty $400, it's no wonder more and more teams are turning to the laced

ankle brace for protection and support.

And McDavid's A-101 Ankle Guard is fast becoming the first choice of thousands of trainers, players and sports medicine professionals alike.

Studies show that a good quality laced ankle brace is actually preferable to tape. The support and protection ankle braces provide is equal to—and often better than—that of tape, yet the cost is a fraction of tape costs.

Pete Farrell, head athletic trainer at New York's Potsdam College, uses the A-101 on basketball players. "The A-101 doesn't loosen up, so it holds its tension much longer than tape," Farrell explains. "It provides better support for extended periods."

In fact, the McDavid A-101 has been proven at hundreds of U.S. colleges, with 60% of top college conference football teams that use laced ankle guards choosing it over competitive models.

Winning Combination

A perfect balance of protection, support, durability and comfort, the trim, lightweight A-101 won't restrict an athlete's speed or agility. And it offers features not found on any other ankle brace.

The unique elastic forefoot minimizes tongue migration and helps it slip on easily. A notched-front design lets feet flex and extend freely. Spring-steel stays provide medial and lateral stability to resist eversion and inversion.

That's why Trainer Farrell favors the A-101 over competitive braces. "It prevents inversion more effectively, plus it simply holds up much better," Farrell notes. "It doesn't have to be retightened at halftime."

The guard is extremely durable, too. "Even in mud or rain, the A-101 really holds up," says Kay Mitchell, head athletic trainer at Pennsylvania's Grove City College. "We tried a different brace, and eyelets popped out all over. One player went through four in one season."

The A-101's sewn-in arch support and elastic heel inset ensure a snug, supportive, yet comfortable flexible fit. "With its elastic in the back for the Achilles, it won't cut in," Mitchell notes.

Ease of application is a big plus, too. As Mitchell explains, "It's more efficient, especially if you have only one trainer."

The A-101 fits either ankle and comes with a season-long guarantee unmatched by any other ankle brace. For more information and a full line catalog, write McDavid at 5420 W. Roosevelt Rd., Chicago, IL 60650 or call 1 800 237-8254. (In Illinois, call 1 312 626-7100.)

positive reason for massage. However, our data indicated that the subjects' lactic acid responses following steady-state exercise were not significantly different. It appears justified to state that the physiological benefits of the sports massage are questionable.

REFERENCES

1. Astrand PO, Rodahl K: *Textbook of Work Physiology*. 2nd edition. New York: McGraw-Hill Book Company, 1977, pp. 391-445.
2. Beard G, Wood EC: *Massage: Principles and Techniques*. Philadelphia, PA: W.B. Saunders Company, 1964, pp. 1-2.
3. Benson H, Dryer T, Hartley LH: Decreased $\dot{V}O_2$ consumption during exercise with elicitation of the relaxation response. *J Human Stress* 4: 38-42, 1978.
4. Birukov AA: Training massage during contemporary sports loads. *Soviet Sports Review* 22: 42-44, 1987.
5. Chor H, Cleveland D, Davenport HA, Dolkart RE, Beard G: Atrophy and regeneration of the gastrocnemius-soleus muscles: Effects of physical therapy in monkeys following section and suture of sciatic nerve. *JAMA* 113: 1029-33, 1939.
6. Fahey TD: *Athletic Training: Principles and Practices*. Palo Alto, CA: Mayfield Publishing Company, 1986, pp. 205-207.
7. Fox EL: *Sports Physiology*. 2nd edition. Philadelphia, PA: W.B. Saunders Company, 1984.
8. Gervino EV, Veazey AE: The physiologic effects of Benson's relaxation response during submaximal aerobic exercise. *J Cardiac Rehabil* 4: 254-259, 1984.
9. Hall D: A practical guide to the art of massage: Anyone can administer a good massage that will give relief to a tired body. *Runner's World* 14(10): 85-89, 1979.
10. Haskell W: Coronary heart disease. In Skinner J (ed): *Exercise Testing and Exercise Prescription for Special Cases*. Philadelphia: Lea & Febiger, 1987, pp. 203-224.
11. Hungerford MH, Bornstein R: Sports massage. *Sports Med Guide* 4: 4-6, 1985.
12. Hurley BG, Hagberg JM, Allen WK, Seals DR, Young JC, Cuddihee RW, Holloszy JO: Effect of training on blood lactate levels during submaximal exercise. *J Appl Physiol* 56: 1260-64, 1984.
13. Kitamura K, Jorgensen CR, Gobel FL, Taylor HL, Wang Y: Hemodynamic correlates of myocardial oxygen consumption during upright exercise. *J Appl Physiol* 32: 516-522, 1972.
14. Kopysov VS: Use of vibrational massage in regulating the pre-competition condition of weight lifters. *Soviet Sports Rev* 14: 82-84, 1979.
15. Kuprian W: Massage. In Kuprian W (ed): *Physical Therapy for Sports*. Philadelphia, PA: W.B. Saunders Company, 1981, pp. 7-51.
16. Pemberton R: *Physiology of Massage in A.M.A. Handbook of Physical Medicine*. Chicago, IL: Council of A.M.A., 1945.
17. Ryan J: The neglected art of massage. *Phys Sportmed* 8(12): 25, 1980.
18. Sigma Diagnostics. Lactate procedure No. 726-UV/826-UV. St. Louis, MO 63178, 1986.
19. Stamford B: Massage for athletes. *Phys Sportsmed* 13(10): 178, 1985.
20. Tzankoff SP, Robinson S, Pyke FS, Brawn CA: Physiological adjustments to work in older men as affected by physical training. *J Appl Physiol* 33: 346-350, 1972.
21. Wright S: Physiological aspects of rheumatism. *Proceed Royal Soc Med* 32: 651-662, 1939.

The Effect of Pre-performance Massage on Stride Frequency in Sprinters

Peter A. Harmer, PhD, ATC

ABSTRACT: Athletic trainers are often called upon to massage athletes prior to competition on the assumption that it will increase the athlete's performance and/or decrease the chance of injury. Despite considerable anecdotal support, research on the efficacy of massage as an ergogenic aid has produced conflicting results. This study investigated the effects of pre-performance massage on the stride frequency of elite male sprinters. Pre-performance massage was not found to significantly increase stride frequency. As an ergogenic aid, pre-performance massage should be considered the responsibility of the coaches or the athletes themselves. However, athletic trainers may wish to continue this practice as a means of providing positive affects to their athletes.

The search for performance advantages in competitive sports has led to athletes' experimenting with various types of ergogenic aids. Physical ergogenic aids, e.g., warm-up techniques, are widely used by athletes as adjuncts to training, and used prior to competition in an effort to improve performance. Massage is a commonly used warm-up strategy, particularly by sprinters and athletes in sprint-related activities who feel that massage may improve performance and/or decrease the chances of injury. However, the degree to which massage is used tends to be based on the athlete's personal preference and not on the demonstrated effectiveness of massage in aiding performance.

Dick (12) analyzed the immediate pre-competition preparation of sprint athletes at the 1980 Olympic Games in Moscow. He noted that there was neither consistency nor organization in the preparation of athletes of different nations or even of athletes on the same team. The same observation has been made of athletes in general (23). Athletic trainers are frequently called on to render pre-performance massage to athletes because of the athletic trainers' use of massage as a prophylatic or therapeutic modality.

Peter Harmer is Assistant Professor and Athletic Trainer, Sparks Center, Willamette University, Salem, Oregon, 97301.

Although massage has been shown to increase skeletal muscle blood flow (14,47,49) and venous return (15,39); induce progressive muscle relaxation (14,46); increase cutaneous temperature (16,32); increase lymph flow (13,18); retard muscular atrophy (45); increase range of motion (37,48); and lower psycho-emotional and somatic arousal such as tension and anxiety (28,33), conclusive evidence of the efficacy of pre-performance massage as an ergogenic aid is lacking. Massage, especially using "Swedish" techniques, is a labor intensive activity. Therefore, athletic trainers need to be cognizant of its relative costs and benefits so that they may make informed decisions regarding the priority of pre-performance massages in their schedules.

This study was undertaken to determine the effects of massage, when used as a pre-performance preparatory technique, on stride frequency in male athletes with proven sprinting ability. Stride frequency has been identified as the more important of the two components of sprinting speed, the other being stride length (1,17,22,30).

METHODS

Fourteen male volunteers were randomly assigned to two groups for the study. A counter-balanced design was used to identify the presence of order or learning effect. Subjects performed two trials of maximal running in place on each of two successive days. All testing was conducted at the same times of day to decrease the possible influence of circadian rhythm. On day one, subjects in group one performed both trials without massage. No alternate preliminary preparation, e.g., stretching or warm-up, was permitted. Subjects in group two were massaged according to the outline below, then tested. On day two of the study, group two was tested without massage, and group one was massaged, then tested. All subjects participated in practice sessions prior to the study to familiarize themselves with the testing procedures.

All subjects were actively engaged in sprint or sprint-related training at the time of the study, and none had suffered a significant running injury within the previous three months. Eight of the subjects were sprint specialists. Six competed for the University of Oregon track program, one for a community college track team, and one for a private track club. Three subjects were jump specialists in the Oregon program. Research citing sprinting ability as the basis of jumping performance argued for the inclusion of the jumpers (8,43). The remaining three subjects were varsity running backs on the University of Oregon football team.

The subjects ranged in age from 18 to 33 years old (X = 21.6 years), and had been engaged in structured training programs for three and one-half to sixteen years (X = 8.3 years). Twelve of the subjects had recorded track times for the 100 meters, ranging from 10.4 to 11.0 seconds (X = 10.66). Of the two subjects with no 100m time, one had recorded a personal best of 50'7" in the triple jump and the other a personal best of 14.4 seconds in the 110m hurdles.

A Licensed Massage Technician (LMT) with 14 years experience as a practitioner and instructor of masssage administered the treatment. The sequence of the massage was adapted from recommendations in the literature (5,31,40) and lasted approximately 30 minutes (4,14,36,41). Application of massage was conducted in a small, comfortable, secured room separate from the testing area. A small electric clock was located for the massage technician's convenience to allow for standardized application. An abundant supply of clean towels, for draping and cleansing, and hypo-allergic massage lotion (Cramer products) were provided.

Each massage proceeded as follows:

1. The subject was instructed to disrobe and position himself supine on the massage table where he was draped with a towel.
2. The LMT began with effleurage and petrissage of the neck followed by petrissage of the shoulder, girdle, and chest. This sequence took approximately four minutes.
3. Immediately following upper body work the LMT moved to the lower extremities and commenced with petrissage of the toes, foot, and ankle. Effleurage of the anterior, medial, and lateral surfaces of the leg and thigh followed.
4. The LMT continued with petrissage of the leg and thigh.
5. Petrissage of the foot and effleurage of the leg and thighs was repeated.
6. Tapotement of the anterior surface of the lower extremities was performed.
   Total time for steps three through six for both limbs was approximately 14 minutes.
7. The subject was directed to prone position.
8. The LMT continued with effleurage and petrissage of the foot, and then proceeded to petrissage of the posterior leg muscles with the knee bent.
9. Effleurage of the medial, lateral, and posterior surfaces of the leg and thigh and the posterior surface of the hip was followed by petrissage of the medial and lateral surfaces of the leg and thigh.
10. Effleurage of the extremity was repeated and the massage was concluded with tapotement of the posterior surface of the hip and extremity.
    Total time for steps seven through ten for both limbs was approximately 13 minutes.

Each subject reported to the test area dressed in shorts and training flats. The testing procedure was explained again. The subject was then placed facing a multicomponent Kistler Force Platform (Model 9261A) and the command "ready" was given. On the command "go" the subject commenced maximal running in place for 10 seconds until the command "stop." Recording and timing were automatically controlled and did not begin until first contact with the force platform, thereby eliminating reaction time as a source of variance between subjects. After a rest period of one to two minutes, the second trial was conducted.

Stride frequency was determined by counting the vertical component of the ground reaction force on the force platform, which was bolted to a concrete block specially constructed to stabilize the platform and reduce the effect of extraneous vibrations on the values being recorded. The electrical output from the force platform was amplified (KIAG SWISS Type 5001 Charge Amplifier) and summed (RTC Summing Amplifier). The summing amplifier was interfaced to a Tektronic 4052 Graphic Calculator via a TransEra Analog-to-Digital Converter (4052 ROM Pack, Model 752-ADC). Data were recorded on a magnetic tape cartridge for later retrieval in graph form. A printout of each trial was obtained and the number of steps taken, as represented by spikes on the graph, were counted. A sampling rate of 100 hz allowed for 1000 points of reference during each 10-second trial.

RESULTS

Means and standard deviations of stride frequency for no massage trials were 97.57 (16.32), 96.43 (16.74) for group one, and 96.57 (15.06), 93.86 (18.32) for group two. Massage trials means and standard deviations were 101.14 (15.18), 99.71 (16.29) for group one, and 98.86 (7.56), 93.86 (12.29) for group two. Mean scores indicate two prevalent patterns: 1) a decrease in mean scores from the first trial to the second trial in all testing periods (Figure 1), and 2) an increase in mean scores from the no-massage trials to the post-massage trials (except for group two, trial two, where the no-massage/post-massage means were unchanged) (Figure 2). In addition, the absolute highest mean scores for both groups occurred in trial one, post-massage.

Preliminary analysis indicated that groups one and two did not differ significantly in their scores [$F(1,12)= .15$, $p= 0.7$], therefore, results were collapsed across order for further analysis. A two factor ANOVA with both factors repeated was conducted on the combined data to investigate the effect of treatment (massage) and trials, and the interaction between treatment and trials on stride frequency. No difference was found between scores following massage and those obtained without massage [$F(1,13)= 1.35$, $p=0.26$]. The interaction of massage and trials was also not significant [$F(1,13)= .46$, $p=0.51$]. Scores in trial one were higher than scores in trial two [$F(1, 13)= 5$, $p=0.04$].

Each subject was interviewed following the conclusion of testing to ascertain his impressions of the massage treatment. All subjects responded positively to massage, stating they felt relaxed and refreshed following treatment. Subjects also reported feeling better able to cope with physical exer-

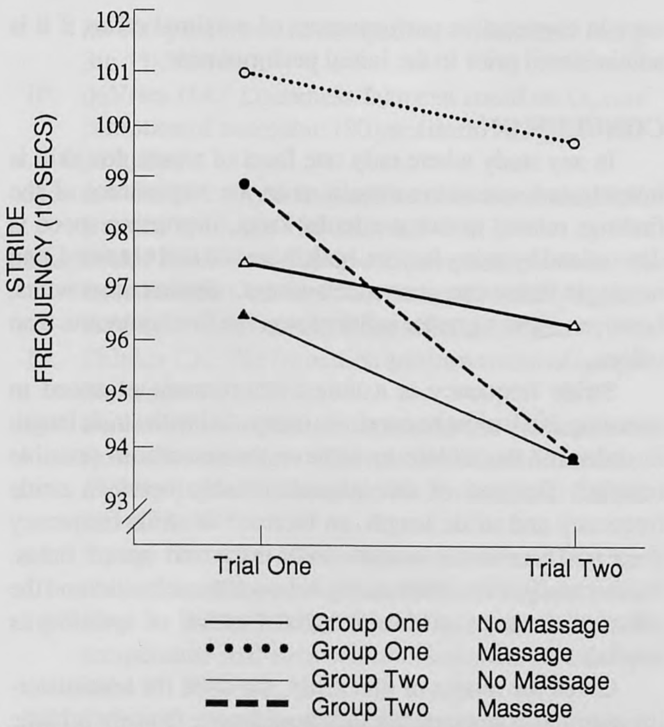


Figure 1. Comparison of trial one and trial two scores for both groups in each test period

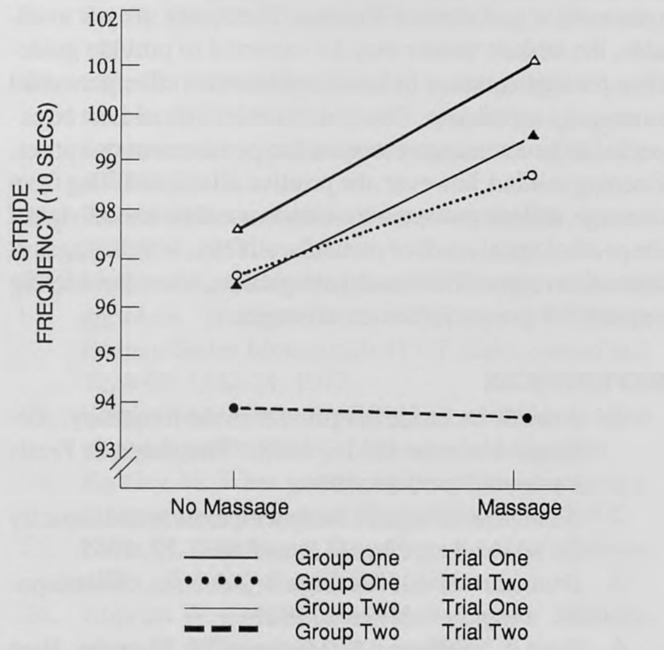


Figure 2. Comparison of no massage *versus* massage scores for both trials of both groups

tion. Several athletes commented that the massage allowed them to perform "better" in their regular work-out sessions for periods ranging from the same day to up to five days after the massage.

DISCUSSION

In sprinting, two interrelated biomechanical factors contribute to speed over the ground: stride frequency and stride length (17,25). Logically, an increase in running speed might be attained by increasing one, or both, of these factors. A variety of characteristics, however, are thought to inhibit or impede sprinting speed by limiting stride frequency and/or stride length. Included among these inhibitors are poor form (40), poor muscular flexibility (7), restricted lower extremity range of motion (31), and psychological factors such as anxiety (19,27). These traits may be manifested in a sprinter's inability to relax prior to competition, or inability to run relaxed in competition. A relaxed body, i.e., one in which a lack of restrictive tension allows unimpaired movement in any direction (34), is held to be a primary prerequisite for success in sprinting (7,15,40).

It has been noted that sprinters' stride frequencies are not necessarily limited by neuromuscular mechanisms. The maximum number of contractions that can be initiated by the nervous system is greater than the maximum number of movements that a runner can make in a given time. The mass of the leg, its moment of inertia in recovery, the rate of development of kinetic energy, the internal muscular viscosity, the weight of the athlete, the angle of propulsion (15), and the resistance offered by the antagonists (40) have been identified as limiting factors in increasing stride frequency. Many athletes believe that massage has a positive effect in countering the restrictive elements of muscle tension and inflexibility, and enables them to perform better.

Although a variety of psychological and physiological effects are widely attributed to massage (3,6,24,26), research to support some of these claims is lacking. The efficacy of massage in promoting positive conditions associated with circulation, muscle tonicity, and psychological well-being has led to claims that massage can have a positive effect on athletic performance (24,26). Some authors have postulated performance improvements of up to 20 percent (3,34,38), but they have failed to identify specific areas of improved performance, or to provide evidence to support their claims. Although these effects have not been substantiated, pre-performance massage is widely used in many sports including swimming, track, and various types of football of European origin.

In sprinting, belief in the benefit of pre-performance massage has been based on one or more of the following purported effects of massage: increased efficiency of limb movement resulting from a decrease in adverse muscle tonicity caused by "nerves," overtraining, or injury (7); increased efficiency of limb movement resulting from an increase in tissue temperature with a resultant decrease in tissue friction and tissue fluid viscosity (21); increased efficiency of limb movement resulting from an increased range of motion as a result of decreased antagonistic opposition (10,40); increased efficiency of metabolic processes as a consequence of increased circulation (11); and better mental attitude because of the effects of massage on the psyche (3).

Statistical analysis of the data in this study found that pre-performance massage did not exert a significant influence on performance. This finding is contrary to popular opinion and some previous research (29,35,42), but is consistent with a number of studies (2,9,20,23).

Although the results were statistically not significant, the magnitude and direction of the means between no massage and massage conditions may lead some athletes and coaches to argue that the use of pre-performance massage is warranted (Figure 2). The highest absolute stride frequency for each group was obtained in the first trial immediately following massage and the mean stride frequencies for three of the four post-massage conditions were 2.4% to 3.1% higher than the no massage conditions. In events that may be decided by one one-hundredth of a second, conventional statistical significance levels in research settings may be considered too stringent to be the only criterion for determining whether the experimental results have practical value. Ecker (17), for example, argued that a stride frequency increase of only one-half stride/second could lower the time to complete a 100 yard sprint by 1.3 seconds. From this contention, the percentage increases noted above could theoretically result in an improvement of approximately one half second for a 100 yard sprint. This possibility, coupled with the fact that massage is not shown to be detrimental nor to involve undue cost, may be enough for athletes and coaches to accept p=.26 as a reasonable indication for use of massage as an ergogenic aid.

If pre-performance massage does exert an ergogenic effect (albeit a questionable one), the potential benefit to athletes of continuing this practice is substantial, i.e., an improvement in performance. However, in keeping with the findings of this study, even though we assume that pre-performance massage does not enhance performance, the cost of continuing the practice is negligible. There are no deleterious effects to the athletes, i.e., massage does not decrease performance or injure the athletes, and positive affects are apparent. The anecdotal assessments of the massage treatment given by the subjects are in keeping with the literature which indicates that a relaxed feeling following massage can put athletes in a positive frame of mind wherein they feel capable of performing up to their potential (3,26,28). Therefore, coaches and athletes may feel the potential reward/risk ratio is sufficient to support the continued use of pre-performance massage. However, athletic trainers should be mindful of the limitations of this approach.

I must emphasize that the results of this study were obtained after an extensive (30 minutes) and conscientious treatment by an experienced massage technician. Given the small changes that followed this thorough preparation, it seems reasonable to assume that more cursory massages may be of less value. Controlled studies that indicate the relationship between "thoroughness" of the massage and variations in performance have not been conducted. The range of that relationship in this study (from no massage producing no ergogenic effect to the values obtained from the treatment provided) argues for the massage to be at least as concerted as that given in this study, if it is to be used in an attempt to elicit a performance effect.

The only statistically significant result obtained in this study (trials effect) may be attributed to the effects of fatigue on performance. Given the requirement of two bouts of maximal effort per test period, with a very short recovery time between the two, a performance decline in the second bout is not unexpected. The lack of a significant treatment times trials interaction suggests that massage does not aid performance in consecutive performances of maximal effort if it is administered prior to the initial performance.

CONCLUSION

In any study where only one facet of a complex skill is investigated, questions remain as to the importance of the findings related to that particular facet. Sprinting speed is determined by many factors, both inherited and obtained, and no single factor can guarantee success. Some components, however, exert a greater influence on the final outcome than others.

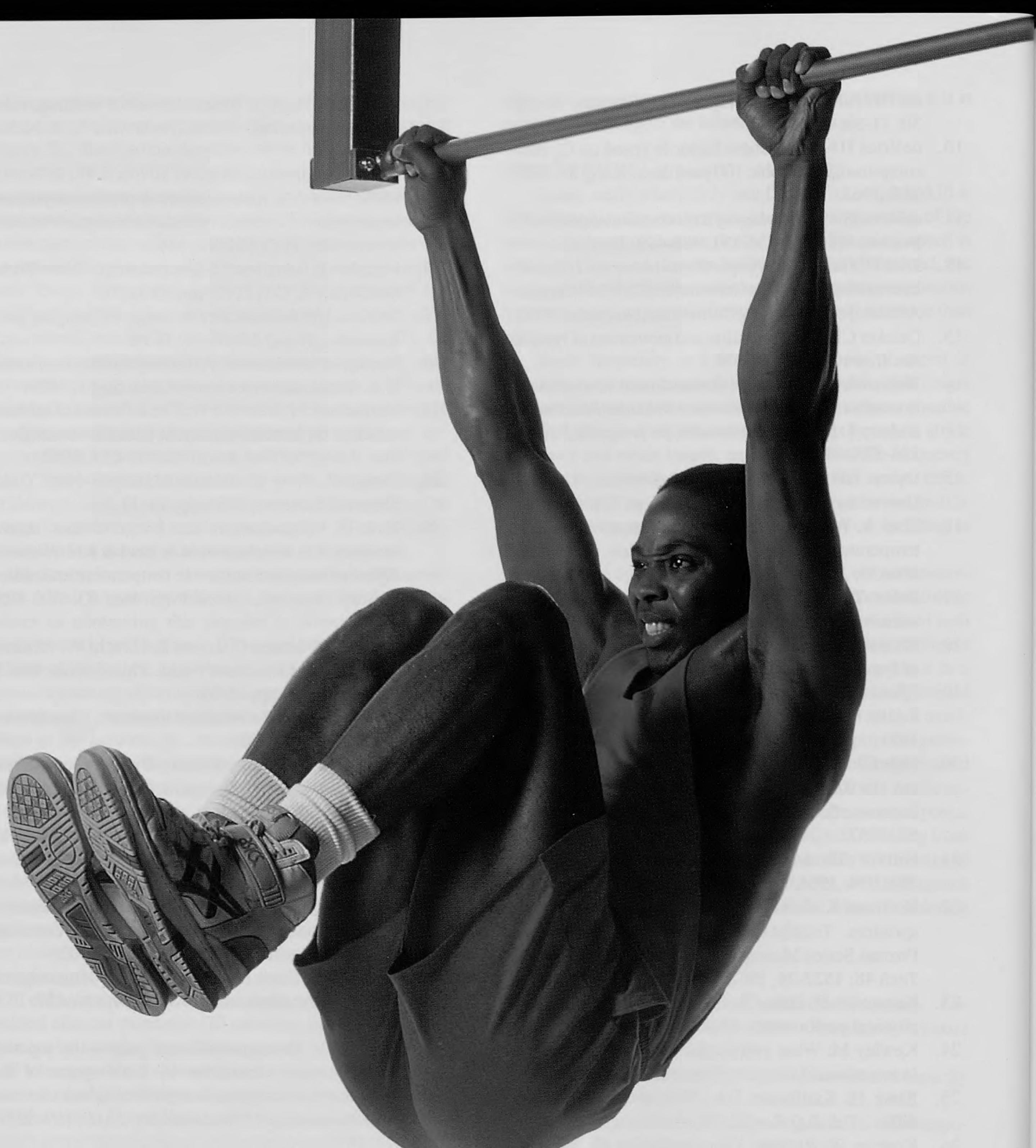
Stride frequency is a major determinant of speed in sprinting, but it must be carefully integrated with stride length in order for the athlete to achieve the maximum possible benefit. Because of the interrelationship between stride frequency and stride length, an increase in stride frequency does not necessarily equate with improved sprint times. Further study of the relationship between these factors and the effect of massage on the intregrated action of sprinting is needed.

Given the results of this study, the onus for administering massage as an ergogenic aid should move from the athletic trainer to coaches or other personnel directly concerned with improving the athlete's performance. The athletic trainer's primary responsibility regarding massage is in using it as a therapeutic modality. In situations where appropriately trained personnel, e.g., Licensed Massage Therapists, are not available, the athletic trainer may be expected to provide guidelines for application or to instruct athletes or other personnel in massage techniques. The athletic trainer should not be expected to be a massage therapist for performance purposes. Keeping in mind, however, the positive affects resulting from massage, athletic trainers may wish to use their knowledge of the psychological needs of particular athletes, weighed against their other responsibilities and obligations, when considering requests for pre-performance massages.

REFERENCES

1. Artinuk D: Stride length and stride frequency. *Legkaya Athletika* 10: 16, 1973. Translated in *Yessis Review* 9(3): 60-61, 1974.
2. Asmussen E, Boje O: Body temperature and capacity for work. *Acta Physiol Scand* 10: 1-23, 1945.
3. Baumgartner AJ: *Massage in Athletics*. Minneapolis: Burgess Publishing, 1947.
4. Bean B, Henderson H, Martinsen M: Massage: How to do it and what it can do for you. *Sch Coach* 52(5): 10-11, 58, 1982.
5. Birukov A: Massage: Its essentials in different track and field events. *Legkaya Athletika* 9: 24-26, 1981. Translated in *Soviet Sports Rev* 17: 69-72, 1982.
6. Breakey BM: An overlooked therapy you can use *ad lib*. *RN* 45: 7, 1982.
7. Bush J: *Dynamic Track & Field*. Boston: Allyn & Bacon, Inc., 1978, pp. 4-20, 478.
8. Christyakov V: The main thing is speed. *Track & Field* 11:18-20, 1975.
9. deVries HA: Effects of various warm-up procedures

on 100 yard times of competitive swimmers. *Res Q* 30: 11-20, 1959.
10. deVries HA: Looseness factor in speed on O_2 consumption of anaerobic 100 yard dash. *Res Q* 34: 305-313, 1963.
11. deVries HA: *Physiology of Exercise*. Dubuque: W.C. Brown, 1980, pp. 136-151, 488-499.
12. Dick F: *Technical Olympic Report Moscow 1980*. XI International Coaches Convention, Scottish Amateur Athletic Joint Coaching Committee, November 1980.
13. Drinker CK: The formation and movement of lymph. *Am Heart J* 18: 389, 1939.
14. Dubrovsky VI: Changes in muscle and venous blood flow after massage. *Teoreya i Praktika Fizicheskoi Kultury* 4: 56-57. Translated in *Soviet Sports Rev* 18: 134-135, 1983.
15. Dyson GH: *The Mechanics of Athletics*. London: University of London Press, 1967, p. 124.
16. Ebel A, Wisham LH: Effect of massage on muscle temperature and radiosodium clearance. *Arch Phys Med* 33: 399-405, 1952.
17. Ecker T: *Track and Field Dynamics*. Los Altos: Tafnews Press, 1971, pp. 99-101.
18. Elkins EC: Effects of various procedures on the flow of lymph. *Arch Phys Med* 34: 31-39, 1953.
19. Elliott C: What price tension? High! *Athletics Arena* 8 (10):134. Reprinted in *T & F Q Rev* 71(4): 250, 1971.
20. Hale CJ: Effects of preliminary massage on 440 yard run. in BA Pacheco, Improvements in jumping performance due to preliminary exercise. *Res Q* 28: 55-63, 1957.
21. Hill AV: The mechanics of voluntary muscle. *Lancet* 261: 974, 1951.
22. Hoffman K: Stride length and frequency of female sprinters. Treatises, Texts & Documents WSWF in Poznan Series Monograph #17 (Polish), quoted in *T Tech* 48: 1522-24, 1972.
23. Karpovich P, Hale CJ: Effect of warming-up upon physical performance. *JAMA*. 162: 1117, 1956.
24. Kewley M: What you should know about massage. *International Swimmer*, September, 29-30, 1982.
25. Kunz H, Kaufmann DA: How the best sprinters differ. *T & F Q Rev* 80 (20), 1980.
26. Kuprian W: *Physical Therapy for Sports*. Philadelphia: W.B.Saunders, 1981, pp.7-51.
27. Lanning W: Competition and anxiety management. *T & F Q Rev* 77 (2): 37-38, 1977.
28. Longworth JCD: Psychophysiological effects of slow stroke back massage in normotensive females. *Adv Nurs Sci* July: 44-61, 1982.
29. Maggiora A: De l'action physiologique du massage sur les muscles de l'homme. *Arch Ital Biol* 16: 225, 1891.
30. Mann RA: The biomechanical analyses of sprinters. *T Tech* 94: 3000-03, 1986.
31. Mann RA, Hagy J: Biomechanics of walking, running and sprinting. *Am J Sports Med* 8: 345-350, 1980.
32. Martin D: Massage. *Jogger*, 10 (5): 8-15, 1978.
33. McKechnie AA: Anxiety states: A preliminary report on the value of connective tissue massage. *J Psychosomatic Res* 27 (2): 125-9, 1983.
34. Meagher J, Boughton P: *Sportmassage*. New York: Doubleday & Co., 1980, pp. vii-xx, 6.
35. Merlino LV: Influence of massage on jumping performance. *Res Q* 30: 66-74, 1959.
36. Nordqvist M: Massage: A training must but not in the U.S. *Track and Field News* 32(4): 50-51, 1979.
37. Nordschow M, Bierman W: The influence of manual massage on muscle relaxation: Effect on trunk flexion. *J Am Phy Ther Assoc* 42: 653-657, 1962.
38. Phaigh R, Perry P: *Athletic Massage*. New York: Simon & Schuster, 1984, pp. 11-19.
39. Pick F: Vehandlungen des kongress fuer innere medizen XX Weisbaden, in A Ebel & LH Wisham, Effect of massage on muscle temperature and radiosodium clearance. *Arch Phys Med* 33: 399-405, 1952.
40. Robison C, Jensen C, James S, Hirschi W: *Modern Techniques of Track and Field*. Philadelphia: Lea & Febeger, 1974, pp. 35-56.
41. Ryan A: The neglected art of massage. *Phys Sportsmed* 8(12): 25, 1980.
42. Schmid L: Increasing athletic efficiency by preliminary warming-up. *Casopisu Lekaru Geskych* 76: 950-963, 1947.
43. Siluyanov V, Maximov R: Speed and strength in the long jump. *Legkaya Athletika* 10: 18, 1977. Translated in *Soviet Sports Rev* 13: 3, 1978.
44. Start KB: Incidence of injury in muscle undergoing maximum isometric contraction without warm-up. *Arch Phys Med Rehabil* 43: 284-286, 1962.
45. Suskind MI, Hajek N, Hinds H: Effects of massage on denervated skeletal muscle. *Arch Phys Med* 27: 133-135, 1946.
46. Thiele GH: Coccygodynia and pain in the superior gluteal region - causation by tonic spasm of the levator ani, coccygeus and piriformis muscles and relief by massage of these muscles. *JAMA* 109: 1271-75, 1937.
47. Wakim KG, Martin GM, Terrier JC, Elkins EC, Krusen EH: The effects of massage on the circulation in normal and paralysed extremities. *Arch Phys Med* 30: 135-144, 1949.
48. Wiktorrson-Moller M, Oberg B, Ekstrand J, Gillquist J: Effects of warming-up, massage and stretching on range of motion and muscle strength in the lower extremities. *Am J Sports Med* 11: 249-251, 1983.
49. Wyper DJ, McNiven D: Effects of some physiotherapeutic agents on skeletal muscle blood flow. *Phys Ther* 62: 83-85, 1976.



Ankle Joint Strength, Total Work, and ROM: Comparison Between Prophylactic Devices

Gale M. Gehlsen, PhD
David Pearson, PhD
Rafael Bahamonde, MS

ABSTRACT: This study compares ankle joint strength (plantar flexion and dorsiflexion isokinetic), total work, and range of motion (ROM) values among four different types of ankle joint protective devices: a) Active Ankle, b) Aircast, c) Swede-O-Universal, and d) protective tape wrap. A control treatment (without a protective device) also was employed. The subjects were ten male volunteers, age 23.5 ± 3.7 yrs. The Cybex 340 isokinetic dynamometer system, using computer-aided programs as well as the Upper Body Exercise Table (UBXT), was employed to measure peak ankle plantar and dorsiflexion isokinetic strength, total work, and ROM at 30°, 120°, and 180°. In addition, passive ROM was measured with a Zimmer goniometer. Statistical analyses (ANOVA and post hoc *analyses) indicated a significant difference (p < 0.05) between and among treatments for plantar flexion peak isokinetic strength, total work, and ROM variables. The results of this study suggest that ankle joint prophylactic guards do limit force production, total work, and ROM. In addition, there was a difference among Active Ankle, Aircast, Swede-O-Universal, and protective tape ankle support devices regarding the magnitude of ankle strength production and ROM permitted.*

Do ankle support devices (orthotics or taping) decrease the probability of sprained ankles without significantly decreasing strength, range of motion (ROM), and performance levels? There is little doubt that some form of ankle support will aid in decreasing the probability of an ankle sprain (4,5,6,11,12). A major criticism of tape wraps and supportive devices, however, is that they decrease the ROM and strength of plantar flexion and dorsiflexion, thereby hindering performance (7,9,10). There are few published studies concerning ankle protective devices. This study compares ankle joint plantar flexion and dorsiflexion isokinetic strength, fatigue, and ROM values among four different types of ankle joint protective devices. The devices studied were a) Active Ankle, Active Innovation, Inc., Louisville, KY, b) Air-Stirrup, Aircast, Inc., Summit, NJ, c) Swede-O-Universal, North Branch, MN, and d) protective taping. As a control a fifth experimental condition, the use of no supportive device (NOS), was studied.

Gale Gehlsen is Professor and Director of the Biomechanics Laboratory at Ball State University, Muncie, Indiana, 47306.

David Pearson is an Assistant Professor of Exercise Physiology in the Human Performance Laboratory at Ball State University.

Rafael Bahamonde is an Instructor of Biomechanics in the Biomechanics Laboratory at Ball State University.

METHODS

The subjects were ten male volunteer college students (age = 23.5 ± 3.7 yrs, ht = 5.83 ± 0.16 ft, and wt = 171.8 ± 22.09 lbs). Four subjects wore a size 9 men's shoe and six wore a size 10 men's shoe. All subjects were apparently healthy and had no history of ankle sprain for at least five months prior to testing. University procedures for the protection of human subjects were followed.

A Cybex 340 isokinetic dynamometer system using computer-aided programs, as well as an Upper Body Exercise Testing Table (Cybex Division of Lumex, Inc., Ronkonkoma, NY), were employed to measure ankle plantar flexion and dorsiflexion isokinetic strength, total work, and active ROM. In addition, passive ROM was measured in degrees with a Zimmer goniometer. The experimental protocol required each subject to report for testing five times, at 48-hour intervals at approximately the same time of day. A computer program dictated the test protocol, although we or the subject could terminate the testing at any time.

The order that subjects were assigned an experimental condition was counterbalanced with a Latin squares design. In the order of testing, the supportive device or tape was applied to each subject's left ankle. All subjects wore new

B.G. Pro athletic shoes during all tests.

The ankle taping was a conventional closed basketweave with three heel locks (1 1/2 inch Johnson & Johnson linen coach tape) applied by a certified athletic trainer over a spray adherent and underwrap (2).

Subjects jogged (6.0 mph) for approximately two minutes on a treadmill, then walked in a hallway at a freely chosen speed for approximately two minutes. They were then tested for plantar flexion and dorsiflexion isokinetic strength, total work, and ROM.

All testing took place with subjects in a prone position on the Upper Body Exercise Table (UBXT) with their knees extended and their left foot in the footplate attached to the dynamometer. The ankles were secured to the footplate using a plantar/dorsiflexion footplate belt, and secured to the UBXT with a pelvic belt applied just above the knees.

The ankle axis of rotation passed obliquely through the tip of the lateral malleolus of the fibula and the trochlea of the talus, exiting just distal to the tip of the medial malleolus of the tibia. Stabilizing the foot on the footplate eliminated movement of the longitudinal arch, which if not controlled might falsely add to the range of motion measurements.

Strength was tested isokinetically at 30°/sec, at 120°/sec, and at 180°/sec, with 20 seconds rest between trials. Subjects were given four practice trials at each speed and were encouraged not to give an all-out effort until the third or fourth attempt. Subjects rested for 20 seconds, then were asked to perform three successive maximum voluntary contractions. A color computer monitor provided the subjects with video performance feedback throughout each trial.

After the three strength tests the subjects rested for 20 seconds, then practiced four contractions of the work performance tests at 180°. They then took the work performance test, which consisted of maximum voluntary plantar/dorsiflexion contractions.

Peak torque values were divided by body weight in order to normalize the data. Each dependent variable was evaluated with an analysis of variance (ANOVA) with repeated measures. Significant F values were further tested with Scheffe's *post hoc* analysis.

RESULTS

The normalized peak torque values are presented in Table 1. There was a significant difference [$F(9,4) = 4.02$, $p < 0.05$] in plantar flexion peak torque between treatments at 30° and 120°, but not at 180°. At 30° peak torques generated for the Air-Stirrup, Active Ankle, protective tape, and Swede-O-Universal treatments were 11 to 19 percent less than the control. At 120°, the Air-Stirrup, Active Ankle, tape, and Swede-O-Universal treatments were 3 to 18 percent less than the mean control peak torque value. Peak torque data at 180° indicated that the Air-Stirrup, Swede-O-Universal, and tape treatments ranged from 9 to 21 percent less than the control treatment. The Active Ankle treatment was 7.8 percent greater than the control treatment mean value.

The mean dorsiflexion peak torque were not significantly different (Table 1). The percent of difference between the control and other experimental treatments ranged from 1 to 22 percent.

The mean values of plantar flexion total work performed are presented in Table 2. There was a significant difference [$F(9,4) = 6.02$, $p < 0.05$] between plantar flexion treatments. Plantar flexion total work for the experimental conditions was 4 to 24 percent of the control condition.

Table 1. Peak torque percent of body weight mean and standard deviation values

SPEED	NOS	AC	AA	SW	TP
		(Nm/kg)			
PLANTAR FLEXION					
30°/sec	72.5^{d}	61.1	64.3^{d}	58.7^{ac}	62.9
	(10.8)	(12.7)	(17.6)	(15.18)	(12.2)
120°/sec	40.7^{d}	34.3	39.5^{d}	30.0^{ac}	33.4
	(10.6)	(4.3)	(10.8)	(8.4)	(7.3)
180°/sec	29.3	26.7	31.6	24.3	23.3
	(8.4)	(3.4)	(13.9)	(6.1)	(7.2)
DORSIFLEXION					
30°/sec	17.5	15.7	17.8	16.8	17.1
	2.0	2.6	3.1	2.7	2.2
120°/sec	9.8	8.5	11.4	9.1	8.7
	1.2	1.8	3.9	2.3	1.5
180°/sec	6.5	6.8	8.1	5.8	5.8
	1.5	2.2	6.6	1.6	1.2

No Support (NOS)
Air Stirrup (AC)
Active Ankle (AA)
Swede-O (SW)
Tape (TP)

a = significantly different ($p < 0.05$) from No Support (NOS)
b = significantly different ($p < 0.05$) from Air Stirrup (AC)
c = significantly different ($p < 0.05$) from Active Ankle (AA)
d = significantly different ($p < 0.05$) from Swede-O (SW)
e = significantly different ($p < 0.05$) from Tape (TP)

Table 2. Plantar flexion and dorsiflexion total work mean and standard deviation values

NOS	AC	AA	SW	TP
		(Nm)		
PLANTAR FLEXION				
409.3^{de}	367.8	393.4^{de}	310.0^{ac}	312.6^{ac}
(133.3)	(129.3)	(177.5)	(149.9)	(139.2)
DORSIFLEXION				
74.2	63.8	71.2	49.2	64.3
(36.6)	(28.6)	(36.7)	(21.0)	(26.8)

a = significantly different ($p < 0.05$) from No Support (NOS)
b = significantly different ($p < 0.05$) from Air Stirrup (AC)
c = significantly different ($p < 0.05$) from Active Ankle (AA)
d = significantly different ($p < 0.05$) from Swede-O (SW)
e = significantly different ($p < 0.05$) from Tape (TP)

Table 3. Average, maximum, and passive range of motion mean and standard deviation values

SPEED	NOS	AC	AA	SW	TP
			(degrees)		
AVERAGE ROM					
30°/sec	55.7[d] (11.3)	52.8 (16.7)	53.8 (14.0)	47.7[a] (15.0)	51.6 (12.4)
120°/sec	61.7[bde] (5.8)	55.1[a] (7.3)	59.2 (8.8)	54.8[a] (7.1)	54.0 (6.2)
180°/sec	56.0[de] (6.4)	52.4 (4.9)	54.6[d] (8.6)	49.1[ac] (6.9)	50.0[a] (6.2)
MAXIMUM ROM					
30°/sec	63.0[d] (11.5)	59.0 (16.7)	61.0 (13.9)	54.8[a] (16.6)	58.5 (12.6)
120°/sec	67.1[e] (6.3)	61.2 (7.9)	65.1 (9.2)	61.2 (7.9)	60.4[a] (6.6)
180°/sec	64.8[d] (5.7)	61.7 (6.7)	63.5 (7.7)	59.0[a] (8.2)	59.8 (5.4)
PASSIVE PLANTAR FLEXION ROM					
	38.6[bcde] (6.1)	33.8[ad] (6.7)	33.3[ad] (5.9)	28.1[abd] (5.0)	32.6[ad] (7.6)
PASSIVE DORSIFLEXION ROM					
	12.7[de] (4.9)	9.9 (4.1)	12.1 (4.5)	9.4[a] (2.9)	9.7[a] (3.9)

a = significantly different ($p < 0.05$) from No Support (NOS)
b = significantly different ($p < 0.05$) from Air Stirrup (AC)
c = significantly different ($p < 0.05$) from Active Ankle (AA)
d = significantly different ($p < 0.05$) from Swede-O (SW)
e = significantly different ($p < 0.05$) from Tape (TP)

There was no significant difference [$F(9,4) = 3.44$, $p > 0.05$] in dorsiflexion total between conditions. The experimental conditions were 4 to 34 percent less than the control condition.

Table 3 contains mean values for average ROM as measured by the isokinetic dynamometer at the three speeds of movement. There was no significant difference [$F(9,4) = 3.21$, $p < 0.05$] between treatments at any of the speeds.

Maximum ROM is defined as the difference between maximum plantar flexion and dorsiflexion angular values. The percentage difference between the control treatment and the other treatments ranged from 4 to 2 percent at 30°, 3 to 10 percent at 120°, and 4 to 9 percent at 180°.

Average passive ROM values for both plantar flexion and dorsiflexion are presented in Table 3. Plantar flexion ROM was significantly greater [$F(9,4) = 5.88$, $p < 0.05$] in the control group than the other experimental treatments. The difference between them ranged from 11 to 27 percent.

Dorsiflexion ROM was significantly greater [$F(9,4) = 5.68$, $p < 0.05$] in the control group than all other treatment groups except the Active Ankle. The percentage of difference ranged from 5 to 27 percent.

DISCUSSION

The results of this study indicate that plantar flexion total work is affected by some supportive devices. If we consider performance to be related to plantar flexion total work, then our tape wrap total work test results are supported by others who found that ankle tape wraps inhibit motor performances (7,9,10).

The plantar flexion peak torque results of this study agree with the findings of Abdenour et al. (1) and Fisher (3) who found that ankle tape wraps do not inhibit ankle plantar flexion strength. In addition, our data indicate that some types of prophylactic ankle devices inhibited the production of peak isokinetic torque at 30° and 120° movement speeds.

Perhaps an athlete should use different types of ankle protection depending on the activity situation. In activities which require maximum plantar flexion strength, a protective device that does not inhibit strength should be used. However, if the activity requires maximum ankle joint total work, a different type of protective device should be used. An activity that requires both strength and total work requires a third type of ankle protection device.

One explanation for finding no significant difference between the dorsiflexion strength tests may be related to the small range of values between dorsiflexion tests.

There are two possible hypotheses concerning the effectiveness of ankle joint supportive devices and ROM. One hypothesis is that a device is more effective if the ROM is restricted, thereby limiting at risk movement. The other hypothesis is that a device is more effective if plantar flexion and dorsiflexion ROM were restricted only when normal ROM limits were exceeded. If the latter hypothesis is accepted, then the Active Ankle and Air-Stirrup braces appear to be the better devices in allowing full ROM. With the exception of plantar flexion and dorsiflexion flexibility tests, the Active Ankle brace was the closest to wearing no brace at all. The tape and Swede-O-Universal braces consistently limited the ROM. This is probably a result of the design of the support device (i.e., restriction in front and in the back of the joint).

In conclusion, these results suggest that the selected ankle joint prophylactic guards tested under these conditions differ in their ability to provide normal isokinetic torque production, total work, and active and passive ROM. In addition, the results presented here indicate that there are significant differences among ankle prophylactic devices in peak ankle torque production, total work, and active and passive ROM.

ACKNOWLEDGEMENT

We wish to express our appreciation to Vicky Graham, ATC, Rex Sharp, ATC, and Kathy Malone, ATC for their assistance with this project. This study was financially supported by Active Innovation, Inc., Louisville, Kentucky.

REFERENCES

1. Abdenour TE, Saville WA, White RC, Abdenour

MA: The effect of ankle taping upon torque and range of motion. *Athletic Training, JNATA* 14: 227-228, 1979.
2. Fahey, TD: *Athletic Training Principles and Practice.* Palo Alto, CA: Mayfield Publishing Co., 1986, pp. 521-523.
3. Fisher RD: The measured effect of taping joint range of motion, and their interaction, upon the production of isometric ankle torques. *Athletic Training, JNATA* 17: 218-223, 1982.
4. Garrick JG, Requa RK: Role of external support in the prevention of ankle sprains. *Med Sci Sports* 5: 200-203, 1973.
5. Gross MT, Bradshaw MK, Ventry LC, Weller KH: Comparison of support provided by ankle taping and semirigid orthosis. *JOSPT* 9: 33-39, 1987.
6. Hughes LY, Stetts DM: A comparison of ankle taping and semirigid support. *Phys Sportsmed* 11(4): 99-103, 1983.
7. Juvenal JP: The effects of ankle taping on vertical jumping ability. *Athletic Training, JNATA* 7:146-149, 1972.
8. Mayhew JL: Effects of ankle taping on motor performance. *Athletic Training, JNATA* 7: 10-11, 1972.
9. McIntyre DR, Smith MA, Denniston NL: The effectiveness of strapping techniques during prolonged dynamic exercises. *Athletic Training, JNATA* 18: 52-55, 1983.
10. Robinson JR, Frederick EC, Cooper LB: Systematic ankle stabilization and the effect on performance. *Med Sci Sports Exerc* 18: 625-628, 1986.
11. Rovere GD, Clarke TJ, Yates CS, Burley K: Retrospective comparison of taping and ankle stabilizers in preventing ankle injuries. *Am J Sports Med* 16: 228-232, 1988.
12. Seitz CJ, Goldfuss AJ: The effect of taping and exercise on passive foot inversion and ankle plantar flexion. *Athletic Training, JNATA* 19: 178-182, 1984.

Quality Physicals that Generate Funds for the Training Room

Suzanne E. Heinzman, MS, ATC

More than five million students participate in senior high school sports programs every year, and many more participate at the junior high level (2). Most states require a yearly preparticipation examination for all athletes who take part in school sponsored sports. The primary purpose of the preparticipation health examination is to identify athletes who are at risk when playing a specific sport (1).

Frequently, preparticipation physicals have been little more than a cursory office review of the various body systems, and often are not precise for the demands of each sport. Efforts should be made to emphasize screening the body systems that are stressed in athletic competition, including musculoskeletal and cardiovascular (3).

Our organization uses the multiple examiner approach for administering preparticipation physical examinations. The multiple examiner or station type of evaluation provides one of the most effective and efficient types of preparticipation health evaluations (5). It is organized so that athletes are examined by several physicians and other health professionals whose specialties coincide with the stations they are managing. This type of evaluation offers the advantage of being sports oriented, and is performed by examiners who are familiar with the risks inherent to sports activities. In addition, the athletic trainer, coach, and student athletic trainer can be involved in such tasks as recording height and weight, taking pulse and blood pressure, and conducting eye exams and urinalysis. This conveys the message to the athlete that each of these individuals cares about their entire well being, and associates sports activity with good health care (4).

We schedule physicals in the spring before school is adjourned for the summer for two reasons. One, it is important that preparticipation physicals take place several weeks before the athlete's season. This allows adequate time for rehabilitation of injuries, or further testing and assessment if deficits or defects are found by the examiner. Two, spring physicals fulfill most summer sports camp physical requirements.

Suzanne Heinzman is the Director of Athletic Training Services, and Health and Fitness Programs for Independent Health Services P.C., 42801 Schoolcraft Road, Plymouth, Michigan, 48170.

Staffing the physicals is the most challenging aspect of this service. Physicians can be obtained several different ways. Asking local physicians who are involved in sports medicine to volunteer their time is one. Another is asking the student athletes' parents who are physicians or nurses to assist. This may be the athletes' first introduction to the local sports medicine system, and therefore can provide positive exposure for these physicians.

A third way is to recruit resident physicians in specialty training at a local medical center. In our organization we employ orthopedic surgeons, physician assistants, physical therapists, and certified athletic trainers, and have a working relationship with a large metropolitan hospital. Our athletic trainers are contracted by local high schools to provide care for their athletes. When providing physicals to a high school, we use all members of our staff. Student athletes from an entire school district can be evaluated in approximately two to four hours.

Students are given physical forms in advance; these include a detailed medical history portion to be filled out and signed by their parents or legal guardian before the exam is performed. Key information can be obtained by the physician via a thorough history questionnaire.

Figure 1 illustrates a simple flow chart used when providing preparticipation examinations. Station 1, check-in, can be managed by high school personnel such as a coach or an athletic director. At this station, the athlete's name is recorded on the official registration sheet, a fee for the physical is paid (if not pre-paid), and the physical form is checked to see if the history portion has been completed and signed. Male and female students are then directed to separate stations where individual screenings and exams are performed. Stations 2 through 5 can be staffed by coaches, athletic trainers, and student athletic trainers. At stations 6 through 8, physicians administer exams which consist of the ear, nose, and throat exam, cardiovascular assessment, and orthopedic exam. Station 9 is manned by one physician in charge of checking the entire physical form to make sure all stations were attended, and recording any deficits, defects, or follow-up testing required for that athlete. In addition, this physician signs the card, which is verification that the athlete has completed all stations, and clears the athlete for participation. If for some reason the athlete is not cleared, the physician will

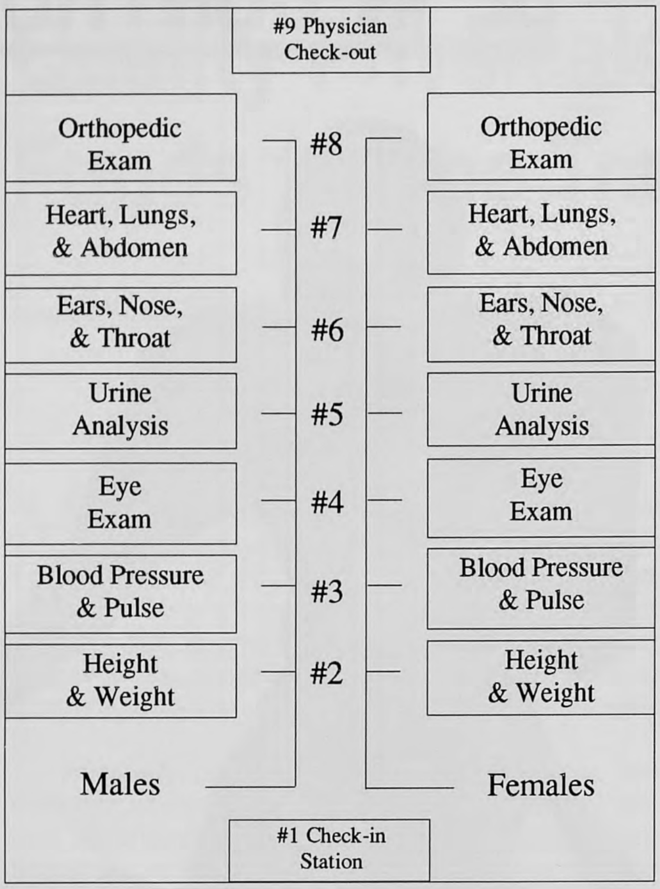


Figure 1. Physical exam flow chart

not sign the card and the athlete will be instructed to see a specialist or family physician for further testing. Letters are then sent to the parents and the athletic director with the results. The system requires seven physicians and nine additional health care professionals. Table 1 outlines specific deficits or defects looked for at each station by our physicians.

The American Academy of Pediatrics published "Recommendations for Participation in Competitive Sports" in 1988, which is an excellent guide of disqualifying conditions which can be used by examiners. This article is available from the American Academy of Pediatrics, 141 Northwest Point Blvd., Box 927, Elk Grove Village, IL 60009-0927.

Physicals are conducted at the school for a nominal fee of $12.00 per athlete, which can be paid at the time of the physical. A successful alternative to this plan is to have the fee sent to the athletic department staff who keep a list of students who have paid. An advantage to the pre-pay system is that you can plan accordingly for the number of students to be examined in terms of staffing. In cases of economic or personal hardship, the fee is waived.

A portion of the physical exam fee goes into an account earmarked for the development of the athletic training room, and the funds are managed by the athletic trainer. This amount varies depending on the cost of supplies and whether a fee is paid to the physicians. Some physicians and resident physicians from local hospitals gain experience and are willing to assist for a nominal fee. Supplies for the physicals include urine dipsticks and cups, tongue depressors, Snellen

Table 1. Physical exam station activities

#	Station	Specific Deficits or Defects Looked For
#2	Height & Weight	• Significant disproportion: *Obesity* - individuals are at risk for heat disorders and during heavy exercise • *Abnormal height* - one of the fibroelastic diseases (e.g.,Marfan's), with concomitant cardiac abnormalities
#3	Blood Pressure & Pulse	• *Hypertension* - systolic pressure above 150, dystolic pressure above 90
#4	Eye Exam	• Significant *amblyopia* (decreased vision in one eye) • Loss of vision in one eye (loss of a paired organ disqualification) • *Myopia* (nearsightedness)
#5	Urine Analysis	• *Proteinuria* - excess protein in repeated early morning specimens; can indicate nephritis and kidney disease • *Hematuria* - blood in the urine; could be caused by several problems and should be investigated further • *Hyperglycemia* - possible indication of diabetes
#6	Ears, Nose, & Throat	• *Perforated eardrum* (tympanic membrane) - disqualifies athlete from participation in swimming • *Infected tonsils, swollen glands, irritated throat* - could indicate infection
#7	Heart, Lungs, & Abdomen	• *Heart* - murmur or grossly irregular heart rate; can indicate underlying disease and must be evaluated • *Lungs* - not clear; possible pneumonia or allergic asthma • *Abdomen* - palpatable spleen or liver could indicate infectious monoucleosis or other conditions. Athletes are at risk of rupturing these organs with exercise.
#8	Orthopedic Exam	• Gross loss of *flexibility* in upper extremities, neck, lower extremities, and back — increase risk of injuries • Assess area of *previous injury* for deformities, pain, weakness, and instability
#9	Check-out	• Assess history section of card and all station findings • Discuss history of head injuries, passing out, dizziness, etc. • Refer for specialty evaluation if any findings are significant.

eye charts, etc.

In servicing a local community that had 479 athletes, we were able to secure, after expenses, $4,500.00 for the expansion of their high school training room (479 X $12.00 =$5,748

- $1,248 costs = $4,500.). Most high school training facilities struggle for monies allocated by the athletic department. A well-organized preparticipation physical program not only boosts the budget of the training room, but it also provides a low-cost convenient service for student athletes.

Our physicals are scheduled either in the evening or on a Saturday morning, and students are scheduled in waves by class (i.e., junior high students 6:00 to 7:00 p.m., freshmen 7:00 to 7:30, sophomores 7:30 to 8:00). We have found that physicians work best in two-hour shifts, and athletic trainers or personnel working stations 2 through 5 should be rotated every hour or two.

Five hundred student athletes can be successfully examined in four hours if the physicals are properly planned and staffed. The community must be informed well in advance that the school is providing physicals for their students. This can be done by sending flyers home, printing announcements in the newspapers, and addressing parents at PTA meetings.

This type of system has worked very well for our communities, and has been a positive public relations tool for our organization. Student athletes receive a quality physical at a low cost, and funds are consequently generated to purchase non-expendable items such as taping tables and ice machines for training rooms. This service involves a great deal of planning, but is well worth the effort.

ACKNOWLEDGEMENT

Special thanks to Dr. Waldomar Roeser and Mr. John Robinson of The Center for Sports Medicine & Fitness, Ypsilanti, MI for help in preparing this article.

REFERENCES

1. Arnheim DD: *Modern Principles of Athletic Training*. 7th Ed. St. Louis: The C.V. Mosby Company, pp. 54-58, 1989.
2. Feinstein RA, Soileau EJ, Daniel WA: A national survey of preparticipation physical examination requirements. *Phys Sportsmedicine* 16(5): 51-59, 1989.
3. Hebert DL: What standards exist for conducting and evaluating preparticipation athletic examinations? *Reporter* January 1989: 13-15.
4. Hulse E, Strong WB: Preparticipation evaluation for athletics. *Pediatrics in Review* 9 (6): 1-10, 1987.
5. McKeag DB: Preseason physical examination for the prevention of sports injuries. *Sportsmed* 2: 413-431, 1985.

An Infection Control Policy for the Athletic Training Setting

Denise L. Webster, MS, ATC
David A. Kaiser, MPE, ATC

ABSTRACT: Athletic trainers need to be concerned about blood-borne infectious agents, such as Human Immunodeficiency Virus (HIV) and Hepatitis B Virus (HBV), because the profession has been slow in implementing programs to prevent exposure to such pathogens. The purpose of an infection control program is to establish a policy and implement procedures relating to the control of infectious disease hazards where health care providers may be exposed to body fluids. The adoption of such a policy should follow five steps. The Central Michigan University (CMU) Sports Medicine infection control policy is presented as a model for consideration.

The transmission of blood-borne infectious agents, most notably the Human Immunodeficiency Virus (HIV), has become a major issue for the health-related professions. Health care workers employed in certain occupations are assumed to be at substantial risk because of their exposure to body fluids. Welch et al. (7) addressed only a portion of this issue for athletic trainers, who need to be concerned not only about the transmission of HIV, but also about the Hepatitis B Virus (HBV) and other blood-borne infectious agents.

The minimum standards for protection against occupational exposure to HIV and HBV are contained in the Federal Register Joint Advisory Notice (4). Based on this Notice, the Occupational Safety and Health Administration (OSHA) has proposed a federal standard to protect health care workers. Should this standard become law, athletic training facilities may be required to provide protection. This article will discuss the entire scope of implementing an infection control policy and present a model for athletic trainers to consider.

DISCUSSION

Instituting an infection control program begins with asking and answering three important questions: 1) Are athletic trainers considered health care workers?; 2) Are athletic training facilities considered health care facilities?; and 3) Do the tasks and procedures performed by athletic trainers place the athletic trainer at risk of exposure to materials listed by the Centers for Disease Control (CDC) as modes of transmission of infectious pathogens (1)?

If we answer "yes" to the above questions, then we must understand the documents, laws, and written procedures that protect individuals from the transmission of HIV, HBV, and other blood-borne infectious pathogens. The implementation of preventive measures includes more than the adoption of the CDC Universal Precautions (1,2).

An infection control policy will establish and implement written procedures relating to the control of infectious disease hazards where employees may be exposed. The suggested steps for formulating a program include:

- Step 1 Identification of Exposure Category
- Step 2 Adoption of Universal Precautions
- Step 3 Management of Biohazardous Waste
- Step 4 Control of the Environment
- Step 5 Education and Training

Step 1. Exposure Category

The first step in establishing a formal infection control program is to evaluate and identify those tasks that expose workers to infectious agents. This evaluation should classify work-related tasks to an exposure category (Table 1) (4). The exposure category will then dictate the amount of protection needed to prevent the transmission of infectious agents. Category II best fits the duties and responsibilities of the athletic trainer.

Step 2. Universal Precautions

The Universal Precautions (Figure 1) recommended by the CDC in 1987 must be instituted in athletic health care. The CDC recommendation is "that blood and body fluid precautions be consistently used for all patients regardless of their blood-borne infection status" (1). Under Universal Precautions, blood and certain body fluids of all patients are considered potentially infectious (1,3).

Step 3. Biohazardous Waste Management

While any item that has had contact with blood, exudates,

Denise Webster is Instructor/Assistant Athletic Trainer at Central Michigan University, Mt. Pleasant, Michigan, 48859.

David Kaiser is Curriculum Director/Assistant Athletic Trainer at Central Michigan University.

Table 1. Exposure categories

CATEGORY	DEFINITION	PROTECTIVE MEASURES
I	Employment involves exposure to blood, body fluids, and tissues.	Protective measures should be required for tasks involving contact with blood, body fluids, and tissues.
II	Employment does not involve exposure to blood, body fluids, or tissues; but unplanned Category I tasks may occur.	Protective measures should be readily available for Category I tasks.
III	Employment does not involve exposure to blood, body fluids, or tissues.	No protective measures need to be available.

Adapted from Federal Register Exposure Categories (4).

or secretions may be infective, it is not usually necessary to treat all such waste as hazardous. Identifying wastes for special precautions is largely a matter of judgement. Once the potentially infective wastes have been identified, special precautions are prudent (2). Two specific containers may be necessary in each training facility to safely handle materials or items that have been exposed to blood or other fluids. Examples of materials from patient-care services include dressings and bandages, and gloves (3,6). These materials may be safely disposed of in a small waste container with a lid, lined with an impervious bag (3,6) (Figure 2).

Of greatest concern is the disposal of sharp instruments such as syringes, needles, and scalpels. A puncture-resistant container (Sharp's box) should be available to all personnel for easy disposal (2,6) (Figure 3). Clipping, breaking, or recapping are not recommended.

When these containers (waste bag and Sharp's box) become full, proper disposal is necessary. This does not include having the custodian collect these items as "normal" trash. Biohazardous material must be disposed of in accordance with applicable local, state, and federal regulations, which may include incineration or disposal at an approved landfill (6).

Step 4. Environmental Control

Even though no environmentally mediated mode of HIV transmission has been documented, precautions should be routinely followed (2). Once again, health care workers must consider all blood-borne pathogens, not just HIV. Environmental considerations include the proper care and handling of laundry and the cleaning of table and counter surfaces (2,3). Although soiled linen, including towels, has been identified as a source of large numbers of certain pathogenic microorganisms, the risk of actual disease transmission is negligible (2). Soiled linen should be handled as little as possible. If hot water is used, linen should be washed with detergent in water of at least 160 degrees F (71 degrees C) for 25 minutes. With low temperture (<158 degrees F/70 C) laundry, chemicals suitable for low-temperature sterilization should be used (2,3).

I. Exposure Category

Category II. Tasks that involve no exposure to blood, body fluids, or tissues, but employment may require performing unplanned Category I tasks.

The normal work routine involves no exposure to blood, body fluids, or tissues, but exposure or potential exposure may be required as a condition of employment. Appropriate protective measures should be readily available to every employee engaged in Category II tasks.

II. Identification of Risk Tasks

A. Injury/Illness Management:
CPR
Mouth to mouth resuscitation
Management of open wounds
Management of compound fractures/dislocations
Blister care

B. Environmental Management:
Soiled laundry/linen
Cleaning surfaces
Disposing of biohazardous bags/Sharp's box

III. Occupational Exposure to Blood-Borne Infectious Agents (Universal Precautions)

These precautions represent prudent practices that apply to preventing transmission of the AIDS virus (human immunodeficiency virus - HIV), Hepatitis B Virus (HBV), and other blood-borne infections, and should be used routinely.

1. When the possibility of exposure to blood or other fluids exists, appropriate barrier precautions to prevent skin and mucous membrane exposure should be followed. GLOVES should be worn for touching blood and body fluids, mucous membranes, or non-intact skin of all patients, and for handling items or surfaces soiled with blood or body fluids. Gloves should be changed after contact with each patient and disposed of in a proper waste container.

2. Hands and other skin surfaces should be washed immediately and thoroughly if contaminated with blood or other body fluids. Hands should be washed immediately after gloves are removed.

3. Sharp items should be considered as potentially infectious and handled with extraordinary care in order to prevent accidental injuries. After they are used, syringes, needles, scalpel blades, and other sharp items should be placed in a puncture-resistant container for disposal. The puncture-resistant container (Sharp's box) should be located as close as practical to the use area. Needles or blades should not be purposefully bent, broken, removed, or otherwise manipulated by hand.

4. Although saliva has not been implicated in HIV transmission, to minimize the potential for infection during emergency mouth-to-mouth resuscitation, mouthpieces, resuscitation bags, or other ventilation devices should be available for use.

5. Staff who have exudative lesions or weeping dermatitis should refrain from all direct patient care and from handling patient care equipment, until the condition resolves.

6. Pregnant staff should be especially careful to minimize the possible transmission of infectious pathogens to the fetus.

Figure 1. Infection Control, Central Michigan University

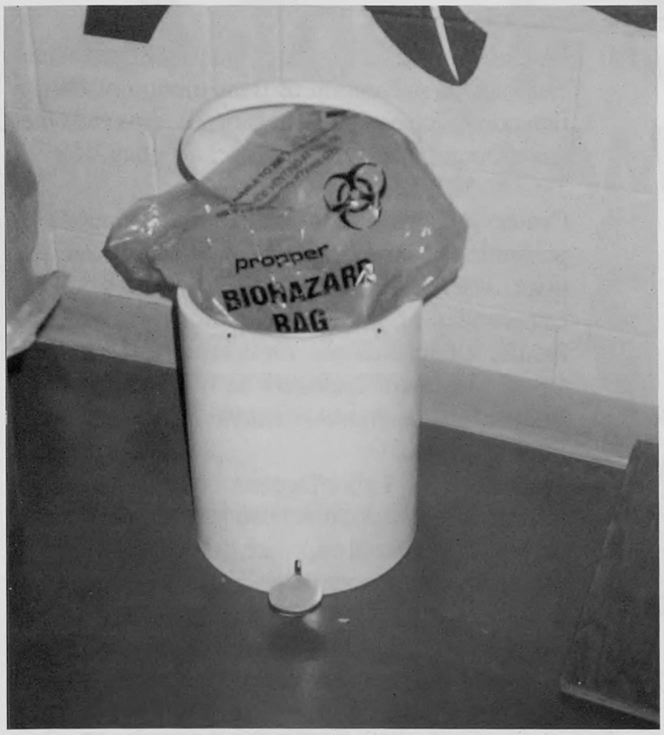


Figure 2. Waste container

Surfaces can be kept clean by using chemical germicides that are approved as hospital disinfectants and are tuberculocidal when used at recommended dilutions. Studies have shown that HIV is inactivated rapidly after being exposed to commonly used chemical germicides at concentrations that are much lower than used in practice. A solution of 5.25 percent sodium hypochlorate (household bleach) diluted at 1:31 with water also is effective (2,3).

Step 5. Education and Training

The final consideration is the education and training program of all individuals who are at risk within the workplace.

Figure 3. Puncture-resistant container (Sharp's box)

I. COLLECTION OF BIOHAZARDOUS WASTE

Gloves, Gauze, Human Tissue, etc.

Each training room is to contain a covered waste container that is lined with a biohazardous trash bag. Materials that have become contaminated with blood, exudates, secretions, body fluid wastes, or other infectious agents are to be placed in these covered containers. Grossly soaked towels will be discarded in a biohazard bag.

Laundry

Towels that have been used and have moderate blood or body fluid contamination may be placed in the normal laundry bag. If there is any sign of blood or waste material on the laundry bag, gloves will be worn to take the laundry bag to the equipment room for laundering.

Sharps

A puncture-resistant container will be located in each training room. All scalpels and sharp objects contaminated with blood, exudates, body fluids, or other infectious agents will be discarded in the Sharp's box.

Tables, Counter Tops

All table and counter top surfaces will be cleaned with a 1:31 bleach to water solution.

II. DISPOSAL

The full-time athletic training staff is responsible for removing full biohazard bags from the covered waste containers, sealing bags securely, and transporting bags to a common collection site. Whenever the Sharp's containers are full, the container is removed and deposited at a common collection site.

FIGURE 4. Environmental Control, Biohazardous Waste, Central Michigan University

The education program should ensure that each person understands the modes of transmission of the infectious pathogens, recognizes at-risk tasks, knows the proper protective equipment to use, knows how to safely handle and dispose of contaminated materials, and knows the proper environmental clean-up procedures (4).

RECOMMENDATION

The Sports Medicine Program at Central Michigan University established an Infection Control Policy in August 1989 (Figure 1 and Figure 4). This policy was based on the following assumptions: 1) Athletic trainers are health care workers. 2) Athletic training facilities are health care facilities. 3) The duties performed by the athletic training staff may place a staff member at risk of exposure to infectious pathogens.

With the cooperation of the University Health Services, a formal, written procedure was established as part of the CMU Sports Medicine Standard Operating Procedure (SOP). The SOP requires that: 1) all staff and students have access to gloves in each training room and carry gloves in kits; 2) resuscitation masks are available and included in kits; 3) disposable scalpels are used and then placed in puncture-resistant containers; 4) waste containers with lids are lined with biohazard bags and placed in each training room; 5) contaminated materials are disposed of in these containers rather than in the regular waste can. Athletic trainers are required to bag materials and safely secure scalpels while on the road, and to dispose of them properly when they return to CMU. An agreement with Health Services ensures proper disposal of waste bags and containers. When the waste bags and Sharp's container are full, a staff member seals the bag or container and transports the material to a collection site on campus. These materials are incinerated at the local hospital in accordance with state regulations.

All students who are in the athletic training program are informed of, and given a copy of, the Infection Control Policy. Modes of transmission, exposure risks, Universal Precautions, and safe handling of hazardous materials are discussed. If students feel that they are at risk of exposure to an infectious pathogen, they can refuse to treat an athlete. A certified staff member will then provide the necessary treatment.

Athletic trainers must become acquainted with all of the guidelines for the implementation of an infection control policy and program (1,2,3,4). The infection control policy needs to include the adoption of universal precautions; the identification of exposure tasks and contaminated materials; the collection of biohazardous wastes within the athletic environment; the disposal of biohazardous waste in accordance with state regulations; and the education and training of staff and student athletic trainers. The Infection Control Policy for Central Michigan University Sports Medicine has been presented as a model to encourage other athletic trainers to address this area of concern.

REFERENCES

1. Centers for Disease Control: Update: Universal precautions for prevention of transmission of human immunodeficiency virus, hepatitis B virus and other blood-borne pathogens in health care setting. *MMWR* 37: 337-382, 1988.
2. Centers for Disease Control: Recommendations for prevention of HIV transmission in health-care settings. *MMWR* 36:1S-16S, 1987.
3. Department of Labor/Occupational Safety and Health Administration: *Enforcement Procedures for Occupational Exposure to Hepatitis B Virus (HBV) and Human Immunodeficiency Virus (HIB)* 1988, 1-26.
4. Department of Labor/Department of Health and Human Services: Joint Advisory Notice Protection against occupational exposure to hepatitis B (HBV) and human immunodeficiency virus (HIV). *Federal Register* 52: 41817-23. 1987.
5. Proposed AIDS law may bring changes to your hospital. *AIDS Guide for Health Care Workers* Summer 1989, 1S-3S.
6. State of Michigan Department of Public Health: *Infectious Wastes from Health Facilities and Laboratories* February 19, 1985.
7. Welch MJ, Sitler MR, Horodyski M: Should athletic trainers be concerned about HIV? Guidelines for athletic trainers. *Athletic Training, JNATA* 24: 27-28, 1989.

Optimal Practice Times for the Reduction of the Risk of Heat Illness During Fall Football Practice in the Southeastern United States

Kennon Francis, PhD
Ronald Feinstein, MD
Joel Brasher, MS

ABSTRACT: Fall football practice generally begins during the hottest period of the year. Exercise during this period exposes athletes to risks of heat illness and possible death. Practice is made even more dangerous by training in a padded football uniform. In order to delineate optimal practice times in which the environmental heat load may not be so severe, air temperature and relative humidity were averaged for the months of August and September for three years (1984-1986) for ten cities in the southeastern United States. The Football Weather Guide *(*FWG*) was used to classify the relative severity of the recorded climatic conditions. The superimposition of daily three-year averages for each three-hour time period on the* FWG *revealed that there were no environmental combinations at any time period during the month of August for any of the ten cities that would be considered safe for outdoor practice in full uniform. Similar results were recorded for September in eight of the ten cities. The only practice times that were outside of the "danger" zone for any of the observed cities during September, were 3 pm and 6 pm for the city of Columbia, South Carolina, and 3 pm for the city of Jackson, Mississippi. These time periods were situated in the "cautionary" zone, which suggests that the players are still at increased risk of developing heat illness.*

Kennon Francis is Professor of Exercise Physiology, Division of Physical Therapy, University of Alabama at Birmingham, Birmingham, AL, 35294.

Ronald Feinstein is chief of the Division of Adolescent Medicine at the University of Alabama at Birmingham.

Joel Brasher is a research assistant in the Exercise Physiology Laboratory, Division of Physical Therapy, University of Alabama at Birmingham.

Football practice at high schools and colleges in most sections of the southeastern United States begins during the early weeks of August when the weather is likely to be very hot and humid. Under these conditions, athletes are especially vulnerable to problems caused by hyperthermia and dehydration. The American College Football Association (ACFA) reports that between 1965 and 1988, a total of 81 heat related deaths occurred as a result of practicing football during the late months of summer and early fall (9).

In addition to reporting heat related injuries, the ACFA provides general suggestions and precautions for decreasing the risk of heat illness. Whereas these suggestions are practical, they are general and non-specific and do not address the characteristics of regional differences in climates in the U.S. The ACFA cautions against practice during extreme environmental conditions, but fails to offer suggestions as to what constitutes environmental extremes and under what conditions should practice be postponed or canceled. Because such guidelines have not been reported, this study was undertaken to: 1) identify the optimal times during the months of August and September for conducting football practice in the southeastern region of the U.S., and 2) offer precautionary guidelines to diminish the likelihood of the occurrence of heat illness during practices conducted under conditions of high heat stress.

METHOD

Ten representative cities located in different regions of the southeastern U.S. (Figure 1) were selected. Each city contained a regional national meteorological weather station. Three year climatological data (1984 through 1986) for the months of August and September were obtained from the recordings of each of the regional weather stations (2). Three-

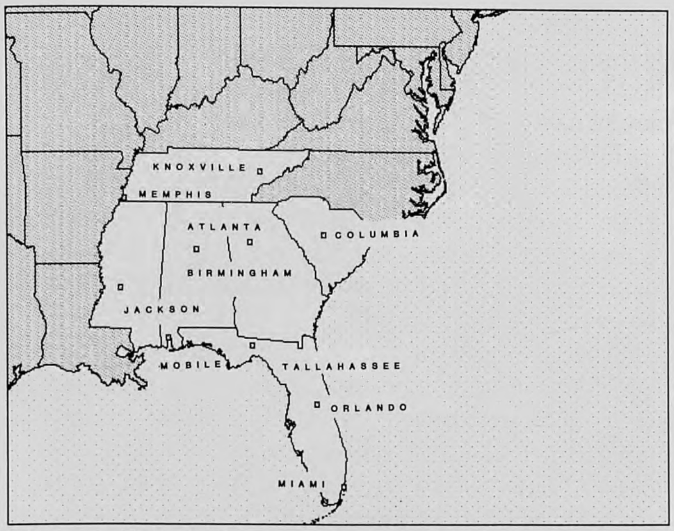


Figure 1. Cities in the southeastern United States used in the study

hour interval data of relative humidity and air temperature were averaged for a three-year period for each city. The three-hour intervals began at 6 am and ended at 9 pm.

The *Football Weather Guide* (*FWG*) as described by Fox et al. (5) was used to classify the relative severity of the recorded climatic conditions. The *FWG* is a graphical depiction of the relationship of air temperature and relative humidity to the risk of developing exertional heat illness in football players. The *FWG* was constructed from climatic data that was collected at the time of recorded heat stroke incidences in football players (4,7). Environmental conditions in which death resulted from heat stroke were labeled "extreme" and were called Zone 3. Based on these and additional heat stress studies, "cautionary" (Zone 2) and "safe" (Zone 1) conditions were established (5) to be used in conjunction with the following recommendations:

Zone 3

Practice in full uniform should be postponed or moved indoors. If practice is performed outdoors under these conditions, it should be of low intensity with players wearing only shorts. Players in this zone should be carefully observed for symptoms of heat illness including profuse sweating, nausea, headache, or lack of coordination. Adequate water replacement is encouraged.

Zone 2

Zone 2 represents a "cautionary" zone in which practice can take place, but the intensity level should be decreased and players should be carefully observed for symptoms of heat illness. Adequate water replacement is encouraged.

Zone 1

Any combination of environmental conditions in Zone 1 would be considered "safe" with no precautions necessary.

RESULTS

Plots of the average daily relative humidity *versus* air temperature for the months of August and September are shown superimposed on the *FWG* in Figures 2 and 3. As

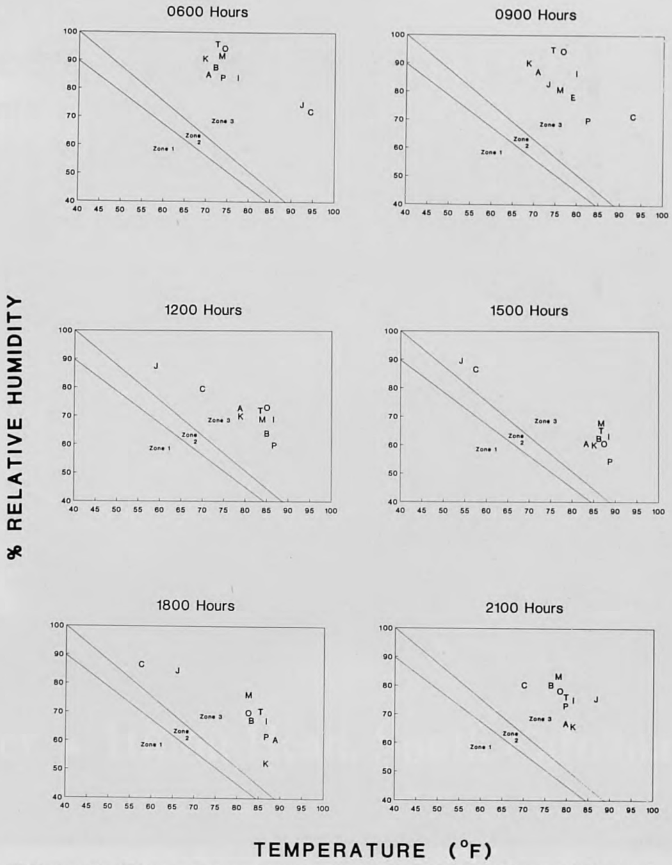


Figure 2. Three-year average of relative humidity and air temperature at three-hour intervals for the month of August in the southeastern United States that has been superimposed on the *FWG

expected, the extreme environmental conditions shown in these figures clearly indicate that the football athlete faces serious heat dissipation problems when exercising in the Southeast during these time periods. There were no environmental combinations at any of the time periods recorded during the month of August (Figure 2), for any of the representative cities, that would be considered environmentally safe for outdoors practice in full uniform. All combinations of air temperature and relative humidity for each three-hour interval, beginning at 6 am for all cities, were situated in the "danger" zone (Zone 3) of the *FWG*.

Similar plots for the months of September (Figure 3) reveal analogous results. The only practice times that were outside of Zone 3 for any of the observed cities during September, were 3 pm and 6 pm for the city of Columbia, SC, and 3 pm for the city of Jackson, MS. These time periods were situated in the "cautionary" zone (Zone 2) which suggests that the players still are at considerable risk of developing heat illness.

***Cities and their graphical symbols**

Atlanta	=	A	Memphis	=	P
Birmingham	=	B	Miami	=	I
Columbia	=	C	Mobile	=	M
Jackson	=	J	Orlando	=	O
Knoxville	=	K	Tallahassee	=	T

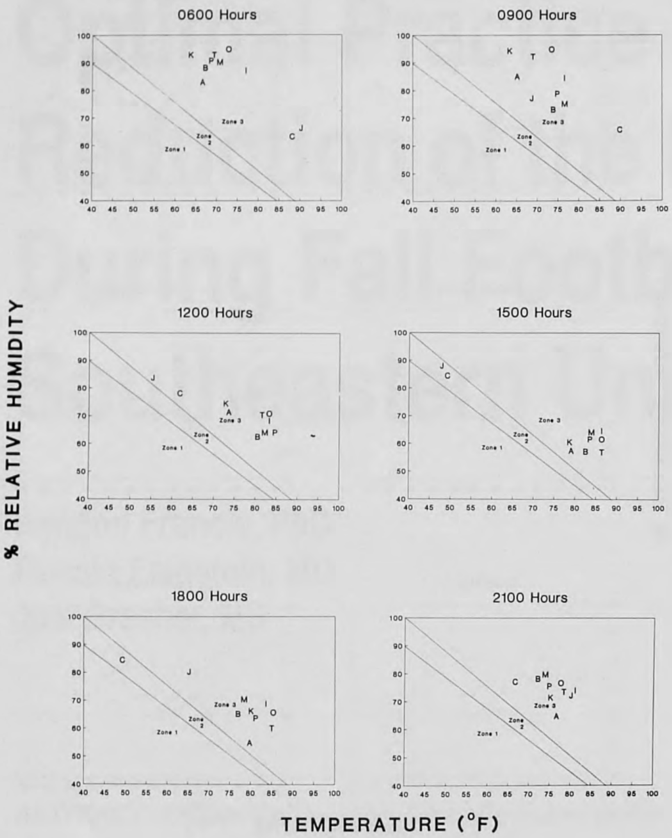


Figure 3. Three-year average of relative humidity and air temperature at three-hour intervals for the month of September in the southeastern United States that has been superimposed on the *FWG

DISCUSSION

There has been no reported effort at the present time by any high school or college to alter the starting times for the first football games. As long as the start of the football season commences during early August and September in other regions of the country, out of necessity, football practice will begin in the Southeast at the same time. Because the season starting time appears to be unalterable, and because there appears to be no environmentally safe practice time in August or September, the coach should implement precautionary measures for preventing heat illness.

In order to reduce the hazard of heat illness and possible death during early season football practice, training sessions should be scheduled according to the time of the least environmental heat load of the day. The data shown in Figures 2 and 3 indicate that this occurs between 3 and 9 pm during August and September. At the other times of the day, the combination of temperature and relative humidity places too great a heat stress on the athlete to allow adequate cooling. Although practicing during the time period of 3 to 9 pm may place less of a heat burden on the player than other times during the day, this time period is still in Zone 3. Practice conducted during this time period requires extreme precautionary measures to prevent dehydration and hyperthermia.

Fishnet jerseys should be used, and jerseys and practice uniforms should be light colored to reflect the sun's rays. Wet t-shirts should be changed often. Frequent rest breaks should be scheduled. Shapiro and Seidman (13) suggest that a compulsory rest period should be incorporated for every 50 minutes of physical activity.

Adequate consumption of water should be promoted both before and during practice. Ingestion of fluids before exercise increases sweating during physical exertion and has been shown to significantly offset increases in core temperature (8). This procedure, however, does not supplant the need for continual fluid replacement and is not as effective in maintaining thermal balance as consuming water on a periodic basis throughout practice (12). Since only about 800 ml of fluid can be emptied from the stomach each hour during vigorous exercise regardless of the quantity consumed, water breaks should be scheduled every 15 minutes during which time the player consumes 150-200 ml (11). A urine output of about 1 ml per minute is a sensitive indicator of sufficient body hydration (13). Because measuring urine output is not feasible in field conditions, players should be instructed to drink enough so that the color of their urine will always be a very light yellow (3).

Continued measurements of daily body weight, which mainly reflect water loss, are particularly important during day-to-day exposure to high environmental heat loads (10). The body weight should be recorded before and after practice so that possible excessive water losses may be detected. A 3% weight deficit caused by water loss is a concern if it is not made up in a 24-hour period (6). The player should be excused from practice until the deficit is overcome.

Tolerance and ability to exercise comfortably in the heat are increased through acclimatization which lessens the likelihood of exertional heat stress (1). Because many players report to the first day of practice in an unacclimatized state, a progressive exercise program should be initiated under the same environmental conditions that will be experienced in regular practice or games. An example program described by Fox et al. (5) consists of 20 minutes of light work (in shorts) followed by 20 minutes of rest on the first day. Workload and uniform dress are increased each day of an eight-day work period until the players are up to full speed.

The final preventative measure includes the careful monitoring of players for signs of heat stress by all individuals on the practice field. Medical personnel supervising events involving strenuous physical activity in the heat should have the authority to evaluate, examine, and/or stop a subject who displays the symptoms and signs of impending heat injury (5,6). Because there is no optimal practice time in the Southeast during August and September, football practice must be conducted under environmental conditions that place great stress on the body's cooling mechanism. Because of the possibility of inducing exertional heat illness, precautionary measures should be enforced. The adherence to the guide-

***Cities and their graphical symbols**

Atlanta	=	A	Memphis	=	P
Birmingham	=	B	Miami	=	I
Columbia	=	C	Mobile	=	M
Jackson	=	J	Orlando	=	O
Knoxville	=	K	Tallahassee	=	T

lines suggested in this paper can aid in reducing the risk of heat illness during these critical times.

REFERENCES

1. Armstrong LE, DeLuca JP, Hubbard RW: Time course of recovery and heat acclimation ability of prior exertional heatstroke patients. *Med Sci Sports Exerc* 22: 36-48, 1990.
2. *Climatological Data Annual Summary*, 1984-1988, Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center, Federal Building, Asheville, NC 28801.
3. Epstein Y, Sohar E: Fluid balance in hot climates: Sweating, water intake, and prevention of dehydration. *Public Health Reviews* 13:115-137, 1985.
4. Fox E, Mathews D, Kaufman W, Bowers R: Effects of football equipment on thermal balance and energy cost during exercise. *Res Quart* 37: 332-339, 1966.
5. Fox EL, Bowers RW, Foss ML: *The Physiological Basis of Physical Education and Athletics.* 4th Edition. Philadelphia, Saunders College Publishing, 1989, pp. 480-519.
6. Herrick RT: Heat illness in the athlete: Siriasis. *Alabama Medicine* 28 (5): 33-37, 1986.
7. Mathews D, Fox E, Tanzi D: Physiological responses during exercise and recovery in a football uniform. *J Appl Physiol* 26: 611-615, 1969.
8. Miroff S, Bass D: Effects of overhydration on man's physiological responses to work in the heat. *J Appl Physiol* 20: 267-271, 1965.
9. Mueller F, Schindler R: *Annual survey of football injury research 1931-1988.* American Football Coaches Association, Orlando, FL 1989.
10. Murphy RJ, Ashe WF: Prevention of heat illness in football players. *JAMA* 194(6): 180-184, 1965.
11. Myers D, Francis KT: On the choice of a regimen for the hydration of football players during early fall practice in Alabama. *J Orthop Sports Phys Ther* 1: 153-158, 1980.
12. Nadel E: Factors affecting the regulation of body temperature during exercise. *J Thermal Biol* 8: 165-169, 1983.
13. Shapiro Y, Seidman DS: Field and clinical observations of exertional heat stroke patients. *Med Sci Sports Exerc* 22(1): 6-14, 1990.

Tip From the Field

Shoulder Positioning for Optimal Treatment Effects

Allan Lovinger, MEd, ATC
Brent C. Mangus, EdD, ATC
Christopher D. Ingersoll, PhD, ATC

Shoulder pathology is a common injury seen by athletic trainers. Activities involving repetitive use of the arm above 90 degrees can lead to "impingement syndrome." This syndrome can afflict many competitive athletes during their careers (1). Proper positioning of the shoulder during treatment can enhance therapeutic effects.

Anatomically, the interval between the head of the humerus and the inferior portion of the acromion is normally 7 to 14 mm (4). Within this space lies the supraspinatus tendon, a portion of the long head of the biceps tendon, the subacromial bursa, and the anterior superior portion of the glenohumeral capsule. The supraspinatus arises from the superior portion of the supraspinatus fossa after which the tendon follows a course between the head of the humerus and the inferior portion of the anterior acromion. It then passes over the head of the humerus and inserts on the superior aspect of the greater tuberosity of the humerus. This is a flat tendon, and the vascular pattern is longitudinal (3).

With the arm in the resting position, adducted and rotated neutrally, the blood vessels are in traction and compression as they follow the tendon to the greater tuberosity of the humerus (3). As the long head of the biceps tendon moves superiorly to its insertion on the supraglenoid, a similar vascular pattern exists. This traction and compression causes a "wringing out" of the blood vessels, creating an area of avascularity in these muscles called the critical zone (3) (Figure 1). It is here that degenerative changes such as tendonitis, calcification, and rupture are frequently experienced by athletes (4).

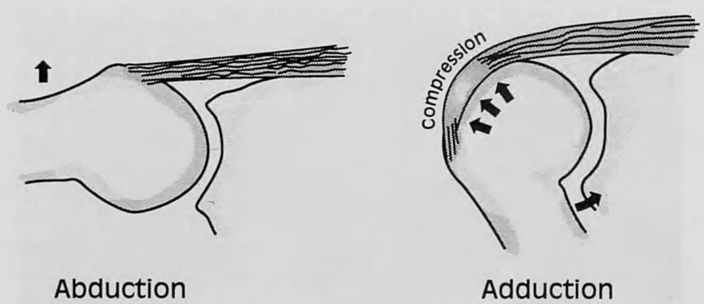


Figure 1. Representation of the theoretical "wringing out" of the vessels as proposed by Rathburn and Macnab

In addition to the degenerative changes experienced, other problems may occur which are exacerbated by the small size of the interval between the humerus and the acromion, combined with the unyielding nature of these structures (2). With abduction and internal rotation, the soft tissues in this small space (supraspinatus tendon, long head of the biceps tendon, and the subacromial bursa) can easily be compressed. With repetition of this movement, a chronic inflammation may develop (2).

Treatment to this area should focus on proper positioning of the shoulder joint in order to maximize the effects of the treatment. We propose that when performing therapy (e.g., ultrasound, muscle stimulation, massage, etc.) on this area,

Allan Lovinger is staff athletic trainer with the Seattle Mariners Baseball Club.

Brent Mangus is Associate Professor and Program Coordinator of Athletic Training Education, and Director of the Sports Injury Research Center, School of HPER, University of Nevada, Las Vegas, Nevada, 89154.

Christopher Ingersoll is Assistant Professor of Athletic Training Education and Associate Director of the Sports Injury Research Center, School of HPER, University of Nevada, Las Vegas.

the arm should be placed in abduction (30 to 70 degrees) with neutral rotation and slight extension. The tendons are relaxed, the blood vessels can fill, and the desired results of increased blood flow to the area can be achieved.

A small box or foot stool can be placed on the treatment table (Figure 2); or have the athlete sit in a chair with the arm resting on the table (Figure 3). Another potential position to obtain the desired results is for the athlete to lie supine on the treatment table with support provided under the shoulder and forearm (Figure 4). These positions are comfortable to the athlete, result in vascular filling, and are advantageous for ultrasound or electrical muscle stimulation.

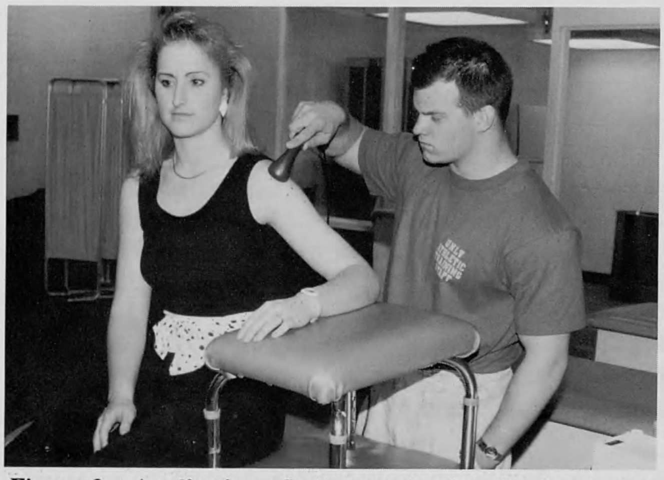


Figure 2. Application of ultrasound using the footstool to maintain slight abduction of treatment

Figure 3. Preferred treatment position can be maintained by using a treatment table and a chair.

Figure 4. Treatment effects also can be accomplished by having the athlete lie supine with a folded towel under the scapula of the affected shoulder.

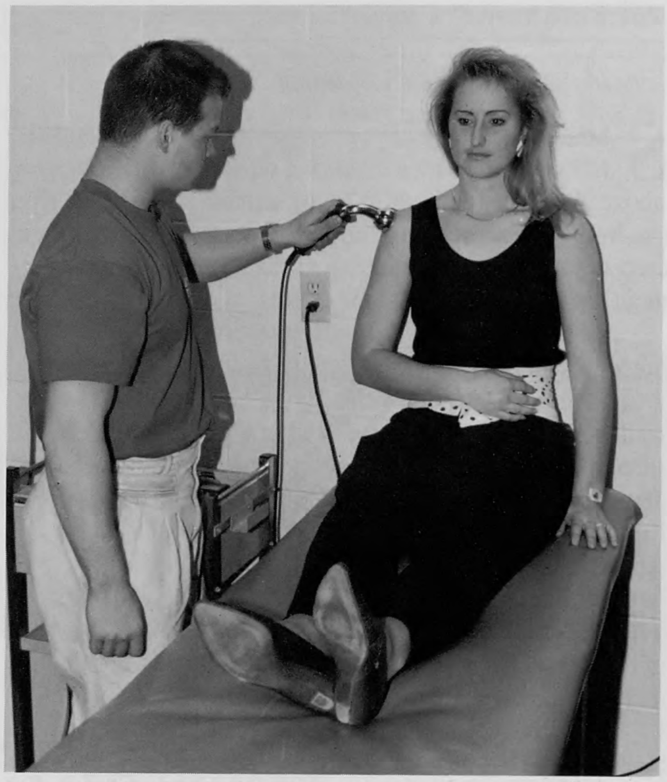


Figure 5. Treatment of shoulder injury in the sling position may not allow optimal blood flow to the area being treated.

Treating the athlete in the "sling position" may be comfortable, but it is self defeating because the critical zone becomes avascular (Figure 5). There may be little if any increase in blood flow if treatment is performed in this position. Logically then, placing the arm in the abducted position during therapy will enhance the blood flow and therapeutic effects of the procedure applied.

REFERENCES

1. Hawkins RJ, Kennedy JC: Impingement syndrome in athletes. *Am J Sports Med* 8(3): 151-157, 1980.
2. Mulligan E: Conservative management of shoulder impingement syndrome. *Athletic Training, JNATA* 23(4): 348-352, 1988.
3. Rathburn J, Macnab I: The microvascular pattern of the rotator cuff. *J Bone Joint Surg* 52B(3): 540-553, 1970.
4. Weiner DS, Macnab I: Superior migration of the humeral head: A radiologic aid in the diagnosis of tears of the rotator cuff. *J Bone Joint Surg* 52B(3): 524-527, 1970.

Student Athletic Trainer Forum

Deloss Brubaker, EdD, ATC

A Case of "Frozen Elbow" Following Immobilization for a Fractured Clavicle

Angeline Bonners, BS, ATC

ABSTRACT: Although not uncommon in athletics, a fracture of the clavicle can have serious implications. These include post-traumatic nerve and blood vessel involvement, as well as the sequela of "frozen elbow" which may result from prolonged immobilization of the upper extremity. Subsequent limited range of motion, muscle atrophy, and soft tissue contracture surrounding the elbow respond to a two-stage rehabilitation program of: 1) thermotherapy plus stretch, and 2) therapeutic exercise. The athlete must be made aware of the importance of full, active range of motion at this joint, and may need encouragement from the athletic trainer to follow the therapeutic exercise plan until all strength and range of motion goals have been achieved.

The clavicle may not be a large bone in size, but it is of great anatomic significance as the only point of articulation between the appendicular and axial skeletons. It has its proximal attachment at the sternoclavicular joint and its distal attachment at the acromioclavicular joint, where it connects to the remaining shoulder complex. The bone is shaped like a gently curving letter "s" with the rounded, proximal portion projecting convexly, and the flatter, distal portion, receding somewhat. The clavicle is frequently injured in athletics, and 80% of the fractures occur at that point of structural change (1,2,4,5,6). In close association to the clavicle are the subclavian blood vessels and the nerves of the brachial plexus.

Angeline Bonners is Assistant Athletic Trainer at William Paterson College, Wayne, New Jersey, 07470.

EDITOR'S NOTE: This paper was the Third Runner-up in the 12th Annual NATA Student Writing Contest.

HISTORY

An 18-year-old high school athlete sustained a fracture of the left clavicle during pre-season football camp. The mechanism of injury was a direct blow from another player as they collided shoulder to shoulder. During the immediate evaluation on the field, the athlete related that he heard and felt a "snapping." There was obvious bony deformity upon visual inspection, and the athlete complained of sharp pain. First aid included ice and immobilization of the upper extremity with a sling and a swathe. The athlete was treated for shock, and his vital signs monitored while his parents were called and informed of the accident. After receiving their consent, Emergency Medical Services was notified, and the injured player was transported to the hospital by ambulance. He was seen in the emergency room by the orthopedist on call who ordered x-rays to be taken.

DIAGNOSIS/TREATMENT

X-rays revealed that there were actually two complete transverse fractures in the bone: 1) a simple, displaced fracture at the lateral end of the middle third of the clavicle, and 2) a simple, non-displaced fracture in the distal third section (Figure 1). The orthopedist decided not to perform surgery at that time, and chose a leather, figure-of-eight clavicle collar to immobilize the injury and stabilize the shoulders in an upward and backward position (1,7). An open surgical reduction of a clavicular fracture would only be indicated in the circumstance of a neurovascular compromise that could not be resolved through closed reduction (5). For additional support, the left upper extremity was placed in a sling. The athlete was released with a prescription for pain medication and was instructed to remain out of school for one week.

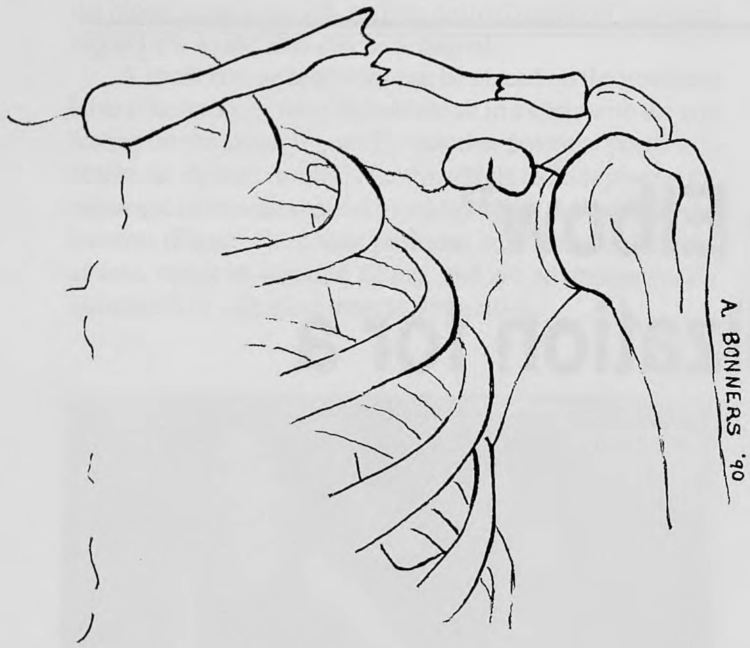


Figure 1. Left clavicle, anterior view, showing fracture sites

PATHOLOGY

Fractures of the clavicle are classified according to location and type. The athlete in this case study sustained a Type II, Class A (a displaced middle third clavicular fracture) and Type I, Class B (a non-displaced lateral third fracture) (8). After a clavicular fracture, the shoulder, in effect, loses its strut, which explains why the shoulder appears depressed and the upper extremity is held in adduction. A sling is applied because the weight of the limb would pull the bony fragments out of alignment even more (3). Excessive callus formation can be a problem with middle third clavicular fractures, not so much for the cosmetic deformity, but for the neurovascular injury that might be produced, which would pose a serious complication to the original bony injury (8).

FOLLOW-UP EVALUATION

After five and a half weeks, healing was complete enough for the slings to be removed. There was a two centimeter displacement at the fracture site, with the proximal portion of the clavicle in a superior position. This is a common development resulting from the pull of the sternocleidomastoid muscle; it gives the appearance of a very obvious "step" on the bone (2). More serious than the cosmetic deformity, however, was the functional disability that was assessed: although there were no muscular contractures at the shoulder joint, the elbow had suffered limitations in range of motion (ROM). Goniometric evaluation revealed that elbow extension was limited to 120 degrees, and both pronation and supination were lacking ten degrees. As a result of the angle of the elbow joint while in the sling, there was extreme weakness of the triceps brachii, and marked contracture of the biceps brachii. Girth measurements showed muscle atrophy in the left arm (Table 1).

REHABILITATION

The initial rehabilitation efforts were concentrated in regaining the lost ROM in elbow extension and forearm pronation/supination. This protocol was followed three days in succession: 1) 15 minutes of pre-heating with hydrocollator packs, 2) an additional 15 minutes of heating with the limb hanging off the end of the treatment table (the elbow in extension) while holding a 5-pound weight in the hand, 3) passive ROM in pronation and supination, 4) 15 minutes of ice.

Table 1. Girth measurements

Site	10/11/89	11/01/89
Left Elbow		
At the joint	25 1/2 cm	25 1/2 cm
3" Proximal	23 1/2 cm	24 cm
6" Proximal	25 1/4 cm	25 1/2 cm
9" Proximal	25 1/8 cm	25 1/2 cm
6" Proximal w/90° flexion	27 3/4 cm	27 3/4 cm
Right Elbow		
At the joint	26 3/4 cm	26 3/4 cm
3" Proximal	25 cm	26 cm
6" Proximal	26 1/2 cm	27 cm
9" Proximal	27 3/4 cm	26 1/2 cm
6" Proximal w/90° flexion	30 cm	30 1/16 cm

The second stage of rehabilitation consisted of a therapeutic exercise program designed to increase the muscle strength and mass to equal the contralateral limb. These exercises were performed: incline biceps curls with forearm in supination; incline biceps curls with forearm in pronation; triceps "kickback;" overhead triceps extension; wrist flexion; wrist extension; wrist radial deviation; wrist ulnar deviation; forearm pronation; forearm supination; broomstick "wrist roller;" and newspaper scrunches. This was a progressive resistance program utilizing hand-held weights.

The athlete was instructed to start with one set of ten repetitions and progress through two sets and three sets of ten repetitions. At that point, if he could perform more than ten repetitions, he increased the amount of weight he was using. (Note: Concurrently with the elbow rehabilitation, a progressive resistance exercise program for the entire shoulder complex should be followed to regain normal function.)

Many athletic trainers have seen the tendency of the elbow joint to lose ROM after immobilization and know well the aggressive rehabilitation required to prevent permanent disability. This case of frozen elbow following a clavicular fracture suggests that, orthopedist willing, the arm sling be removed and elbow exercises be performed with the athlete lying supine on a treatment table with the arm supported. That way, active ROM could be maintained while avoiding a traction pull on the fracture site.

PROGNOSIS

The clavicular fracture was completely healed by the end of the fall athletic season, and no disability was anticipated. According to the orthopedist, future surgery was recommended, however, to file down the bony surface into a more regular contour. Regarding the exercise program, compliance can be a problem with patients of any age, but certainly never more than with a teenager who can always find something more fun to do than exercise, or more urgent to accomplish than coming to the training room for periodic girth measurements. To that end, the word was spread to his parents, coaches, and fellow athletes that their support and encouragement would enhance the athlete's level of commitment. At the same time, the athletic training staff continued to stress the importance of not settling for less than full ROM at the elbow and radioulnar joints for proper upper extremity function. The combination of a concerned support group and a short term goal, such as achieving a specific ROM, is instrumental to successful rehabilitation (6). The efforts paid off for this athlete — the young man was skiing that same winter.

REFERENCES

1. Arnheim DD: *Modern Principles of Athletic Training*. St. Louis: Times Mirror/Mosby, 1985, p. 711.
2. Booher JM, Thibodeau GA: *Athletic Injury Assessment*. St. Louis: Times Mirror/Mosby, 1989, p. 525.
3. Gartland JJ: *Fundamentals of Orthopaedics*. Philadelphia: W.B. Saunders, 1979, p. 253.
4. Micheli LJ: *Pediatric and Adolescent Sports Medicine*. Boston: Little, Brown, 1984, pp. 75-76.
5. Pettrone FA, ed: *American Academy of Orthopaedic Surgeons Symposium on Upper Extremity Injuries in Athletes, Washington, DC, 1986*. St. Louis: Times Mirror/Mosby, 1984, p. 279.
6. Prentice WE: *Rehabilitation Techniques in Sports Medicine*. St. Louis: Times Mirror/Mosby, 1990, pp. 116-119.
7. Salter RB: *Textbook of Disorders and Injuries of the Musculoskeletal System*. Baltimore: Williams & Wilkins, 1970, pp. 440-441.
8. Simon RR, Koenigsknect SJ: *Orthopedics in Emergency Medicine*. New York: Appleton-Century-Crofts, 1982, pp. 177-180.

Abstracts

Clint Thompson, MS, ATC

Baker RJ, Bell GW: The effect of therapeutic modalities on blood flow in the human calf. *JOSPT* 13: 23-27, 1991.

One goal during the acute phase of musculoskeletal injuries is to decrease swelling by reducing blood flow. However, a common goal during the rehabilitation phase is to increase blood flow to enhance healing. Health professionals use modalities such as cryotherapy in both of these phases. The purpose of the authors' research was to measure the changes in circulation in the human calf during and after the application of an ice pack, ice massage, heat pack, ultrasound, ice and ultrasound, and heat and ultrasound. The results revealed that neither form of ice significantly decreased blood flow when compared to the control. The hot pack, however, did significantly increase blood flow during its application. The ultrasound application demonstrated a significant increase in blood flow up to 45 minutes following application. The results also showed that the application of hot packs before the ultrasound treatment did not significantly augment the effect of ultrasound. On the other hand, ice prior to ultrasound did not reduce the effect of the ultrasound on circulation. The authors concluded that ultrasound could be advantageous in increasing blood flow during rehabilitation. However, the use of another modality prior to ultrasound will not augment the effect on blood flow.

Scott T. Doberstein
Millikin University
Decatur, IL

Greene TA, Hillman SK: Comparison of support provided by a semirigid orthosis and adhesive ankle taping before, during, and after exercise. *Am J Sports Med* 18: 498-506, 1990.

Individuals who perform vigorous physical activity are very susceptible to ankle sprain injuries. The single most injured structure in athletes is the lateral ligament complex. Fifteen percent of all athletic injuries occur here. Many professionals involved in the prevention and treatment of ankle injuries have used various external support devices in an attempt to maintain ankle stability. The purpose of this study was to compare the Ankle Ligament Protector (ALP) to ankle tape for eversion/inversion range of motion restrictiveness before, during, and after a three-hour volleyball practice. Also, both support systems were checked for their effect on vertical jumping ability. When using the ALP, ankles showed a 42% initial range of motion restriction that decreased to 37% after three hours of exercise. The taped ankles demonstrated a 42% initial range of motion restriction which decreased to 15% following exercise. At 20 minutes into the volleyball practice, taped ankles showed maximal losses in restrictiveness for both eversion and inversion. In terms of the athletes' vertical jumping ability, neither support system had a significant effect. The authors concluded that a semirigid orthosis may be more effective than ankle taping in the protection of ankle sprains.

Scott T. Doberstein
Millikin University
Decatur, IL

Howell SM: Anterior tibial translation during a maximum quadriceps contraction: Is it clinically significant? *Am J Sports Med* 18: 573-578, 1990.

Quadriceps exercises following anterior cruciate ligament (ACL) reconstructions have long been a major concern of athletic trainers and orthopedic surgeons because of the possibility that the new graft can be adversely affected. The concern arises because the quadriceps muscle group generates an anterior drawer and an extensor torque. One purpose of this study was to determine the amount of tibial translation, as measured by employing a known anterior drawer (extrinsic), and to compare this amount of translation with the displacement produced by isometric quadriceps contractions (intrinsic) at 15°, 30°, 45°, 60°, and 75° of knee flexion. Secondly, the author wanted to ascertain the specific role of the ACL in knee stability under the same intrinsic and extrinsic conditions, but comparing normal, ACL deficient, and reconstructed knees. A third purpose of the study was to determine the flexion angles at which maximum quadriceps contraction causes the most anterior translation of the tibia. The results revealed that anterior tibial translation occurred between 15° and 60° of flexion during an isometric knee extension. However, the tension in the ACL during a maximum isometric quadriceps contraction is not greater than the tension developed during the artificial laxity testing. These findings were the same in the ACL deficient, reconstructed, and normal knees. The author concludes that anterior tibial translation is controlled by interactive effects of compression forces and the articular surfaces, and not the ACL. These results raise serious questions about the role of quadriceps exercises on ACL reconstructed knees.

Scott T. Doberstein
Milikin University
Decatur, IL

Gross MT, Lapp AK, Davis M: Comparison of Swede-O-Universal ankle support and Aircast Sport-Stirrup orthoses and ankle tape in restricting eversion/inversion before and after exercise. *JOSPT* 13: 11-19, 1991.

Ankle sprains are one of the most frequent injuries suffered by athletes and active individuals. This high incidence of ankle sprains, and its detrimental effects on normal daily activities and sport participation, has resulted in an attempt by health professionals to devise external support systems that defend against recurrent as well as initial ankle sprains. Researchers have studied the efficacy of various support systems such as adhesive tape, elastic guards, lace-up braces, and semirigid orthotic devices. This study compares the efficacy of Swede-O-Universal Ankle Support (SO), Aircast Sport Stirrup Orthoses (AS), and ankle adhesive tape (T) in limiting eversion/inversion range of motion before and after exercise. All three external support devices significantly decreased inversion and eversion immediately following application, and after exercise. Following exercise, inversion range of motion was less for the T and AS systems than for the SO system. These results will help health professionals in choosing among the various ankle support systems currently available to protect against ankle sprains.

Scott T. Doberstein
Millikin University
Decataur, IL

Potpourri

Dennis Aten, MS, ATC, RPT

Injuries and Age

Running and Fitnews

By the time the "baby boom" group reaches age 65, estimates are that one in six persons will be over 65 years old. Regular aerobic exercise is on the increase because of its favorable impact on risk factors for several diseases. Sports and exercise bring improved health, but they also can cause injuries. Do older people have a different pattern of overuse injuries when compared to younger people?

Gordon Metheson, MD, and his colleagues at the University of British Columbia in Vancouver, have analyzed 1,407 cases at an outpatient sports medicine clinic. Here are the highlights:

- Running, fitness classes, and field sports were more common causes of injury in younger people.
- Racquet sports, walking, and low-intensity sports accounted for more injuries in the older group.
- The frequency of tendonitis was similar in both groups.
- Injuries to toe joints and bones, and heel and knee cartilage were more frequent in older persons.
- Other knee injuries, stress fractures, and bone inflammations were more common in the younger population.
- Older people had 2.5 times more cases of arthritis pain associated with their exercise or sport.

The doctors found that 85% of the injuries in the older group were a result of overuse; however, the injuries responded to conservative treatment. Injury should not deter older people from regular exercise, because it appears that they respond well to rehabilitation programs.

The authors conclude, "While it was once thought that the body would wear out with activity and that lower physical capacity was a natural accompaniment of aging, it is now recognized that activity will add years to life and life to years." (*Medicine and Science in Sports and Exercise*, Vol. 21, No. 4, pp. 379-385)

MRI - Improved DX of Knee Injury

Running and Fitnews

To find out what is causing your knee pain, your doctor may need to stick instruments into your knee. Yet now, Peter Fowler, MD, at the University of Western Ontario in London, finds that a special magnetic resonance imaging (MRI) procedure scored 100% in detecting and finding tears of the anterior cruciate ligament in 30 knees. This makes the procedure as successful as arthroscopy, in which optical instruments are inserted into the knee.

No procedure is infallible, but because not all ligament tears need repair, many patients may be spared surgery if other doctors can match Fowler's success (*Orthopedics Today*, Vol. 9, No. 11, p. 199).

In addition to ligament tears, MRI is valuable in the diagnosis of problems with the bone surfaces and cartilage. While MRI is cheaper than arthroscopy, it does cost up to $1,000 a test. When they're available, MRI scanners have replaced knee arthroscopy as a diagnostic test, but arthroscopy may still be needed to repair some injuries.

Many insurance companies now request MRI scans, as well as second opinions, before approving the cost of knee surgery. Unfortunately, MRI scanners are very expensive and are not available everywhere. Finally, it is important to remember that many knee injuries can be diagnosed by a well-experienced sports medicine specialist who will review your training and medical history and perform a comprehensive physical examination.

Physical Activity May Prevent Colon Cancer

Good Health Digest

In what is believed to be the first-of-its-kind study on the effects physical activity has on reducing the risks of specific cancers, researchers at Kuakini Medical Center in Honolulu found that high levels of activity can significantly decrease the risk of colon cancer in the study population of Hawaiian and Japanese men.

Previous studies have suggested that increased activities may reduce the risk of colon cancer; but in most of these studies, activity was determined by approximate measure such as the subjects' occupations.

The scientists developed a direct measure of physical activities and evaluated relative risks of several cancers in a population of 8,006 men. The measure described activities undertaken at both work and home.

The study, which took 21 years to complete, was reported in the *American Journal of Epidemiology*. It measured level of activity and resting heart rate. Increased physical activity has been associated with decreased heart rate while the person is at rest.

New Edition RDA Changes

Dairy Council Digest

In the 10th (1989) edition of the Recommended Dietary Allowances (RDAs) published by the Food and Nutrition Board, the National Research Council/National Academy of Sciences makes some significant changes from the ninth (1980) edition. Some of these changes include:

- An extension of the age grouping of 19 to 22 years to now include age 24, in recognition that peak bone mass generally is not reached before age 25
- A change in the heights and weights of reference individuals resulting from the use of actual medians of height and weight for the U.S. population at designated ages, rather than use of arbitrary ideals
- Absolute figures for RDAs during pregnancy and lactation instead of additions to the basic allowances. RDAs for lactating women are based on new knowledge of their nutrient needs.
- Establishment of RDAs for vitamin K (i.e., 1 microgram/kg body weight) and the trace element selenium (i.e., 70 micrograms/day for men and 55 micrograms/day for women). An increase in the calcium RDA from 800 mg to 1200 mg/day for males and females ages 19 to 25. The RDA for calcium for older adults remains at 800 mg. Attention to calcium intakes from childhood to age 25 is encouraged. The calcium recommendations "... do not address the possible needs of persons who may have osteoporosis and should receive medical attention."
- Decreases in the RDAs for vitamin B_6, B_{12}, and folate
- Reductions in the RDAs for magnesium, iron, and zinc for specific populations
- Decreases in the estimated safe and adequate intakes for the vitamin biotin, and the trace element molybdenum. As in the ninth edition, estimated safe and adequate intakes are recommended for those nutrients for which scientific data are insufficient to develop an RDA, but for which sufficient information is available to estimate a range of requirements.
- Recognition that cigarette smokers need to consume at least 100 mg of vitamin C per day. However, the RDA for vitamin C for adults remains at 60 mg/day. The vitamin C allowance during pregnancy is lowered from an additional 20 mg/day in the previous edition to 10 mg/day.
- Designation of estimated minimal requirements for the electrolytes sodium, chloride, and potassium — a change from the ninth edition in which adequate ranges of intake were provided for these nutrients. The minimum requirement for sodium for adults is 500 mg/day.

The 10th edition of the RDAs can be purchased for $19.95 plus $2.00 shipping from the National Academy Press, 2101 Constitution Avenue, NW, Washington, DC 20418. To order by phone, call toll free at 1-800-624-6242.

APMA Redefine Scope

American Academy of Orthopedic Surgeons Report, April, 1990

The members of the American Podiatric Medical Association have voted by a 4 to 1 margin to redefine the scope of podiatric medicine, specifying "foot and ankle" instead of "foot and leg." The first referendum in the 78-year history of the organization revised the existing resolution to read: "Podiatric medicine is that profession of the health sciences concerned with the diagnosis and treatment of conditions affecting the human foot and ankle, including the local manifestations of systemic conditions, by all appropriate systems and means."

Knowledge Best Defense Against Health Fraud

Food & Nutrition News

Fast Scan: Health fraud is big business. It can delay a patient's entry into the legitimate health care system, and can cause serious bodily harm. In addition, it can mesmerize people into thinking they are practicing good health care habits.

Many of these fraudulent health schemes involve dubious diagnostic tests; phony weight-loss gimmicks; unnecessary nutrition supplements; other nutrition-related "ideas" and "miracle cures;" and treatments for cancer, AIDS, arthritis, and many other diseases.

It is very important for both professionals and the lay public to understand quackery's scope and the techniques quacks use to defraud health consumers.

Knowledge is the best defense against health fraud.

Book Reviews

Phil Callicut, EdD, ATC

Clinical Experiences in Athletic Training
Kenneth L. Knight, PhD, ATC
Human Kinetics Publishers, Inc.
Box 5076
Champaign, IL 61825-5076
1990
112 pages
Price: $16.00

One primary fear in the minds of all athletic trainers preparing for the NATA Certification Examination is, "Did I really study the important areas?" With the publication of Dr. Ken Knight's new text, the age old worry is no longer a problem. Athletic training students must acquire a wide range of practical skills. These skills require a knowledge base, but abstract knowledge is not enough — it must be applied. These skills can only be developed through solid clinical experience. In the past, "clinical experience" was defined by the certified athletic trainer offering the situation to the student trainers. At times this approach was too haphazard. Realizing this existing condition, Dr. Knight, a nationally recognized leader in athletic training education, and a veteran of over twenty years as an athletic trainer and educator, developed a modular program to solve this problem. His objective was the development of a plan whereby all students can develop and demonstrate their competence in basic athletic training skills. It did not take this reviewer too much reading to be able to state without reservation that this objective was accomplished.

Clinical Experiences in Athletic Training is a modular program. Each module contains instructions for the student to develop specific skills, practice them on a peer, and then demonstrate competence to a module supervisor.

Modules are arranged so that the students can begin developing simple skills and progressively acquire more complex ones. They are arranged into three levels and subgrouped within those levels, based in part on the difficulty and complexity of the skills involved. Basic skills developed during many first level modules are part of more complex skills required for the second level modules.

The modular program contained within this text will prove to be most effective for students in the NATA-approved curriculum programs and in the internship programs. Although students in the internship programs spend more time in the training room, the extra clinical time does not always ensure that they will have greater exposure to injury situations. They need guidance and direction, as do curriculum students.

This text is long overdue, as the profession of athletic training enters the 90s. We can no longer leave our skill development and pre-certification preparation to the "hit and miss" approach of the past. It is forms of written work by experienced members of our profession, such as Dr. Knight, which will serve as a medium to bring us to a higher level in the allied medical world. I strongly recommend this text for all levels of the profession.

Thermal Agents in Rehabilitation
Editor: Susan L. Michlovitz, MS, PT
F.A. Davis Company/Publishers
1915 Arch Street
Philadelphia, PA 19103-1493
1990
2nd Edition
300 pages, illustrated
Price: $33.00

The first edition of ***Thermal Agents in Rehabilitation*** became an instant success with practitioners and students alike. Ms. Susan Michlovitz, after listening to comments from educators and clinicians, encouraged the contributing authors to make changes and incorporate new information in this latest edition.

The second edition contains nine chapters on the latest information in the ever changing area of thermal agents and the role they play in the rehabilitative process. Section I, Foundation for the Use of Thermal Agents, elaborates on the stages of inflammation and repair, and clarifies the proliferative and remodeling phases of inflammation. There is more information provided on trigger points and muscle spasm in the chapter on pain.

In Section II, Instrumentation: Methods and Application, additions are made to relevant chapters on documenting treatment procedures and home use of heat and cold. The sections about wound evaluation and care, whirlpool additives, and pool therapy are expanded in the chapter on hydrotherapy. In addition, AIDS precautions are presented. The chapter on ultrasound has been revised to include additional information on ultrasound for tissue healing, and more detail on recording and selecting ultrasound intensities. Also, the theoretical foundation for the use of pulsed electromagnetic fields (PEMFs) is included. The reader should be advised though that much of this work still needs further investigation to determine the efficiency of PEMFs in managing soft-tissue trauma. Chapter 9 has been retitled to reflect the inclusion of ultraviolet. While PEMFs, low-power laser, and ultraviolet are not considered thermal agents, information on these is often included in introductory courses with thermal agents. Therefore, these agents have been included. At the time of the writing, low-power laser was still considered an investigative device by the Food and Drug Administration.

This text is filled with useful information and will be of great interest to athletic trainers and physical therapists. It should answer many of the ever present questions on the use of thermal agents.

Guide to Contributors

(Revised February 1991)

Athletic Training, JNATA 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 counseling and educating athletes concerning health care). 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 the editor.
2. Manuscripts are accepted for review with the understanding that they are original, have been submitted solely to *Athletic Training, JNATA*, and are not under simultaneous review by any other publication. All manuscripts must be accompanied by a letter signed by each author, and must contain the statements below. Manuscripts which are not accompanied by such a letter will not be reviewed.
   "This manuscript contains original unpublished material that has been submitted solely to *Athletic Training, JNATA*, is not under simultaneous review by any other publication, and will not be submitted elsewhere until a decision has been made concerning its suitability for publication by *Athletic Training, JNATA*. In consideration of the NATA's taking action in reviewing and editing my (our) submission, the author(s) undersigned hereby transfers, assigns, or otherwise conveys all copyright ownership to the NATA, in the event that such work is published by the NATA."
3. Materials taken from other sources, including text, illustrations, or tables, must be accompanied by a written statement giving *Athletic Training, JNATA* 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.
4. *Athletic Training, JNATA* utilizes a double blind review process. Authors should take care that they are not identified in any way except on the title page.
5. Manuscripts are reviewed and edited to improve the effectiveness of communication between the author and the readers, and to assist the author in a presentation
6. compatible with the accepted style of *Athletic Training, JNATA*. The author agrees to accept any minor corrections of the manuscript made by the editors.
   Published manuscripts and accompanying artwork cannot be returned. Unused manuscripts will be returned when submitted with a stamped, self-addressed envelope.

STYLE POLICIES

7. See Day (Reference b in #19 below) for elaboration of the following points.
8. Personal pronouns (I, we), and the active voice are preferred. Use the third person for describing what happened, "I" or "we" (if more than one author) for describing what you did, and "you" or the imperative for instruction.
9. Each page must be typewritten on one side of 8 1/2 x 11 inch plain paper, double spaced, with a one and one-half inch left margin and one inch margins elsewhere. **Do not right justify pages.**
10. Manuscripts should contain the following, organized in the order listed below, with each section beginning on a separate page:
    a. Title page
    b. Acknowledgements
    c. Abstract & 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 - each on a separate page
11. Begin numbering the pages of your manuscript with the abstract page as #1, and consecutively number all successive pages.
12. Titles should be brief within descriptive limits (a 16 word maximum is recommended). The name of the disability treated should be included in the title if it is the relevant factor; if the technique or type of treatment used is the principle reason for the report, it should be in the title. Often both should appear.
13. The title page should also include the names, titles, and affiliations of each author, and the name, address, and phone number of the author to whom correspondence is to be directed.
14. A comprehensive abstract of 75 to 200 words must accompany all manuscripts except **Tips From the Field**. Number this page one, type the complete title (but not the author's name(s)) on the top, skip two lines and begin the abstract. It should be a single paragraph and succinctly summarize the major intent of the manuscript, the major points of the body, and the author's summary and/or conclusions. It is unacceptable to state in the abstract words to the effect that "the significance of the information is discussed in the article." Also, do not confuse the abstract with the introduction.
15. List three to six key words or phrases that can be used in a subject index to refer to your paper. These should be on the same page as, and following, your abstract. For **Tips From the Field**, the key words should follow immediately after the title on the first numbered page.
16. 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. It should tell *why* the study needed to be done or the article written, and culminate with a statement of the problem (or controversy). Highlights of the most prominent works of others as related to the subject at hand are often appropriate for the introduction, but a detailed review of the literature should be reserved for the discussion section. In this brief (1 to 2 paragraphs) review of the literature, identify and develop the magnitude and significance of the controversy. This is often done by pointing out differences between others' results, conclusions, and/or opinions. Remember, 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.
17. The body or main part of the manuscript varies according to the type of article (examples follow). Regardless of the type of article, 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 subhead ings, charts, graphs, and figures is recommended.
    a. The body of an **experimental report** consists of a methodology section, a presentation of the results, and a discussion of the results. The methodology section should contain sufficient detail concerning the methods, procedures, and apparatus employed so that others can reproduce the results. The results should be summarized using descriptive and inferential statistics, and a few well planned and carefully constructed illustrations.
    b. The body of a **review of the literature** article should be organized into subsections in which related thoughts of others are presented, summarized, and referenced. Each subsection should have a heading and brief summary, possibly one sentence. Sections must be arranged so 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), resulting or 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 *Athletic Training, JNATA* receive, along with the submitted manuscript, a signed release form by the individual being discussed in the Case Study. Case Studies cannot be reviewed if the release is not included.
    d. The body of a **technique article** should include both the "how" and "why" of the technique; a step-by-step explanation of how to perform the technique, supplemented by photographs or illustrations; and why the technique should be used. The discussion of "why" should review similar techniques, point out how the new technique differs, and explain the advantages and disadvantages of the technique in comparison to other techniques.
    e. A **tip from the field** is similar to a technique article but much shorter. The tip should be presented and its significance briefly discussed and related to other similar techniques.
18. 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.
19. Citations in the text of the manuscript take the form of a number in parentheses, (7), which indicates the number assigned to the citation. It is placed directly after the reference or the name of the author being cited. References should be used liberally. It is unethical to present others' ideas as your own. Also, use references so that readers who desire further information on the topic can benefit from your scholarship.
20. 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 family names then initials, title of article, journal title with abbreviations as per *Index Medicus* (underlined), volume, inclusive pages, year; b) books: author(s), title of book (underlined), publisher, city and state of publication, year, inclusive pages of citation. Examples of references to a journal, book, chapter in an edited book, and presentation at a meeting are illustrated below.
    a. Knight K: Tips for scientific/medical writers. *Athletic Training, JNATA* 25 (1): 47-50, 1990.
    b. Day RA: *How to Write and Publish a Scientific Paper*. 3rd Ed. Phoenix: Oryx Press, 1988.
    c. Albohm M: Common injuries in women's volleyball. In Scriber K, Burke EJ (eds): *Relevant Topics in Athletic Training*. Ithaca NY: Monument Publication, 1978, pp. 79-81.
    d. Behnke R: Licensure for athletic trainers: problems and solutions. Presented at the 29th Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association. Las Vegas, NV, June 15, 1978.
21. Photographs should be glossy black and white prints. Graphs, charts, or figures should be of good quality and clearly presented on white paper with black ink in a form which will be legible if reduced for publication. Tables must be typed, not handwritten. Photographs cannot be returned if the manuscript is published. Please refrain from using paper clips or writing on the back of photographs.
22. All artwork to be reproduced should be submitted as black and white line art, with a Rapidograph, a velox stat, or PMT process. Tonal values, shading, washes, Zip-a-tone-type screens effects, etc., are not to be used. All artwork to be reproduced in black plus a second (or more) colors should be submitted as black and white line art (see above paragraph), with an Amberlith or similar-type overlay employed for each area of additional color(s). Also, all areas of tonal value, shading, washes, etc., should be supplied on a separate clear or frosted acetate or Amberlith overlay. In addition, all areas to be screened (a percent or tint of black or color) should be supplied on an Amberlith overlay.

<u>NEW</u> Fall Jacket
Made of polar fleece; 80% poly., 20% cotton. Lined with 100% quilted polar fleece. NATA logo embroidered on the left chest. Available in red, silver, and jade. All come with a Navy blue collar and cuff. Sizes S-XL.
$75.00

Spring Jacket
Oxford cloth, felt lined jacket. NATA logo is embroidered on the left chest, available in red, white, and royal blue and sizes S-XL.
$43.00

Fall Jacket
Corduroy jacket with quilt lining. <u>Limited supply</u>. The NATA logo is embroidered on the left chest, available in white/royal, royal/white & grey/royal, grey/maroon and sizes S-XL. **$54.00**

Polo Shirt
White 50% cotton 50% polyester jersey knit with the NATA logo embroidered on the left chest. Available in S-XXL. **$35.00**

Golf Shirt
White 60% cotton 40% polyester shirt with four button placket, tailored collar, and left chest pocket with the NATA logo embroidered on the left chest S-XXL.
$35.00

Golf Hat
Twill golf hat with adjustable leather strap and metal clasp with the NATA logo embroidered on the cap; available in white and navy blue. **$15.00**

Window Sticker
4" x 4" window sticker with the four color NATA logo. **$1.00**

Coffee Mug
White coffee mug with the four color logo on the side. **$6.00**
NATA Tie Tack **$7.50**
NATA Stick Pin **$7.50**
NATA History Book **$7.50**
NATA Desk Clock/Calendar* **$45.00**
NATA Arm Patches **1/$3.00 2/$5.00**
* Limited Supply

NATA 1950
IOWA STATE ATHLETIC TRAINING CLUB
HALL OF FAME

*Staff shirts are available with the NATA logo embroidered on the shirt at the location of your choice with your school's name and logo printed on the shirt. A minimum order of 12 is needed. Ask for details.

Men's & Ladies Wrist Watch
Attractive, modern wrist watch with the NATAlogo on the face of the watch.
$60.00

***Through your support we have, in just three years, donated over $9,000 toward the new NATA Hall of Fame.**

Prices subject to change without notice.

Please specify certified, student or associate trainer patches.

Support Your NATA Hall of Fame!

ORDER FORM

- Money Order, Purchase Orders, Personal Checks, MasterCard, and VISA Accepted
- Make checks payable to *ISAT/NATA Hall of Fame.*
- NO Cash Accepted.

Circle one
MasterCard—VISA
Card # ____________ Exp. Date ________

Qty.	Item Description	Color	Size	Price	Total

Sub-Total	
4% IA Tax (IA only)	
10% Shipping	
TOTAL	

Mailing Address:
Name ____________
Address ____________
City ____________ State ________
Zip Code ____________
Phone # ____________

Send to:
ISAT/NATA Hall of Fame
P.O. Box 1055 Welch Ave. St.
Ames, IA 50010
(515) 294-4453

Video Review

Tom Gocke, MS, ATC

Physical Examination of the Musculoskeletal System
Larry B. Conochie, MD, FRSC; Author/Narrator
American Academy of Orthopedic Surgeons
222 South Prospect Avenue
Park Ridge, IL 60068-4058
Color 1/2" VHS
Playing Time: 12 minutes (pre-view tape)
45 minutes (approximate time per tape)
Price: none listed

One of the most important aspects of athletic training lies in the area of physical (orthopedic) assessment of injuries. A poor initial examination could delay the athlete's treatment/ rehabilitation program and ultimately hinder a return to competition. This situation could also produce serious consequences for the evaluator. Therefore, it is paramount that the athletic trainer remain current in physical assessment skills. It is also important that students, in the early stages of learning physical assessment skills, start out with a sound and strong background in this area.

Physical Examination of the Musculoskeletal System is an exceptional video series on physical assessment, which will be a great aid to any instructor who is looking for ways to support those techniques taught in the classroom. This series on physical assessment will also serve as a valuable study guide for the student who is learning the proper procedures of physical assessment.

The video assessment series is divided into nine (9) tapes each concentrating on a particular area of the body. The first tape provides the viewer with general information pertaining to physical assessment. Here the importance of full joint range of motion (ROM), goniometric measurements, and proper positioning of patients when conducting an evaluation is emphasized. Tapes 2 through 8 deal specifically with the different joint areas of the body. In each tape, a comprehensive physical examination is conducted as well as as a complete neurologic examination of the upper and lower extremities (Tapes 5 and 6). Dr. Conochie provides a thorough explanation of proper physical assessment techniques and common pathologies related to a specific joint. He uses patients with actual abnormalities to demonstrate a specific pathology that would indicate a positive finding during the evaluation. The last video concentrates on the area of gait analysis. The emphasis here is to educate the evaluator about the various gait phases and specific problems that are exhibited by someone with gait abnormalities.

My first thoughts, upon viewing this program, were that the material was too comprehensive and would be better suited for the medical student or the resident. However, after watching my colleagues conduct evaluations on our athletes, I found that Dr. Conochie's information is very useful to the athletic trainer. While some of the emphasis is outside of our realm, the vast majority of the information conveyed in this video series addresses the orthopedic assessment needs for all athletic trainers.

Physical Examination of the Musculoskeletal System contains advice and many useful reminders for those who are interested in developing or enhancing their assessment skills. I was impressed with the thoroughness of the subject matter covered for the musculoskeletal system and the detailed information given with respect to positive pathology for each joint area.

Another appealing aspect of this program is that it can be used as a self-instructional program. Although this video program has no printed instructional materials, the viewer can watch the program, pause the tape, practice these skills, and continue at his/her own pace. This video series would serve as a good review source for those who are studying for board examinations related to physical assessment.

I consider ***Physical Examination of the Musculoskeletal System*** an excellent video program. It should be a "must viewing" for all athletic trainers. The information contained in this video series is comprehensive, in addition to being easy to understand. I would not hesitate to use this physical assessment program in my classroom or in laboratory settings.

Current Literature

Brian Barry, MA, ATC

Alexander RH: Triage and transport: The golden hour begins. *Topics in Emergency Medicine* December 1990: 1-9.

Delisa JA, Leonard JA, Meier RH, Hammond M, Smith BS: Educational survey: Common questions asked by medical students about physiatry. *American Journal of Physical Medicine and Rehabilitation* October 1990: 259-265.

Derlet RW, Heischober B: Methamphetamine - Stimulant of the 1990's? *The Journal of Western Medicine* December 1990: 625-628.

DiNubile MJ: Antibiotics: The antipyretics of choice? *The American Journal of Medicine* December 1990: 787-788.

Dorman AN, Marcos, NW: Congenital bipartate scaphoid. *The Journal of Hand Surgery* November 1990: 869-873.

Fiedler KM, Raguso A, Morgan G, Renker L: A retrospective study of graduates of a coordinated internship/master's degree program. *Journal of the American Dietetic Association* April 1990: 591-596.

Finsterbush A, Frankl U, Matan Y, Mann G: Secondary damage to the knee after isolated injury of the anterior cruciate ligament. *The American Journal of Sports Medicine* September/October 1990: 475-479.

Harris JS: Why doctors do what they do: Determinants of physician behavior. *Journal of Occupational Medicine* December 1990: 1207-20.

Hurt RD, Lauger GG, Offord KP, Kottke TE, Dale LC: Nicotine - replacement therapy with use of transdermal nicotine patch - A randomized double-blind placebo-controlled trail. *Mayo Clinic Proceedings* December 1990: 1529-37.

Kunisaki TA, Vukich DJ: Airway management in the golden hour of trauma. *Topics in Emergency Medicine* December 1990: 10-18.

Mason JO, McGinnis JM: "Healthy people 2000": An overview of the national health promotion and disease prevention objectives. *Public Health Reports* September/October 1990: 441-446.

May ME, Hill JO: Energy content of diets of variable amino acid composition. *The American Journal of Clinical Nutrition* November 1990: 770-776.

Ostrowski DM, Miller ME, Gould JS: Dorsal dislocation of the trapezoid. *The Journal of Hand Surgery* November 1990: 874-878.

Ploski MR, Helfst RH, Shelbourne KD: Rehab after ACL reconstruction. *REHAB Management* August/September 1990: 39-47, 63.

Radford WJP, Amis AA: Biomechanics of a double prosthetic ligament in the anterior cruciate deficient knee. *The Journal of Bone and Joint Surgery* (British Volume) November 1990: 1038-43.

Rafii M, Firooznia H, Sherman O, Minkoff J, Weinreb J, Golimbu C, Gidumal R, Schinella R, Zaslav K: Rotator cuff lesions: Signal patterns at MR imaging. *Radiology* December 1990: 817-824.

Salonen OLM: Case of anaphylaxis and four cases of allergic reaction following Gd-DTPA administration. *Journal of Computer Assisted Tomography* November/December 1990: 912-913.

Silbaugh BR: Managed care. *The Journal of Western Medicine* December 1990: 667-668.

Steiner ME, Brown C, Zarins B, Brownstein B, Koval PS, Stone P: Measurement of Anterior - Posterior displacement of the knee. A comparison of the results with instrumented devices and with clinical examination. *The Journal of Bone and Joint Surgery* (American Volume) October 1990: 1307-15.

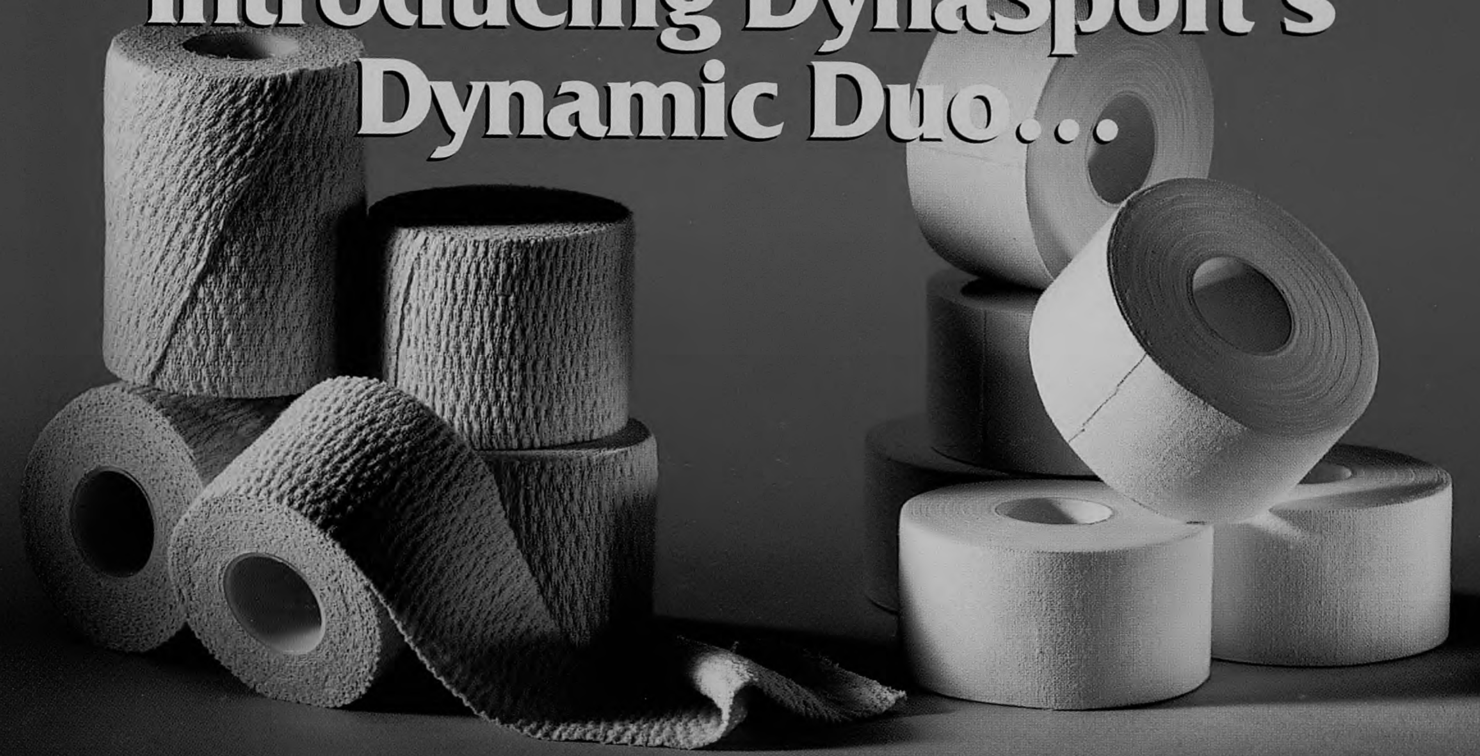
Walsh NE, Schwartz RK: The Influence of prophylactic orthoses on abdominal strength and low back injury in the workplace. *American Journal of Physical Medicine and Rehabilitation* October 1990: 245-250.

Wilson GD, Stitt KR, Bonner JL, Ballentine M: Dietary guidelines: Compliance and attitudes of a selected group of registered dietitians. *Journal of the American Dietetic Association* April 1990: 572-574.

Wojtys EM, Loubert PV, Samson SY, Viviano DM: Use of a knee-brace for control of tibial translation and rotation: A comparison, in cadavers, of available models. *The Journal of Bone and Joint Surgery* (American Volume) October 1990: 1323-29.

Advertisers' Index

Introducing DynaSport's Dynamic Duo...



DynaWrap & SpeedWrap

DynaSport's new and unique "DynaWrap" rippable elastic bandage features:

- A porous all natural adhesive
- Strong and durable back cloth/adhesive provides excellent conformability
- Consistent unwind tension— no ballooning or gaping
- Moisture resistant

CATALOG NO.	SIZE	QUANTITY
#51-308-9	2" x 7½ yds	24 rolls per case
#51-309-9	3" x 7½ yds	16 rolls per case

DynaSport introduces "SpeedWrap" Athletic tape featuring:

- Consistent unwind tension to the core
- Superb tensile strength
- Extended shelf life
- Manufacturer direct

CATALOG NO.	SIZE	QUANTITY
#51-310-9	1½" x 15 yds	32 rolls per case
#51-311-9	2" x 15 yds	24 rolls per case

DynaPlast

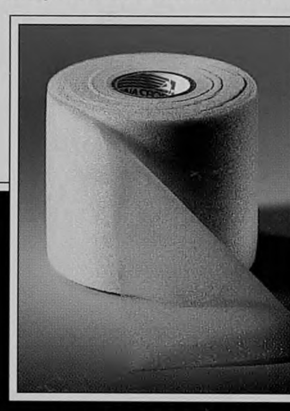
This DynaSport elastic tape features an all natural, moisture resistant adhesive combined with a strong back cloth for optimum conformability and strength. DynaPlast's balanced adhesive gives it a smooth, consistent unwind tension for easy application.

Catalog No.—#51-313-9
Size—3" x 5 yds
Quantity—16 rolls per case

PreWrap

DynaSport's PreWrap underwrap is a highly porous underwrap designed to protect the skin from repeated tapings. It tears easily and conforms well to the skin.

Catalog No.—#51-312-9
Size—2¾" x 30 yds
Quantity—48 rolls per case



DYNASPORT™
BY
Smith & Nephew DonJoy Inc.

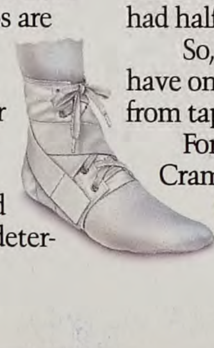
FOR A DYNASPORT CATOLOG, SAMPLES, OR TO PLACE AN ORDER PLEASE CALL US TOLL FREE AT
1-800-228-4421

FAX (619) 438-3210,
TELEX # 5101007208
5966 La Place Court,
Carlsbad, CA 92008

WHAT MAKES CRAMER THE BEST ANKLE SUPPORT?

WE'RE STRAPPED FOR A REASON.

Unlike basic laced ankle supports, the patented Cramer design utilizes two straps. These straps are positioned to create a heel-lock and lateral stability in much the same manner as a good tape job. However, the Cramer Ankle Stabilizer proved significantly more effective than tape in preventing ankle injuries.



In a six-year on-the-field study* conducted by an NCAA Division I football team, it was determined that a player wearing the Cramer Ankle Stabilizer had half the risk of ankle injury as a player wearing tape.

So, if you want to reduce the number of players you have on the sidelines, hobbled with ankle injuries, switch from tape to Cramer Ankle Stabilizers.

For more information, write:
Cramer Products, Inc., P.O. Box 1001,
Gardner, KS 66030 or call:
1-800-255-6621 or 913-884-7511.

Cramer

KEEPING YOU IN THE GAME.™

*Research results available upon request.