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Guidelines for Preventing Blood-Borne Pathogen Diseases

Kenneth L. Knight, Editor-in-Chief

Many aspects of athletic training, and medicine in general, are an art that can be approached in a variety of ways. Other practices, such as the handling of bodily fluids, must be performed within much more stringent limits. But AIDS is such an emotional issue (and understandably so, since there is no known cure), that it is hard to determine truth from exaggeration and emotionalism. The fear of contracting AIDS is one of the greatest concerns of our time. In this issue, we have three pieces of information about the handling of bodily fluids: NATA blood-borne pathogen guidelines, the Centers for Disease Control and Prevention (CDC) statement regarding the spread of HIV via sweat, and suggestions for smaller institutions such as high schools that have small volumes of infectious waste disposal.

NATA Blood-Borne Pathogen Guidelines

Most athletic trainers seem to have a healthy respect for AIDS and other blood-borne pathogen diseases and take appropriate precautions against contracting or spreading them. But because of the great emotionalism of the issue, many athletic trainers find themselves at either extreme: either under- or over-reacting to the possibility of spreading the HIV virus through contact with bodily fluids. With the assistance of Dr. Brent Arnold, the NATA Board of Directors has established a set of guidelines concerning blood-borne pathogens, which we have reproduced on page XX.

These guidelines are the result of an extensive review of the scientific and legal literature, as well as extensive discussion by the Board of Directors and legal counsel. In June, the Board adopted the guidelines, although they stressed that they were not establishing specific standards or policy. Their intent is to provide guidelines for individual athletic trainers to use in establishing their own policies and procedures. It would behoove all athletic trainers to make sure they have written policies and procedures and that these policies and procedures are either in line with these guidelines or based on a written rationale that explains why they deviate from the guidelines.

The HIV Virus Cannot Be Spread Through Sweat

Athletic trainers need not be concerned with athletes spreading HIV through wiping their sweat on the same towel. The CDC has determined that the HIV virus cannot be passed through perspiration alone. They state: “HIV has been found in saliva and tears in only minute quantities from some AIDS patients. It is important to understand that finding a small amount of HIV in a body fluid does not necessarily mean that HIV can be transmitted by that body fluid. HIV has not been recovered from the sweat of HIV-infected persons. Contact with saliva, tears, or sweat has never been shown to result in transmission of HIV.” (Personal communication with Michelle Bonds, spokesperson for the CDC Press Office in Atlanta, GA June 23, 1995. See also “Fact Sheet: HIV and Its Transmission FS7” published by the CDC in May, 1994.)

Disposing of Small Volumes of Infectious Waste

On page 208, Mary Brkich, a high school athletic trainer, shares the results of her search to find a way to dispose of small volumes of infectious waste. For those in similar situations, this is super information.

A Word About Written Policies and Procedures

Whether they are consciously defined or not, each of us lives our lives (both private and professional) according to a set of policies and procedures. An athletic training unit will operate more efficiently if these policies and procedures are written down and made available to all concerned. Staff and students will need to refer to them much more often than coaches and athletic department administrators, but all must know of their existence and know where to find them for review. An efficient operation requires staff who work together toward a common objective. Chaos will result from everyone following individual policies and procedures.
The WordPerfect Thesaurus lists “policy” and “procedure” as synonyms of each other, along with course, practice, tactics, procedure, strategy, method, and routine. My Webster's Universal Unabridged Dictionary defines the words differently; “policy” is any governing principle, plan, or course of action, and “procedure” is a particular course of action or way of doing something. So a policy is an overall statement of belief, an idea, and a procedure is a specific course of action based on general policies, a plan implementing the idea. Often, many procedures are based on a single policy, and some procedures are based on more than one policy.

Both policies and procedures are important so that all concerned know how to operate their training room as desired, and to establish why that mode of operation is preferred. It is important that policies are referenced to scholarly texts and literature, such as the ones referenced above, so that folks can determine the thinking behind such policies, and so that policies can be changed as scholarship advances knowledge. Procedures should be referenced to established policies. They may contain specific instructions or refer to texts and manuals that give the specific instructions and accepted variations.

Flour-Filled Balloon

Here is an inexpensive creative idea I picked up from my wife, who substituted for a fifth-grade class. Take a deflated rubber balloon, and fill it with flour using a funnel. Then tie a knot in the balloon. The flour-filled balloon is great for forearm strengthening. It is perfect for take-home exercise programs, and patients can make their own if necessary.

Jeffrey Hewlett, ATC
Head Trainer
South Houston High School
South Houston, TX 77587

NATA Research & Education Foundation
1996 Request For Proposals

The National Athletic Trainers' Association Research & Education Foundation is pleased to announce that $75,000 is available during 1996 to fund research which enhances the health care of the physically active.

Of this total, $50,000 will be used to fund proposals which address important issues in five categories: basic science, clinical studies, sports injury epidemiology, educational research, and observational studies. The Foundation has designated the remaining $25,000 to fund studies that investigate the validity and efficacy of therapeutic techniques, modalities, clinical procedures, and equipment used by allied health practitioners.

Grant application submission deadlines are March 1 and September 1 of each year. Priority consideration will be given to research proposals which include an NATA-certified athletic trainer as an integral member of the research team. Proposed studies may be one or two years' duration.

Research grant applications and guidelines may be obtained by writing to the NATA Research & Education Foundation, 2952 Stemmons Freeway, Dallas, TX 75247, calling 800-TRY-NATA, ext. 142, faxing the request to 214-637-2206 or e-mailing the request to brianae@aol.com.
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Blood-Borne Pathogens Guidelines for Athletic Trainers*

The NATA recognizes that blood-borne pathogens such as HIV, HBV, and HCV present many complex issues for athletic trainers, athletic administrators, and others involved with the care and training of athletes. As the primary health care profession involved with the physically active, it is important for athletic trainers to be aware of these issues. The NATA therefore offers the following guidelines and information concerning the management of blood borne pathogen-related issues in the context of athletics and settings in which the physically active are involved.

It is essential to remember, however, that the medical, legal, and professional knowledge, standards, and requirements concerning blood-borne pathogens are changing and evolving constantly, and vary, in addition, from place to place and from setting to setting. The guidance provided in these guidelines must not, therefore, be taken to represent national standards applicable to members of the NATA. Rather, the guidance here is intended to highlight issues, problems and potential approaches to (or management of) those problems that NATA members can consider when developing their own policies with respect to management of these issues.

ATHLETIC PARTICIPATION

Decisions regarding the participation of athletes infected with blood-borne pathogens in athletic competitions should be made on an individual basis, following the standard or appropriate procedures generally followed with respect to health-related participation questions, and taking into account only those factors that are directly relevant to the health and rights of the athlete, the other participants in the competition, and the other constituencies with interests in the competition, the athletic program, the athletes, and the sponsoring schools or organizations.

The following are examples of factors that are appropriate in many settings to the decision-making process:

1. The current health of the athlete.
2. The nature and intensity of the athlete’s training.
3. The physiological effects of the athletic competition.
4. The potential risks of the infection being transmitted.
5. The desires of the athlete.
6. The administrative and legal needs of the competitive program.

EDUCATION OF THE PHYSICALLY ACTIVE

In a rapidly changing medical, social, and legal environment, educational information concerning blood-borne pathogens is of particular importance. The athletic trainer should play a role with respect to the creation and dissemination of educational information that is appropriate to and particularized with respect to that athletic trainer’s position and responsibilities.

Athletic trainers who are responsible for developing educational programs with respect to blood-borne pathogens should provide appropriate information concerning:

1. The risk of transmission or infection during competition.
2. The risk of transmission or infection generally.
3. The availability of HIV testing.
4. The availability of HBV testing and vaccinations.

Athletic trainers who have educational program responsibility should extend educational efforts to include those, such as athletes’ families and communities, who are directly or indirectly affected by the presence of blood borne pathogens in athletic competitions.

All education activities should, of course, be limited to those within athletic trainers’ scope of practice and competence, be undertaken with the cooperation and/or consent of appropriate personnel, such as team physicians, coaches, athletic directors, school or institutional counsel, and school and community leaders.

THE ATHLETIC TRAINER AND BLOOD-BORNE PATHOGENS AT ATHLETIC EVENTS

The risk of blood-borne pathogen transmission at athletic events is directly associated with contact with blood or other body fluids. Athletic trainers who have responsibility for overseeing events at which such contact is possible should use appropriate preventive measures and be prepared to administer appropriate treatment, consistent with the requirements and restrictions of their jobs, and local, state, and federal law.

In most cases, these measures will include:

1. Pre-event care and covering of existing wounds, cuts, and abrasions.
2. Provision of the necessary or usual equipment and supplies for compliance with universal precautions, including, for example, latex gloves, biohazard containers, disinfectants, bleach solutions, antiseptics, and sharps containers.
3. Early recognition and control of a bleeding athlete, including measures such as appropriate cleaning and covering procedures, or changing of blood-saturated clothes.
4. Requiring all athletes to report all wounds immediately.
5. Insistence that universal precaution guidelines be followed at all times in the management of acute blood exposure.
6. Appropriate cleaning and disposal policies and procedures for contaminated areas or equipment.
7. Appropriate policies with respect to the delivery of lifesaving techniques in the absence of protective equipment.
8. Post-event management including, as appropriate, re-evaluation, coverage of wounds, cuts, and abrasions.
9. Appropriate policy development, including incorporation, with necessary legal and administrative assistance, of existing OSHA and other legal guidelines and conference or school rules and regulations.

STUDENT ATHLETIC TRAINER EDUCATION

NATA encourages appropriate education of and involvement of the student athletic trainer in educational efforts involving blood-borne pathogens. These efforts and programs will vary significantly based on local needs, requirements, resources, and policies.

At the secondary school level, educational efforts should include items such as the following:
1. Education and training in the use of universal precautions and first aid for wounds.
2. Education regarding the risks of transmission/infection from the participants that they care for.
3. Education on the availability of HIV testing.
4. Education on the availability of HBV vaccinations and testing.
5. Education of parents or guardians regarding the students’ risk of infection.

At the college or university level, education efforts should include items such as those listed above, and additionally, as appropriate, the following:
1. Education in basic and clinical science of blood-borne pathogens.
2. Discussions regarding the ethical and social issues related to blood-borne pathogens.
3. The importance of prevention programs.
4. Education concerning the signs and symptoms of HBV and HIV, as consistent with the scope of practice of the athletic profession and state and local law.

UNIVERSAL PRECAUTIONS AND OSHA REGULATIONS

Athletic trainers should, consistent with their job descriptions and the time and legal requirements and limitations of their jobs and professions, inform themselves and other affected and interested parties of the relevant legal guidance and requirements affecting the handling and treatment of blood-borne pathogens.

Athletic trainers cannot be expected to practice law or medicine, and efforts with respect to compliance with these guidelines and requirements must be commensurate with the athletic trainer’s profession and professional requirements. It may be appropriate for athletic trainers to keep copies of the Center for Disease Control regulations and OSHA regulations and guidelines available for their own and others’ use.

MEDICAL RECORDS AND CONFIDENTIALITY

The security, record-keeping, and confidentiality requirements and concerns that relate to athletes’ medical records generally apply equally to those portions of athletes’ medical records that concern blood-borne pathogens.

Since social stigma is sometimes attached to individuals infected with blood-borne pathogens, athletic trainers should pay particular care to the security, record-keeping, and confidentiality requirements that govern the medical records for which they have a professional obligation to see, use, keep, interpret, record, update, or otherwise handle.

Security, record-keeping, and confidentiality procedures should be maintained with respect to the records of other athletic trainers, employees, student athletic trainers, and athletes, to the extent that the athletic trainer has responsibility for these records.

THE INFECTED ATHLETIC TRAINER

An athletic trainer infected with a blood-borne pathogen should practice the profession of athletic training, taking into account all professionally, medically, and legally relevant issues raised by the infection. Depending on individual circumstances, the infected athletic trainer will or may wish to:
1. Seek medical care and ongoing evaluation.
2. Take reasonable steps to avoid potential and identifiable risks to his or her own health and the health of his or her patients.
3. Inform, as or when appropriate, relevant patients, administrators, or medical personnel.

HIV AND HBV TESTING

Athletic trainers should follow federal, state, local and institutional laws, regulations, and guidelines concerning HIV and HBV testing. Athletic trainers should, in appropriate practice settings and situations, find it advisable to educate or assist athletes with respect to the availability of testing.

HBV VACCINATIONS

Consistent with professional requirements and restrictions, athletic trainers should encourage HBV vaccinations for all employees at risk, in accordance with OSHA guidelines.

WITHHOLDING OF CARE AND DISCRIMINATION

NATA’s policies and its Code of Ethics make it unethical to discriminate illegally on the basis of medical conditions.

REFERENCES

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Infectious Waste Disposal Plan of the High School Athletic Trainer
Mary Brkich, MA, ATC

ABSTRACT: Many athletic training settings, especially high schools, do not have an effective method of properly classifying and disposing of infectious waste. In this article, I provide a set of guidelines for identifying infectious waste and outline several options for effective and safe disposal for the high school athletic trainer. Such a plan can help to reduce the total output of infectious waste as well as safeguard athletes, athletic trainers, the general public, and local authority workers against infectious diseases.

Because of the growing number of HIV cases in recent years, there is increasing emphasis on the implementation of universal precautions when dealing with bodily fluids. In many allied health settings, clinicians are exposed to risks daily, and programs have been instituted to deal with the exposure and the byproducts. Athletic trainers do not appear to be at significant risk of infection in their day-to-day contact with athletes. Independent of frequency, however, each exposure must be considered potentially harmful. While athletic trainers are being educated about universal precautions, it is a concern that many athletic training settings, especially high schools, often do not have an effective method of properly classifying and disposing of infectious waste.

Because of the growing number of HIV cases in recent years, there is increasing emphasis on the implementation of universal precautions when dealing with bodily fluids. In many allied health settings, clinicians are exposed to risks daily, and programs have been instituted to deal with the exposure and the byproducts. Athletic trainers do not appear to be at significant risk of infection in their day-to-day contact with athletes. Independent of frequency, however, each exposure must be considered potentially harmful. While athletic trainers are being educated about universal precautions, it is a concern that many athletic training settings, especially high schools, often do not have an effective method of properly classifying and disposing of infectious waste.

Identification of what is infectious is limited. Articles that have been published discuss universal precautions, biohazardous containers, environmental control, and the importance of staff education and training. Webster and Kaiser mention that proper disposal of these materials is necessary and “does not include having the custodian collect these items as normal trash.” Brubaker and Izumi advocate disposing of the materials “according to local government regulations.” Therefore, it is the intent of this article to provide the high school athletic trainer with a set of guidelines for identifying infectious waste, and to outline several options for effective and safe disposal.

DEFINING INFECTIOUS WASTE

Medical waste is generated as a result of patient treatment. Infectious waste, in particular, is considered to be the portion of medical waste that may potentially transmit infectious disease. In relation to total waste produced in the United States, medical waste represents 1% to 3% of the yearly total. Infectious waste comprises 10% to 15% of all medical waste; however, this amount is increasing due to the confusion in identification of what is infectious.

B

IDENTIFYING INFECTIOUS WASTE

To date, there are no reported cases of HIV transmission in athletic training settings, and risk of occupational transmission appears to be very low. The potential for infection comes in the form of contaminated “sharps,” with other materials posing a smaller risk. Blood is by far the most hazardous body fluid. Materials of concern for the athletic trainer include: 1) used scalpel blades, 2) needles (possibly generated from puncturing blisters, injecting diabetics/those allergic to bees, or from injections given by the team physician), 3) soiled gauze and bandages, 4) soiled latex gloves, and 5) towels soiled with blood or potentially hazardous body fluid.

DISPOSAL PLAN

The athletic trainer must develop and implement a written waste management program in the form of a policy and procedures manual. This should include a review of universal precautions. Additionally, one must consider what is infectious waste and segregate it from other waste. As part of the disposal plan, specific colored bags are used for storing separated materials. All clean packaging and sterile wrappers are discarded in a general waste container, which is usually green, black, or brown plastic. Infectious waste is packaged in red bags or a biohazardous waste container. Soiled towels are placed in a green cloth bag or clear plastic. Finally, a disposal schedule is arranged to remove the waste.

For high schools that generate a low volume of infectious waste, disposal can be a significant problem. Typically, there is not a hospital or medical center on campus that can be used for disposal, and off-site hospitals usually will not accept the infectious waste. Low volume of waste and high cost of disposal do not warrant selecting a medical disposal service. Regular trash costs between 6 cents and 10 cents per pound for disposal, whereas the cost for medical waste is between 40 cents and $1 per pound. One possible solution to this problem is to make arrangements with the team physician to accept the high school infectious waste and dispose of it as his/her own. A relatively new alternative to this problem is to consider a biological waste mailing system. Cramer Products, Inc (Gard-

*EDITOR'S NOTE: Sweat, saliva, and tears are not considered hazardous. See complete statement on Editorial page.
ner, KS) and Stericycle (Woodinville, WA) provide this type of service. It is a simple system and requires no long-term contract or commitment. When containers are full (they are available in various sizes), the waste disposal kits are mailed back to an approved waste disposal facility in a rugged red plastic carrying case identified with a biohazard logo via regular US mail. The waste is destroyed at the plant’s incineration facilities that meet or exceed all state and federal requirements for clean air and environmental standards. More information can be obtained by contacting Cramer Products, Inc (800-255-6621) or Stericycle (800-643-0240 x340).

Following a disposal plan can reduce the total output of infectious waste by distinguishing it from regular waste. Infectious waste is handled separately and thereby shields athletic trainers and athletes from infectious diseases. In addition, a disposal plan can prevent against hazardous dumping, contamination of the environment, and unnecessary risk of exposure to the general public and local authority employees.

ACKNOWLEDGMENTS

I would like to thank Mark Hoffman, MA, ATC, EMT, for his never-ending encouragement and support of this article and for his editorial assistance.

REFERENCES


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Oxygenation and Exercise Performance-Enhancing Effects Attributed to the Breathe-Right Nasal Dilator

Marc Trocchio, ATC; Jeffrey W. Wimer, MS, ATC, EMT; Anna W. Parkman, MBA, RRT; Jean Fisher, MBA, RRT

ABSTRACT: Recently, many professional football players have elected to wear spring-loaded nasal dilators during competition. Many athletes believe that wearing the “Breathe-Right” nasal dilator will increase nasal gas conduction and oxygenation to their body, subsequently improving their performance. The purpose of this experiment was to investigate the advantages of wearing a nasal dilator while performing aerobic and anaerobic exercise, as opposed to not wearing a nasal dilator. It was hypothesized that the “Breathe-Right” nasal dilator, manufactured by CNS, Inc (Chanhassen, MN) would increase nasal gaseous conduction and increase oxygenation to the body. Nasal gaseous conduction and oxygenation are essential components for using aerobic power. We examined whether wearing a nasal dilator improves performance by using a ramped cycle ergometer stress test on athletes until they reached VO2 max maximum progressing from aerobic to anaerobic exercise. Baseline data were collected (ie, VO2, VO2/kg, respiratory exchange ratio, anaerobic threshold time, and onset of VO2 max) using a MedGraphics CardiO2 System. The subjects included 16 college-aged male athletes. Dependent t-tests implemented on each physiological response; VO2 max, peak VO2/kg, onset of anaerobic threshold, onset of VO2 max, respiratory exchange ratio at VO2 max, and maximum WATT output, showed there was no difference in the athletes’ performance when they wore the nasal dilators and when they did not wear the dilators.

Professional football players attracted media attention last season by wearing what looked like a bandage for a broken nose. Athletic trainers working with the NFL tell us that many players believed wearing the “Breathe-Right” nasal dilator would increase their nasal gas conduction and subsequently improve performance.3 Jerry Rice of the San Francisco 49ers was one of the first NFL players to bring notoriety to the “Breathe-Right” device (Fig 1).9 The purpose of this experiment was to see if it is advantageous to wear a nasal dilator while performing aerobic and anaerobic exercise. The “Breathe-Right” nasal strips, manufactured by CNS Inc, Chanhassen, MN, have been used to relieve nasal gas congestion, obstruction associated with allergic rhinitis, septal abnormalities, congestion, snoring, and sleep apnea. CNS claims that the “Breathe-Right” device reduces nasal airway resistance by 31%.1 Since 1980, physicians have made significant progress in treating and managing conditions such as sleep apnea and hypopnea syndrome through the use of continuous positive airway pressure and the “Breathe-Right” device. Sleep apnea and hypopnea syndrome occur when there is a narrowing of the upper airway that stops or decreases breathing.5,9,11,17 Apnea is defined as a cessation of oronasal airflow for at least 10 seconds in duration. When it occurs 30 or more times during a 7-hour period of nocturnal sleep, it is further defined as obstructive sleep apnea.9,11,17 Given these manufacturer’s claims, it was hypothesized that the “Breathe-Right” device would increase VO2 max, peak VO2/kg, onset of anaerobic threshold, and increase WATTs and the ability to tolerate increased respiratory exchange ratio levels, subsequently prolonging the onset of anaerobic threshold.

The medical conditions that the “Breathe-Right” nasal dilator were designed to treat will not be explored in this study. However, because the nasal dilator was designed to increase airway flow and theoretically increase oxygenation, it may now be classified as a performance-enhancing device. Cardiorespiratory responses such as VO2 max, peak VO2/kg, onset of anaerobic threshold, onset of VO2 max, max WATTs, and respiratory exchange ratio toleration may be increased from wearing such a device. We tested whether the nasal device would enhance performance by measuring these cardiorespiratory responses.

Medium and large “Breathe-Right” nasal strips are recommended for adults with an average to above-average nose size. The “Breathe-Right” nasal strip is approved by the FDA as an over-the-counter device. No new claims regarding the effectiveness of the device have been made since athletes began using them. This small adhesive strip has a special backbone that mechanically opens the nasal passages. Each strip is lined with two parallel plastic strips. On the underside is a special adhesive, that when properly placed across the bridge of the nose, gently lifts the soft area above the flare of each nostril. As the plastic strips straighten, they provide approximately 25 grams of pulling force that carefully grabs and opens the nasal passages.1
Athletic trainers should consider the nose as a structure that affects performance. It can cause certain respiratory problems when structural abnormalities inhibit proper airway conduction. The nose should be capable of thoroughly warming and humidifying inspired air before it reaches the lungs. With this in mind, one must consider the vast exercise benefits gained through nasal decongestion and increased airway flow during inhalation at high-intensity work.

Theoretically, increasing VO$_2$ and peak VO$_2$/kg would mean added energy due to increased fuel combustion. At the cellular level, oxidation of substrates occurs with the production of energy. Thus, the skeletal muscle gets its fuel from food substrates and uses the oxygen for combustion. Increased oxygen levels could enhance the combustion of food substrates with increased VO$_2$. Ultimately, this would result in increased energy production and increased athletic performance.

Oxygen uptake is one of the most important metabolic measurements for accessing responses to acute exercise. The traditionally accepted criterion measure of cardiorespiratory endurance is to directly measure maximal oxygen consumption (VO$_2$ max). Oxygen use can be used as a determinant of the total work done. This study measured the difference in athlete’s VO$_2$ max, peak VO$_2$/kg, onset of anaerobic threshold, onset of VO$_2$ max, max WATTs produced and respiratory exchange ratio level at VO$_2$ max, with and without the use of a “Breathe-Right” nasal dilator. Jardins believed that no significant arterial oxygen pressure, arterial carbon dioxide pressure, or pH changes occur between rest and approximately 60% to 70% of maximum heart rate. This is also the average time in which the anaerobic threshold is met in aerobic exercise. Thus, we hypothesized that added nasal gaseous conduction or oxygenation may increase VO$_2$ and peak VO$_2$/kg due to the physical changes in the nasal pathway.

Poiseuille’s law states that pressure is directly proportional to flow, length, and velocity and inversely proportional to the radius cubed of a tube. In other words, an increase in the radius of a tube will decrease the pressure in the tube and increase the flow rate at that given pressure. The opposite is also true. Pressure will increase in response to a decreased radius. Considering Poiseuille’s law, the “Breathe-Right” nasal dilator should increase nasal tube radius, and thus increase the nasal flow rate. Decreased nasal tube pressure should result in
an increased nasal flow, increased VO₂ max, and increased peak VO₂/kg.

In humans, the respiratory quotient or respiratory exchange ratio is a useful indicator of maximal exercise. The body becomes less efficient when respiratory exchange ratio reaches 1.0 CO₂:O₂ during continuous exercise. Most people will discontinue exercise within 3 minutes after reaching 1.0 CO₂:O₂ and are unable to continue immediate exercise due to increasing lactic acidosis at respiratory exchange ratio levels above 1.10 CO₂:O₂. Ventilatory anaerobic threshold usually occurs at a work rate that corresponds closely to that at which lactic acid begins to accumulate in the blood. Most people who exercise regularly are able to perceive ventilatory anaerobic threshold and respiratory exchange ratio as the exercise intensity increases and breathing becomes labored. Although ventilatory anaerobic threshold was not measured for this study, the “Breathe-Right” nasal dilator may in effect change individual ventilatory anaerobic threshold levels.

METHODS

The subjects for this study included 16 college-age male athletes (age = 20.1 ± 1.5 yr, wt = 167.1 ± 17.3 lb, and ht = 70.4 ± 2.9 inches). All subjects participated in collegiate varsity athletics. They were tested at a respiratory care lab under the supervision of a registered respiratory therapist on a MedGraphics Cardio2 system (Medical Graphics Corporation, St Paul, MN) integrated with an Invivo finger probe pulse oximeter. A 10-lead ECG and ramped bicycle ergometer were used. Two individual trials were conducted at the same time of day and after similar daily events (ie, amount of sleep the night prior and approximate time after the ingestion of meals). Each subject was randomly assigned to a condition on whether they exercised while wearing the nasal dilator during the first trial or the second trial. Nine subjects completed their first exercise test with the nasal dilator applied to their nose. Seven subjects completed their first test without the “Breathe-Right” device. Thirty-two individual bicycle ergometer tests were done (16 subjects × 2 trials).

The goal of cardiorespiratory exercise testing was for the subject to achieve a maximum test as defined by Wasserman; a maximum cardiorespiratory stress test that induced respiratory exchange ratio values above 1.10 CO₂:O₂. Subjects who did not reach these criteria were rejected.

Each subject filled out a written consent form before the test. Subjects were scheduled and arrived for testing at set times. The second test was performed 48 hours after the first. Each subject had no prior history of circulatory problems or insufficiencies, no history of smoking or nasal passage problems, and had passed a physical exam within the past year. The manufacturer’s instructed procedures for the “Breathe-Right” device include: Wipe excessive skin oils from sides of nose. Remove backing, center the Breathe Right device between the bridge and the end of the nose, fold both sides down so the lower spring strip is positioned on the nasal crease above the flare of each nostril. Press firmly in place. This procedure was followed for each athlete.

Subjects were connected to the 10-lead ECG machine in standard 10-lead stress testing fashion. Subjects were instructed to perform as vigorously as they could tolerate. The cycle ergometer was increased at 30 WATTs per minute while maintaining at least 50 to 70 RPM. This was done until maximum VO₂ was reached. Subjects were told that the test was to quantify effects of the “Breathe-Right” device on the body.

Breath by breath, VO₂ and other gas exchange data (respiratory exchange ratio, ventilatory equivalent, and respiratory rate/heart rate) were collected in real time with the MedGraphics Cardio2 system (Fig 2). The functional capacity of the entire circulatory system was accurately quantified when combined with 10-lead ECG stress testing system. The pulse oximeters interfaced with the computer system and the information was automatically added to the gas exchange data. ECG monitoring was performed not only during the test, but also for 4 to 5 minutes afterward to monitor any exercise-induced abnormalities under the supervision of a registered respiratory therapist. A digital sampling rate of 500/sec/channel was used for recording and analysis. The computer software program provided a signal every second to adjust for breaking force generated by the cycles flywheel.

A pneumotach was also used for testing. It is a bidirectional flow device validated to meet American Thoracic Society guidelines in measurements of flow and volume in cardiorespiratory testing (Fig 3). Subjects placed the pneumotach fitted face mask onto their faces and breathed normally. Each person was told not to remove the pneumotach fitted face mask until completion of the test. No verbal communication occurred during the procedure between subject and tester.

Calibration of the MedGraphics Cardio2 system was performed before testing. A set-up calibration was done before all tests to verify room temperature, barometric pressure, relative humidity, ambient oxygen, ambient carbon dioxide and pneumotach volume measurements. The actual procedure consisted of pedalling until VO₂ max was reached, at which time the face mask was removed and the trial was deemed complete. Throughout each test, subjects’ ECG, blood pressure, and oxygen saturation were monitored as a safety precaution.

A matched paired t-test (dependent t-test) was used to compare the mean difference between the two groups (ie, wearing and not wearing the “Breathe-Right”) for VO₂ max, onset of VO₂ max,
Physiological Responses of the Subjects While Wearing and Not Wearing the “Breathe-Right” Nasal Dilator (Mean ± SD)

<table>
<thead>
<tr>
<th>Units</th>
<th>VO₂ Max</th>
<th>Peak VO₂/kg</th>
<th>Onset of VO₂ Max</th>
<th>Max Watt Output</th>
<th>Respiratory Exchange Ratio</th>
<th>Onset of Anaerobic Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Breathe Right</td>
<td>L/Min</td>
<td>mLO₂/kg</td>
<td>Seconds</td>
<td>Watts</td>
<td>CO₂/O₂</td>
<td>Seconds</td>
</tr>
<tr>
<td>3326 ± 520</td>
<td>44.0 ± 6.7</td>
<td>13.2 ± 1.9</td>
<td>291 ± 57</td>
<td>1.2 ± 1</td>
<td>7.4 ± 2.1</td>
<td></td>
</tr>
<tr>
<td>With Breathe Right</td>
<td>3367 ± 615</td>
<td>43.8 ± 6.5</td>
<td>13.2 ± 2.0</td>
<td>280 ± 40.2</td>
<td>1.2 ± 1</td>
<td>7.5 ± 2.1</td>
</tr>
<tr>
<td>Difference</td>
<td>41.4 ± 438.3</td>
<td>.2 ± 3.9</td>
<td>.02 ± 2.9</td>
<td>11.6 ± 39.5</td>
<td>.008 ± .07</td>
<td>.09 ± 1.8</td>
</tr>
</tbody>
</table>

Table. Wearing the “Breathe-Right” nasal dilator does not significantly improve any of the performance variables measured in this experiment (p values ranged between .26 to .84).

DISCUSSION

While all statistical tests show that there were no significant physiological findings, all 16 subjects mentioned that the “Breathe-Right” device in some way opened up their nasal passages. Although physiologically the “Breathe-Right” device does not seem to enhance exercise performance, the psychological edge of having open nasal airways may dictate the reason that athletes have come to depend on the “Breathe-Right” device during competition. For many athletes, the comfort associated with decongested nasal passages is priceless, especially for those who suffer from upper respiratory dysfunctions such as allergies. All in all, the psychological and nasal decongestion benefits of wearing a “Breathe-Right” device are appealing to many athletes and will probably attract many more athletes from all realms of competition to the “Breathe-Right” device during competition. For many athletes, the psychological and nasal decongestion benefits of wearing a “Breathe-Right” device are appealing to many athletes and will probably attract many more athletes from all realms of competition to the product. Future study should explore the “Breathe-Right” device’s attributed effects on exercise performance and oxygenation in nasal-congested subjects of different genders. The possibility of significant physiological findings may improve by testing congested subjects versus decongested subjects.

The MedGraphics Cardio2 bicycle ergometer was used because of its true zero work rate and 1000 WATT peak power range. Therefore, the cycle enabled us to assess aerobic capacity using a 30 WATT ramping protocol. The 30 WATT ramp protocol exercise is a preferred method of cycle exercise. It consists of continuous increased work rate over work rate maximum. The major advantages of the ramp test are: 1) The production of a linear VO₂ response, 2) the yield of large amount of data in a short period of aerobic function, and 3) good acceptance by subjects because of a smooth transition to higher work loads without a sudden noticeable increase in pedal resistance.

CONCLUSION

This study suggests that wearing a “Breathe-Right” device will not significantly increase oxygenation, and, therefore, will not enhance exercise endurance.

REFERENCES

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Airway Preparation Techniques for the Cervical Spine-Injured Football Player

Richard Ray, EdD, ATC; Carl Luchies, PhD; Doug Bazuin, BS; Robert N. Farrell, BA, ATC

ABSTRACT: Athletic health care professionals have been concerned about how to optimize the emergency care the cervical spine-injured football player receives on the field. Much of the discussion has centered on how to best expose and prepare the airway for rescue breathing in the quickest and safest manner possible. This study compared the time required and the extraneous motion induced at the cervical spine during three traditional and one new airway exposure and preparation technique. Twelve subjects wearing football helmets and shoulder pads were exposed to multiple trials of airway exposure via face mask repositioning using a manual screwdriver, power screwdriver, and the Trainer's Angel cutting device. Subjects also underwent airway preparation using the pocket mask insertion technique. Cervical spine motion was measured in two dimensions using an optoelectronic motion analysis system. Time and qualitative assessment were obtained through videotape analysis. Significant differences were found between the techniques with respect to time and cervical spine motion. The pocket mask allowed quicker activation of rescue breathing than the other three traditional techniques. There was no significant difference in the amount of extraneous motion induced at the cervical spine between the pocket mask, manual screwdriver, and power screwdriver techniques. The Trainer's Angel induced significantly more motion than the other three techniques in each of the four motions measured. Changes in traditional protocols used to treat cervical spine-injured football players on the field are recommended based on these data.

Field management of football players with cervical spine injuries has been a topic of discussion among athletic health care professionals. Although a consensus regarding the need to eliminate cervical spine movement following injury exists, there is some controversy over the most efficacious way to prepare the airway of a cervical spine-injured football player in respiratory arrest. One particularly vexing problem is the issue of how to expose, prepare, and manage the airway with minimal extraneous head and neck movement. The purpose of this investigation was to compare three traditional techniques and one new method of airway preparation to determine which method allowed quickest application of rescue breathing with the least amount of cervical spine movement.

Previous work on this question has provided helpful suggestions to practitioners, but has lacked the quantitative assessment and scientific rigor needed to reassure athletic trainers and other first responders that any particular method was best. Specifically, there is an absence in the literature of any reference to biomechanical motion analysis to determine which of the traditional airway preparation techniques introduces the least amount of cervical spine motion. Although athletic trainers, physicians, and Emergency Medical Technicians (EMTs) agree that face mask removal via one of three traditional methods (manual screwdriver, power screwdriver, and cutting face mask clips) is appropriate, none have demonstrated conclusively that these methods are safe.

The Occupational Safety and Health Administration’s (OSHA) Bloodborne Pathogen Standard requires health care practitioners to use a barrier device when performing rescue breathing. A pocket mask fitted with a one-way air valve is a popular device which should be carried by athletic trainers for this purpose. In 1992, we discovered that it was possible to perform rescue breathing on a CPR mannequin outfitted with a football helmet using the modified jaw thrust and a pocket mask with the one-way air valve protruding through the bars of the still-affixed face mask (the pocket mask insertion technique). We developed the following questions: 1) Since the pocket mask insertion technique requires only one task (inserting the mask under the face mask and over the mouth and nose), and since all of the traditional airway preparation techniques require at least four tasks (cutting or unscrewing two face mask clips, repositioning the face mask, and applying the pocket mask), would the implementation of rescue breathing be speeded with the pocket mask insertion technique? 2) Since cutting or removal of the face mask clips by traditional methods presumably causes some extraneous cervical spine motion, and since the pocket mask or another barrier device must be used anyway, would the use of the pocket mask, without face mask removal, reduce the extraneous cervical spine motion associated with airway preparation? We tested two hypotheses: 1) The pocket mask insertion technique allows quicker initiation of rescue breathing than face mask removal with either a manual screwdriver, power screwdriver, or Trainer’s Angel. 2) The pocket mask (Laerdal Medical Corp, Armonk, NY) insertion technique causes less cervical spine motion than face mask removal with either a manual screwdriver, power screwdriver, or Trainer’s Angel.
METHODS

We conducted this experiment in the Hope College Biomechanics Laboratory. Two athletic trainers (RR & RF) performed the techniques in the same manner on each subject to insure uniformity in the methods. The experiment took approximately 45 minutes for each subject. The data was archived for later analysis.

We recruited 12 young adult male volunteer subjects from our NCAA Division III football team to take part in the experiment. Only players normally fitted with a large shell Bike Air Power (Bike Athletic Co, Knoxville, TN) football helmet were recruited. Eleven subjects were linemen and one was a running back. Table 1 contains a summary of other subject information. After we explained the experimental procedure and answered all the subjects’ questions, the subjects signed an informed consent form to comply with the college’s Human Subjects Institutional Review Board.

Helmet motion was measured using an optoelectronic motion analysis system (Optotrak 3020, Northern Digital Inc, Waterloo, Ontario, Canada). This system tracks the locations of infrared-emitting diodes in three-dimensional space. When used in studies of the present type, the system can measure displacements to within 0.75 mm and rotations to within 0.1°.

An adjustable multi-segmented aluminum boom, which terminated in a “T,” was rigidly attached to the crown of the helmet (Fig 1). Four infrared-emitting diodes were attached to the “T” on the boom to define a horizontal axis and a vertical axis that pointed toward and perpendicular to the cervical spine. The distance from the infrared-emitting diodes on the horizontal axis of the “T” to the subject’s ear was measured and used in the data analysis to calculate the approximate location of the cervical spine (Fig 2). The measured location and orientation of the infrared-emitting diodes attached to the boom were then used to calculate the cervical spine motions, including spine translations and rotations. Data were collected at 50 Hz for 40 seconds. All tasks were videotaped to determine the time required to complete each task and for later qualitative analysis.

Reference data were first taken on each subject to measure the cervical spine motion due to signal noise, subject breathing, applying in-line stabilization, maintaining in-line stabilization, face mask rotation, and pocket mask application. (Note: Cervical spine motion was inferred in this study from helmet motion. Although all subjects were fitted in a manner that prevented the helmet from sliding on the head, the imperfect nature of this indirect technique is acknowledged. Future references to cervical spine motion are inferred from helmet motion.) The apparent motion due to signal noise was estimated by measuring the helmet motion with the helmet placed on the floor. Motion introduced due to the subject’s breathing was measured with the subject wearing the helmet and lying relaxed and supine on the floor. Cervical spine motion data were collected for each of the following: athletic trainer #1 (RF) applying in-line stabilization, athletic trainer #1 maintaining in-line stabilization; athletic trainer #2 (RR) rotating the face mask with athletic trainer #1 maintaining in-line stabilization; athletic trainer #2 applying the pocket mask with athletic trainer #1 maintaining in-line stabilization.

Each subject, wearing a helmet fitted to manufacturer’s specifications with a lineman style face mask (JNOP, Schutt Manufacturing, Litchfield, IL) and hard-shelled chin strap, shoulder pads, and a jersey, lay supine and relaxed on a carpeted floor. Each subject was exposed to four airway preparation techniques: 1) removal of the face mask with a
manual screwdriver, 2) removal of the face mask with a power screwdriver, 3) removal of the face mask with a Trainer’s Angel cutting device, and 4) insertion of a pocket mask without face mask removal. For the techniques involving face mask removal (manual screwdriver, power screwdriver, Trainer’s Angel), the face mask was partially detached by unfastening the side clips and then rotating it out of the way before placing the pocket mask on the player’s face. For the two screwdriver methods, the face mask clip screws on both sides of the helmet were unscrewed and removed. The Trainer’s Angel method involved using the Trainer’s Angel to cut through the face mask clips. The screws used to attach the face mask to the helmet were replaced after every fourth trial and the screws were installed and tightened to three inch-pounds of torque for each trial using a torque screwdriver (Apco Mossberg Co, Attleboro, MA).

Each airway preparation technique was defined as a task. Before initiation of each task, athletic trainer #1 (a senior student athletic trainer and licensed EMT) applied in-line stabilization. Athletic trainer #2 (an ATC with 15 years of clinical experience) began the task when a light stimulus was introduced simultaneously with the onset of data collection. The techniques were tested in two blocks of data collection, with each technique tested once in a block in a fixed, initially randomized order for each subject.

The infrared-emitting diodes data were analyzed using MATLAB (The MathWorks Inc, Natick, MA) routines developed in the laboratory and the statistical analysis was performed using SYSTAT (SYSTAT Inc, Evanston, IL). The motion of the cervical spine was quantified in terms of anterior-posterior translation, lateral translation, magnitude of displacement from initial spine location, and the angle of rotation about the cervical spine. The range of each translation and rotation and the maximum displacement and rotation are reported here. The cervical spine translations and rotation were calculated using the initial location and orientation as a reference.

The effect of technique on the time and motion parameters was determined using a one-way analysis of variance (ANOVA) with a post hoc Scheffé test. The effect of subject and athletic trainer learning from trial 1 to trial 2 for each method was determined using t-tests for each method. t-tests were also used to compare the time and motion parameters for the first six subjects with those of the second six subjects to examine the effect of athletic trainer learning over the group of subjects tested.

RESULTS

Motions associated with signal noise, subject breathing, applying in-line stabilization, maintaining in-line stabilization, face mask rotation, and pocket mask application with jaw thrust were all significantly smaller than the motions introduced by any of the four experimental techniques (Table 2; t(118) > 8.0, p < .001 for each motion). The dominant motions were those introduced by the athletic trainer applying one of the four airway preparation techniques as opposed to any of the other subtasks associated with rescue breathing under these circumstances.

We estimated subject and athletic trainer learning by comparing the time and motion parameters observed in trial 1 with those in trial 2 within each airway preparation technique. Since trial 1 took place in the first data block and trial 2 in the second, any observed differences between the two trials could be due to either a lack of repeatability in technique on the athletic trainer’s part or a change in the subject’s reaction to the technique. There were no significant differences in the time and motion parameters between trial 1 and 2 (T(11)11 = 1.4, p > .18), suggesting that the techniques were repeatable and the subjects were consistent in how they reacted to the techniques. Subsequent data analysis, therefore, will only use trial 1.

Learning by the athletic trainer could also occur over the time from when the first subject was tested to when the last subject was tested. We estimated this type of learning by comparing the time and motion parameters observed in the first six subjects tested to those in the last six tested. Improvements in athletic trainer learning were observed in three cases: Time for the manual screwdriver (p < .01), anterior-posterior displacement for the pocket mask (p < .009), and peak displacement for the pocket mask (p < .006).

Significant differences were observed in the time required to perform the airway preparation techniques and the motion

<table>
<thead>
<tr>
<th>Technique</th>
<th>Rotation (°)</th>
<th>Time (sec)</th>
<th>Anterior-Posterior Translation (mm)</th>
<th>Lateral Translation (mm)</th>
<th>Peak Displacement (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>0.0 ± 0.5</td>
<td>9.7 ± 5.2</td>
<td>10.0 ± 0.7</td>
<td>0.0 ± 0.5</td>
<td>0.8 ± 0.6</td>
</tr>
<tr>
<td>Breathing</td>
<td>0.05 ± 0.5</td>
<td>1.1 ± 0.6</td>
<td>1.1 ± 0.7</td>
<td>0.0 ± 0.5</td>
<td>0.8 ± 0.6</td>
</tr>
<tr>
<td>Applying In-Line Stabilization</td>
<td>0.24 ± 0.14</td>
<td>0.4 ± 0.24</td>
<td>0.1 ± 0.1</td>
<td>0.0 ± 0.5</td>
<td>0.8 ± 0.6</td>
</tr>
<tr>
<td>Holding In-Line Stabilization</td>
<td>0.08 ± 0.06</td>
<td>1.6 ± 0.13</td>
<td>1.3 ± 0.1</td>
<td>0.0 ± 0.5</td>
<td>0.8 ± 0.6</td>
</tr>
<tr>
<td>Rotating the Face Mask</td>
<td>0.38 ± 0.14</td>
<td>1.7 ± 0.69</td>
<td>1.5 ± 0.5</td>
<td>0.0 ± 0.5</td>
<td>0.8 ± 0.6</td>
</tr>
<tr>
<td>Applying the Pocket Mask</td>
<td>0.28 ± 0.08</td>
<td>0.54 ± 0.26</td>
<td>1.17 ± 0.33</td>
<td>0.91 ± 0.39</td>
<td></td>
</tr>
<tr>
<td>Pocket Mask</td>
<td>1.4 ± 0.9</td>
<td>19.5 ± 5.9</td>
<td>2.2 ± 1.1</td>
<td>3.1 ± 1.3</td>
<td>2.8 ± 1.4</td>
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<tr>
<td>Power Screwdriver</td>
<td>1.0 ± 0.4</td>
<td>26.8 ± 4.5</td>
<td>2.8 ± 1.1</td>
<td>3.1 ± 0.9</td>
<td>2.8 ± 0.7</td>
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<tr>
<td>Manual Screwdriver</td>
<td>1.6 ± 0.9</td>
<td>27.9 ± 3.0</td>
<td>2.9 ± 1.0</td>
<td>5.3 ± 3.2</td>
<td>4.0 ± 2.9</td>
</tr>
<tr>
<td>Trainer’s Angel</td>
<td>4.6 ± 1.7</td>
<td>25.3 ± 4.6</td>
<td>9.7 ± 5.2</td>
<td>8.2 ± 2.9</td>
<td>6.6 ± 3.2</td>
</tr>
</tbody>
</table>

Based on ANOVA: 1 Pocket mask < power screwdriver, manual screwdriver, Trainer’s Angel (F(3,44) = 7.7, p < .001) 2 Trainer’s Angel > pocket mask, power screwdriver, manual screwdriver (F(3,44) = 26.1, p < .0001) 3 Trainer’s Angel > pocket mask, power screwdriver, manual screwdriver (F(3,44) = 19.3, p < .0001) 4 Trainer’s Angel > pocket mask, power screwdriver, manual screwdriver (F(3,44) = 12.3, p < .0001) 5 Trainer’s Angel > pocket mask, power screwdriver, manual screwdriver (F(3,44) = 7.2, p < .001)
introduced at the cervical spine. The pocket mask technique required less time than the other three. The Trainer’s Angel introduced significantly more rotation, anterior-posterior translation, lateral translation, and peak displacement than the other three airway preparation techniques (Table 2).

DISCUSSION

The management of the cervical spine-injured football player is an entry-level skill expected of nearly all certified athletic trainers. Fortunately, the incidence of catastrophic cervical spine injuries in football is low. For the period 1980 to 1993, the rate of catastrophic cervical spine injuries among high school football players was less than 1/100,000, and among college players the rate was 1.33/100,000. Although the number of cervical spine injuries in football associated with respiratory or cardiac arrest is presumed to be even smaller, the proper management of these injuries is critical. Field management of cervical spine injuries is far from standardized, with some EMTs arguing that the helmet and shoulder pads should be removed on the field to provide maximum exposure of the chest and airway. The only treatment principle commonly agreed upon is that the head and cervical spine should be rigidly immobilized following injury to prevent extraneous motion and subsequent aggravation of the injury. This lack of standardization poses a serious threat to athletes who suffer from cervical spine injuries. The risk of exacerbating the symptoms associated with cervical spine damage during transportation and treatment is significant, adversely affecting 10% of patients in one study and 25% in another.

Several techniques exist for exposing the mouth and nose of the cervical spine-injured football player. One of the oldest techniques involves the use of bolt cutters to clip the face mask off the helmet. We chose not to include this technique in our study for two reasons. First, in pilot trials, the force required to cut through the wire face mask and the subsequent rebound effect rendered this technique not only impractical, but probably dangerous as well. Second, the development of the plastic face mask clip has rendered this technique obsolete. The use of bolt cutters may have been justified in the days when football face masks were screwed directly to helmets. Now that clinicians can either remove or cut through the plastic face mask clips, bolt cutters should be viewed as a technique of last resort.

Putnam suggested that the use of either a manual or electric screwdriver can, under certain circumstances, be an effective method for removing the screws that hold the side face mask clips, thus allowing the face mask to be rotated out from in front of the mouth and nose. Our data seem to confirm this method as a relatively safe, although slower, method for exposing the athlete’s airway. No clear advantage in either speed or limitation of cervical spine motion is gained from using a power screwdriver as opposed to a manual screwdriver. Clinicians should be reminded, however, that our tests were carried out in laboratory conditions. Athletic trainers attempting to remove these screws under actual field conditions may experience more extraneous cervical spine movement caused by trying to remove rusted or stripped hardware. The higher levels of efficacy associated with screw removal as opposed to cutting of face mask clips suggest that athletic trainers should focus on periodic screw maintenance as an important element of the overall helmet fitting and upkeep process.

The Trainer’s Angel is another device purported to be safe and effective in the treatment of football players with cervical spine injuries. Ortolani has used this device to remove the face mask of an injured football player in approximately 10 seconds. In our study, after months of practice and preparation and under ideal conditions, the quickest we could remove the face mask using the Trainer’s Angel and position the pocket mask for artificial respiration was 20 seconds. The average time for all 12 subjects was over 25 seconds. This represents a 6-second increase over the pocket mask insertion technique. In practical terms, the pocket mask insertion technique allows the clinician to begin artificial respiration one cycle earlier than is possible with the Trainer’s Angel or a screwdriver.

The issue of extraneous cervical spine motion introduced through use of the Trainer’s Angel deserves attention. The results of our study suggest that the faith placed in this tool may be unwarranted. In all of our measurements of cervical spine motion, the Trainer’s Angel consistently introduced a significantly greater amount of motion than the other techniques. The Trainer’s Angel does seem to cut quickly and easily through the plastic face mask clips. There is, however, a rebound effect when the face mask is pulled over the anterior remnant of the cut face mask clip that causes the cervical spine to move almost 10 mm. This represents nearly one third of the width of the vertebral foramen at its widest point. Compression of the spinal cord into two thirds of its normal space can obviously have catastrophic consequences. These large extraneous movements were recorded although the head and cervical spine were being held by a licensed EMT in in-line stabilization and the face mask was being rotated by an experienced ATC who had practiced the maneuver repeatedly. We speculate that any cutting device that leaves an anterior remnant of the cut face mask clip may result in relatively large extraneous movements of the cervical spine due to rebound when the face mask slips over the remnant.

Although the pocket mask insertion technique allowed quicker access to the airway of a cervical spine-injured football player, its use did not introduce less extraneous motion than either the manual or power screwdriver methods. It should be noted, however, that more work remains to be done with this method. The pocket mask insertion technique we used involved sliding the mask between the chin and the lowest portion of the face mask. (There were moderate to high correlations between the chin-to-face mask distance and four of the five dependent measures.) The larger the athlete’s face, the more extraneous motion is likely to occur and the longer it takes to complete the procedure. An alternative pocket mask insertion technique that involves sliding the mask through the eye hole of the face mask and into position over the mouth and nose has shown considerable promise in terms of reducing the amount of motion introduced when positioning the mask.

We do not view the pocket mask insertion technique as a “stand-alone” or exclusive management method for cervical spine-injured football players in respiratory arrest. Intubation is still the gold standard for managing patients in respiratory arrest. Although the practicality of intubation with the face
mask in place was not addressed in this paper, we assume that the face mask will have to be removed before intubation. The pocket mask insertion technique, therefore, should be viewed as a preliminary step to ventilate the athlete while the face mask is being removed, preferably by screw removal.

CONCLUSIONS AND RECOMMENDATIONS

Under ideal conditions, the pocket mask insertion technique (using a Laerdal pocket mask) allows quicker initiation of rescue breathing for cervical spine-injured football players wearing large shell Bike Air Power helmets than the use of a manual or power screwdriver or the Trainer’s Angel. The pocket mask insertion technique does not reduce the amount of extraneous cervical spine motion when compared to face mask repositioning using either a manual or power screwdriver. All of these techniques, however, introduced significantly less motion than the Trainer’s Angel.

More research should be conducted on this topic in an attempt to validate our results and expand the body of knowledge on cervical spine management in athletics. In addition to the aforementioned suggestion to maintain the face mask clip screws in the most systematic way possible, we also offer the following recommendations:

1. Our study considered only two-dimensional motion. Future studies should attempt to measure motion in three dimensions.
2. Moments and forces acting on the cervical spine should also be studied.
3. Future studies should examine the alternative pocket mask insertion technique that uses the eye hole in the face mask as a point of entry.
4. Future studies should examine the cervical spine motion associated with logrolling and various helmet and shoulder pad removal techniques.
5. Although our study convinced us of the efficacy of the pocket mask insertion technique, researchers may wish to study the technique in terms of the clinician’s ability to maintain an adequate seal until intubation can be accomplished.
6. The efficacy of the pocket mask insertion technique in other sports that use face protection, like ice hockey and lacrosse, should be investigated.
7. If future studies validate our results, we would suggest the following protocol for football players suffering from suspected cervical-spine trauma:
   A. Maintain in-line stabilization at all times.
   B. Leave the helmet on with the chin strap fastened until radiographs confirm the presence or absence of cervical-spine fracture or dislocation.
   C. If the athlete is breathing, do not attempt to remove or reposition the face mask.
   D. If the athlete is not breathing, logroll into position and open the airway using the modified jaw thrust.
   E. If the athlete does not begin breathing after the airway has been opened, perform the pocket mask insertion technique and begin rescue breathing or CPR, whichever is appropriate.
   F. Have a third rescuer attempt to remove the screws holding the face mask clips to the helmet. If the screws are rusted or stripped and cannot be removed, use a Trainer’s Angel to cut through the clips.
   G. Stop rescue breathing long enough to CAREFULLY rotate the face mask out of position. If the face mask clips have been cut with a Trainer’s Angel, exercise extra caution to hold the head and neck still. Attempt to spread the face mask to reduce the contact with the remnant of the face mask clips.
   H. Resume rescue breathing or CPR.
   I. Transport to emergency room.

ACKNOWLEDGMENTS

We would like to thank Brad Mulder for his assistance in building the boom used in this study. The assistance of Kevin Poppink and Dr. Anne Irwin in the research design and data collection, along with the financial support of Hope College’s Carl Frost Center for Social Science Research, is gratefully acknowledged.

REFERENCES

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Ankle Ranges of Motion During Extended Activity Periods While Taped and Braced

David L. Paris, PhD, ATC, CAT(C); Vassilios Vardaxis, MSc;
Jimmy Kokkaliaris, BSc, CAT(C)

ABSTRACT: Tape has traditionally been used to support the ankle during activity. More recently, commercial ankle braces have been worn as an alternative. The cumulative information on the effects of taped versus braced ankle support or interbrace comparisons is inconclusive. With few exceptions, ankle brace studies have collected data soon after support conditions were administered. Plantar-dorsiflexion and inversion-eversion ranges of motion (ROM) of 30 subjects were compared under conditions of unsupported, nonelastic adhesive-taped, and Swede-O and SubTalar Support-braced ankles. We recorded measurements before activity and after periods of 15, 30, 45, and 60 minutes of selected activity on a motorized treadmill. All support conditions significantly reduced preactivity ankle ROM in all directions compared to unsupported ankles. Results showed that the ankle significantly increased in plantarflexion ROM 15 minutes after the initiation of activity with tape or the SubTalar Support-brace, and after 30 minutes with the Swede-O brace. Tape showed further significant increases in plantarflexion ROM after 15-minute intervals of 30, 45, and 60 minutes of activity. All three support conditions had increased significantly in inversion ROM by 15 minutes of activity. The SubTalar Support brace showed a further significant inversion ROM increase between 15 and 30 minutes postactivity. We conclude that the Swede-O and SubTalar Support braces and tape offer significant preactivity ankle support in all four directions of movement. We also conclude that both braces offer longer postactivity support than tape. In inversion ROM and plantarflexion ROM, actions prevalent in ankle sprains, the Swede-O brace retained support longer than the SubTalar Support brace.

METHODOLOGY

We randomly selected 30 volunteer male undergraduate students from the Department of Exercise Science at Concordia University, Montreal, for this ROM study. Their ages ranged from 19 to 35 years with a mean age of 22 ± 3.3 years. Only subjects who had not experienced ankle pathology within 6 months before testing were included. Footwear was standardized to eliminate extraneous support variables. All subjects wore the AVIA 2060 MZ running shoe (AVIA (Canada) Athletic Footwear Co, Burlington, Ontario, Canada). Shoe sizes, from which brace sizes were extrapolated, ranged from 7 to 12.

We recorded ROM measurements on a modified Inman Ankle machine as shown in Figure 1.14 The design of our machine replicated that of the original with the exception of aluminum being substituted for wood structures from the first model. With the subject lying supine, the thigh and leg were stabilized with the knee and hip joints each at 90°. The subject’s foot was placed into the Inman footplate and stabilized in a position of dorsi-plantarflexion and inversion-eversion (assumed) neutrals. These positions were calibrated at 0°. With neutral retained on one axis (ie, neutral dorsi-plantarflexion on the coronal axis), passive ROM was recorded on the sagittal axis in both inversion and eversion. We instructed each subject to relax his lower limb, after which a weight with a mass of 9 kg passively rotated the foot by a pulley system to the end range in each direction. We followed a similar protocol for plantarflexion and dorsiflexion measurements with the sagittal axis locked in neutral.

Rotation was converted to a degree rating from precision potentiometers positioned at the axes of the Inman machine. End ROMs were read from an LCD (liquid crystal display) once movement had been stabilized.
Introduction of activity sessions to simulate sports activity that would stress the various ankle support conditions. In each session, the subject speed-walked on a treadmill inclined at 9° at a speed of 3 mph for 10 minutes. Treadmill walk time and actions were broken down as follows: forward, 2 minutes; left facing crossover (caricoca) strides, 3 minutes; right facing crossover strides, 3 minutes; and, forward, 2 minutes. We repeatedly instructed subjects to take maximum forward or side strides, and to maintain foot contact with the treadmill for as long as possible. We added 5 minutes of activity time after completion of treadmill activity to reseat the subject comfortably on the Inman ankle machine, and for ankle adjustment setup for retesting. Therefore, a total of 15 minutes was allotted to each activity session. Each subject performed the activity session four times under each support condition.

Control ROM measurements were recorded before any ankle treatment condition was applied. The order of support condition for the Swede-O, SubTalar Support, and taped trials was randomly selected. The braces were put on according to the manufacturers' specifications over an athletic sock. For the taped condition, the subjects' ankles were shaved to 6 inches above the malleoli and a coating of tape adherent was then sprayed on the skin to minimize slippage. Antifriction heel and lace pads with skin lubricant and underwrap were then applied before first quality 1-1/2-inch nonelastic adhesive athletic tape. We used the Gibney Closed Basketweave ankle taping method as described in Arnheim.2 Proximal and distal anchor strips were attached to the underwrap but allowed to overlap directly onto the shaved skin to prevent slippage. Modifications included two extra half stirrups to afford the rearfoot more support in valgus (calcaneal eversion). The same athletic trainer administered the taping technique bilaterally to control for individual variations.

Although support conditions were put on bilaterally for symmetry during activity sessions, we tested only the dominant foot. We recorded a second series of ROM measurements at this time (0 minutes). Subsequent data were taken for each subject after each treadmill activity session at 15, 30, 45, and 60 minutes. We tested all subjects under each of the following conditions: unsupported, nonelastic adhesive taped, Swede-O braced (Fig 2; Swede-O-Universal, North Branch, MN) and SubTalar Support-braced ankles (Fig 3; Sport-Mate Services Ltd, Mississauga, Ontario, Canada).

Four two-way 4 x 2 (brace type vs condition of brace on or off) analyses were used to identify the effect of the braces on the ROM before exercise on each of the above variables. The General Linear Model30 of the SAS Institute Inc statistical procedure was used on a two-way design (brace type vs duration of exercise) with repeated measures on the second factor. We conducted four separate two-way analyses, one for each dependent variable: ankle inversion and eversion on the frontal plane, and ankle plantarflexion and dorsiflexion on the sagittal plane. Percentage values of the maximum unsupported ranges of motion were used to normalize the data for individual differences. Significant main effects and interactions were further analyzed by the Tukey Honestly Significant Difference Test.

RESULTS

Table 1 shows mean ankle ROM and standard deviations for inversion and eversion under the three support conditions (Swede-O, SubTalar Support, and tape) over various durations of activity. Unsupported and preactivity supported ankle ROMs and standard deviations are also shown.

There were significant differences in inversion and eversion support over activity times (Table 2). Significant reductions in ankle inversion ROM were found between unsupported ankles and preactivity (0 minutes) support conditions of Swede-O and SubTalar Support braces and tape (F(1,29) = 182, p < .001). Conversely, postactivity inversion ROM increased significantly under all three support conditions between 0 minutes and 15 minutes. Inversion ROM showed a further significant postactivity increase with the SubTalar Support brace between the 15 and 30 minute intervals (F(1,29) = 13.4, p = .001). Swede-O and SubTalar Support braces and tape significantly restricted preactivity (0 minutes) eversion ROM compared to unsupported ankles (F(1,29) = 228, p < .001). Eversion ROM of taped ankles was shown to significantly increase after 15 minutes of activity (F(1,29) = 22.8, p < .001), whereas those Swede-O braced did not show a significant eversion ROM increase until after 60 minutes (F(1,29) = 18.3, p < .001).
Table 1. Mean and Standard Deviation Values for the Different Ankle Braces at Each Level of Exercise in All Directions of Movement

<table>
<thead>
<tr>
<th>Brace</th>
<th>Direction</th>
<th>Unsupported</th>
<th>min 0</th>
<th>min 15</th>
<th>min 30</th>
<th>min 45</th>
<th>min 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swede-O</td>
<td>Inversion</td>
<td>44.3 ± 5.8</td>
<td>32.0 ± 5.2</td>
<td>34.3 ± 4.9</td>
<td>34.6 ± 4.6</td>
<td>35.1 ± 4.3</td>
<td>35.7 ± 4.1</td>
</tr>
<tr>
<td></td>
<td>Eversion</td>
<td>35.5 ± 7.3</td>
<td>23.6 ± 7.6</td>
<td>24.3 ± 7.2</td>
<td>24.7 ± 7.1</td>
<td>25.3 ± 6.8</td>
<td>26.1 ± 6.8</td>
</tr>
<tr>
<td></td>
<td>Plantar Flexion</td>
<td>44.8 ± 6.1</td>
<td>27.5 ± 6.1</td>
<td>29.0 ± 5.9</td>
<td>29.7 ± 5.7</td>
<td>30.5 ± 5.9</td>
<td>30.8 ± 5.9</td>
</tr>
<tr>
<td></td>
<td>Dorsiflexion</td>
<td>25.9 ± 10</td>
<td>20.3 ± 9.1</td>
<td>21.6 ± 8.6</td>
<td>20.2 ± 8.1</td>
<td>21.2 ± 8.4</td>
<td>21.2 ± 8.6</td>
</tr>
<tr>
<td>SubTalar Support</td>
<td>Inversion</td>
<td>44.4 ± 7.1</td>
<td>32.1 ± 6.3</td>
<td>36.3 ± 6.8</td>
<td>37.9 ± 5.7</td>
<td>37.6 ± 6.5</td>
<td>38.7 ± 5.9</td>
</tr>
<tr>
<td></td>
<td>Eversion</td>
<td>36.2 ± 6.5</td>
<td>31.9 ± 7.1</td>
<td>31.6 ± 6.9</td>
<td>31.8 ± 6.7</td>
<td>32.6 ± 6.6</td>
<td>32.4 ± 6.6</td>
</tr>
<tr>
<td></td>
<td>Plantar Flexion</td>
<td>44.2 ± 7.2</td>
<td>32.0 ± 8.8</td>
<td>34.2 ± 7.7</td>
<td>35.0 ± 8.2</td>
<td>35.5 ± 7.8</td>
<td>35.7 ± 7.6</td>
</tr>
<tr>
<td></td>
<td>Dorsiflexion</td>
<td>25.7 ± 10</td>
<td>25.0 ± 9.2</td>
<td>23.7 ± 9.2</td>
<td>23.6 ± 8.9</td>
<td>24.7 ± 9.9</td>
<td>23.9 ± 9.4</td>
</tr>
<tr>
<td>Tape</td>
<td>Inversion</td>
<td>41.5 ± 8.2</td>
<td>28.7 ± 6.9</td>
<td>32.5 ± 6.6</td>
<td>33.5 ± 6.5</td>
<td>34.2 ± 7.2</td>
<td>35.2 ± 8.0</td>
</tr>
<tr>
<td></td>
<td>Eversion</td>
<td>36.1 ± 7.3</td>
<td>24.8 ± 6.3</td>
<td>27.0 ± 6.3</td>
<td>27.9 ± 6.7</td>
<td>29.1 ± 6.2</td>
<td>29.3 ± 6.4</td>
</tr>
<tr>
<td></td>
<td>Plantar Flexion</td>
<td>45.0 ± 7.0</td>
<td>25.6 ± 5.9</td>
<td>28.0 ± 5.8</td>
<td>29.9 ± 5.9</td>
<td>31.7 ± 5.2</td>
<td>32.5 ± 5.6</td>
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<tr>
<td></td>
<td>Dorsiflexion</td>
<td>24.9 ± 10</td>
<td>18.6 ± 8.3</td>
<td>19.2 ± 8.0</td>
<td>19.1 ± 7.8</td>
<td>20.5 ± 7.7</td>
<td>20.2 ± 7.7</td>
</tr>
</tbody>
</table>

DISCUSSION

Several studies comparing the pre- and post-exercise supportive effect of braces to taped or unsupported ankles have had pretesting activity limited to between 4 and 20 minutes.1,3,6,7,9,11-13,18,24 Lyle18 reported that both tape and the Swede-O brace lost support after 13 minutes of exercise. Myburgh et al.24 showed that tape offered significantly more support than the Ace and Futuro elastic ankle braces after 10 minutes of squash. However, after 60 minutes, neither tape nor the braces offered any significant support.

In a study using an anatomically correct polyurethane foot form, tape was shown to restrict pre-exercise ankle motion significantly more than the Swede-O and Mikros braces. After 20 minutes of movement, no significant difference in residual support was seen between the two braces and tape.3 We concurred that tape and braces offer preactivity support in all directions of ankle movement compared to untaped ankles, and increased ankle ROMs were reported after varying durations of activity.

Similarly, after 20 minutes of exercise, Gross et al.10 reported that, although taped ankles provided greater inversion support pre-exercise compared to the Ankle Ligament Protector brace, the two support systems provided equivalent eversion and inversion restriction following exercise. Others7 found that the Ankle Ligament Protector brace retained significantly more inversion/eversion support compared to untaped ankles after 20 minutes of exercise. We found that tape and the Swede-O and SubTalar Support braces significantly decreased inversion ROM support after 15 minutes, with the SubTalar Support brace losing significantly more after 30 minutes. We also found tape to lose significant eversion support after 15 minutes and the Swede-O to lose after only 60 minutes. However, the SubTalar Support brace did not appear to lose any eversion support. Recent studies report similar comparisons to tape with the Ankle Ligament Protector and Air-Support braces9 and the Air-Support, Ankle Ligament Protector, Swede-O, and Kallassy braces.1 The latter study also determined that the Air-Support and Ankle Ligament Protector offered significantly more support than the Swede-O and Kallassy braces after 10 minutes of exercise.

SubTalar Support-braced ankles did not gain significantly in postactivity eversion ROM.

Table 1 shows mean ankle ROMs and standard deviations for plantar and dorsiflexion under the three support conditions (Swede-O, SubTalar Support, and tape) over various durations of activity. Also shown are unsupported and preactivity (0 minutes) supported ankle ROMs and standard deviations on the sagittal plane. Significant differences were found in plantar and dorsiflexion support over activity times (Table 2). Our results indicated significant restriction of plantarflexion ROM between unsupported ankles and preactivity (0 minutes) Swede-O and SubTalar Support brace and tape supported ankles (F(l,29) = 32.7, p < .001). However, we observed that the SubTalar Support braced and taped ankles significantly increased in plantarflexion ROM after 15 minutes postactivity. Taped ankles showed further significant increases in plantarflexion ROM after respective 15-minute intervals at 30, 45, and 60 minutes postactivity. An initial significant increase in plantarflexion ROM of Swede-O braced ankles was recorded at 30 minutes postactivity (F(l,29) = 10.0, p = .004).

We reported significant reductions in ankle dorsiflexion ranges of motion between unsupported and supported ankles with the Swede-O and SubTalar Support braces and tape preactivity (0 minutes) (F(l,29) = 32.7, p < .001). Taped ankles significantly increased in dorsiflexion ranges of motion after 45 minutes postactivity (F(l,29) = 8.4, p = .007), whereas both the Swede-O and SubTalar Support-braced ankles did not appear to significantly increase in postactivity dorsiflexion ranges of motion.
Table 2. ANOVA Repeated Measures Table for Brace by Time of Exercise. A Summary of the Significant F Values Are Reported for All Directions of Movement

<table>
<thead>
<tr>
<th>Source</th>
<th>Inversion</th>
<th>Eversion</th>
<th>Plantar Flexion</th>
<th>Dorsiflexion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>brace</td>
<td>11.71†</td>
<td>46.51†</td>
<td>11.61†</td>
<td>21.60†</td>
</tr>
<tr>
<td>time</td>
<td>101.2†</td>
<td>123.1†</td>
<td>368.4†</td>
<td>23.22†</td>
</tr>
<tr>
<td>brace x time</td>
<td>2.947§</td>
<td>16.77§</td>
<td>14.35§</td>
<td>6.094§</td>
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<tr>
<td><strong>Interaction Contrasts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Un vs Time 0 min</td>
<td>83.48†</td>
<td>228.5†</td>
<td>566.7†</td>
<td>32.68†</td>
</tr>
<tr>
<td>Time 0 vs 15 min</td>
<td>182.2†</td>
<td>6.685†</td>
<td>35.06†</td>
<td>—</td>
</tr>
<tr>
<td>Time 15 vs 30 min</td>
<td>12.14§</td>
<td>—</td>
<td>20.79†</td>
<td>—</td>
</tr>
<tr>
<td>Time 30 vs 45 min</td>
<td>—</td>
<td>7.206†</td>
<td>24.83†</td>
<td>8.395‡</td>
</tr>
<tr>
<td>Time 45 vs 60 min</td>
<td>6.457*</td>
<td>—</td>
<td>7.378‡</td>
<td>—</td>
</tr>
<tr>
<td><strong>Swede-O Contrasts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Un vs Time 0 min</td>
<td>149.5†</td>
<td>179.4†</td>
<td>307.2†</td>
<td>29.49†</td>
</tr>
<tr>
<td>Time 0 vs 15 min</td>
<td>16.20†</td>
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<td>—</td>
<td>10.01‡</td>
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<tr>
<td>Time 0 vs 30 min</td>
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<td>—</td>
<td>1.151 ns</td>
<td>—</td>
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<tr>
<td>Time 0 vs 60 min</td>
<td>18.31†</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>SubTalar Support Contrasts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Un vs Time 0 min</td>
<td>96.20†</td>
<td>30.11†</td>
<td>138.2†</td>
<td>1.151 ns</td>
</tr>
<tr>
<td>Time 0 vs 15 min</td>
<td>42.05†</td>
<td>—</td>
<td>21.58†</td>
<td>—</td>
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<tr>
<td>Time 15 vs 30 min</td>
<td>13.38§</td>
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<td>—</td>
<td>—</td>
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<td><strong>Tape Contrasts</strong></td>
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<tr>
<td>Un vs Time 0 min</td>
<td>125.7†</td>
<td>313.3†</td>
<td>479.4†</td>
<td>33.62†</td>
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<tr>
<td>Time 0 vs 15 min</td>
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<td>22.79†</td>
<td>15.69†</td>
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<td>Time 0 vs 45 min</td>
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<td>24.41†</td>
<td>8.384‡</td>
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<td>Time 15 vs 30 min</td>
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<td>—</td>
<td>9.803#</td>
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<td>Time 30 vs 45 min</td>
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<td>Time 45 vs 60 min</td>
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</table>

† level of significance at $p < .000$
§ level of significance at $p < .001$
# level of significance at $p < .005$
‡ level of significance at $p < .01$
* level of significance at $p < .05$
nonsignificant

Gehlsen reported significant increases in postactivity plantarflexion restraint with the Active Ankle, Aircast, and Swede-O braces and dorsiflexion support with the Aircast and Swede-O braces when compared to taped ankles. Others have shown that the Aircast brace and both the Aircast and Swede-O braces retained more postexercise ankle inversion support than tape. We had similar findings in that tape lost significant plantarflexion support after 15 minutes of activity and further losses at intervals of 30, 45, and 60 minutes. We also found that the SubTalar Support brace lost significant plantarflexion support at 15 minutes, whereas the Swede-O brace did not reduce in support until 30 minutes postactivity. In a comparison of braces over a prolonged period of activity, Greene & Wight found that, although the Air-Support lost some support and the Swede-O brace’s support reduced significantly during a 90-minute softball practice, the Ankle Ligament Protector had no significant loss.

Figure 4 shows percentage changes in inversion, eversion, plantarflexion, and dorsiflexion ROMs with Swede-O and SubTalar Support braces and nonelastic adhesive tape during extended activity periods. We found reduced movements under preactivity (0 minutes) support conditions ranged from 88.1% (SubTalar Support eversion ROM) to 56.9% (Tape plantarflexion ROM) of the unsupported ankle ROM, which represented the control movement of 100%. Our data are supported in the literature. The reductions were significant between unsupported ankles and all preactivity support conditions for all actions with the exception of SubTalar Support braced dorsiflexion. Similar preactivity reductions have been recorded for tape and braces.

In our study, postactivity ROM increased at certain times during activity, and under varying support conditions. An increase in ankle ROM was analogous to a decrease in the support offered by the braces and tape. Significant eversion...
ROM increases (8.8%) were limited to taped ankles within 15 minutes, and Swede-O braced ankles (10.5%) after 60 minutes postactivity. We found no significant postactivity increase in eversion ROM for the SubTalar Support-braced ankles throughout the study. This is contrary to two studies that showed significant increases in eversion ROM for taped and various braced ankles.9 12 Taped ankle dorsiflexion ROMs significantly increased (10.2%) at 45 minutes in our study. We suggest that activity sessions did not produce stress sufficient enough to further reduce the residual support effects in eversion and dorsiflexion. This may be due to anatomical considerations in that the talocrural joint is at its most stable (close-packed) position in dorsiflexion.19 Similarly, eversion may not have been overly manifested in the present study, as excessive movement is usually associated with medial ligament disruption.28 We remind the reader that all subjects had nonpathological ankles.

We found increased ROM during inversion and plantarflexion postactivity compared with preactivity support conditions. This was expected, as the literature has stated that ankles are in a vulnerable position when inverted, with 85% of ankle injuries being of the inversion type.17 The ankle is at an even greater risk to inversion trauma when positioned in plantarflexion.4 17 28

Initial postactivity increases in plantarflexion ROM were significant while wearing the SubTalar Support (6.8%) and Swede-O (8.0%) braces at 15 and 30 minutes, respectively. Taped ankles increased in plantarflexion ROM (9.3%) at 15 minutes, but also recorded significant increases between each of the subsequent 15-minute intervals of 30, 45, and 60 minutes (Table 2). Similar initial percentage increases were reported for all ankles under the three supportive devices. The Swede-O brace did not lose support in plantarflexion ROM until 30 minutes postactivity, whereas the SubTalar Support brace reduced less, but significantly so, by 15 minutes postactivity. On the other hand, we found tape lost the greatest amount of plantarflexion ROM support after the initial 15 minutes, and it appeared to lose support consistently throughout the remaining activity sessions. Previous studies have also reported reduced postactivity support with tape.3 31

Of the following significant reductions, tape reduced preactivity ankle plantarflexion ROM to 56.9% of unsupported measurement compared to that Swede-O (38.6%) and SubTalar Support (27.6%) braces. However, by 60 minutes postactivity, taped ankles recorded a greater plantarflexion ROM increase (26.9%) than those with the Swede-O (12.0%) and SubTalar Support (11.5%) braces compared to preactivity support. These data reflect the early reduction in taped ankle support reported by Bunch.3

Even though the data reported the increased plantarflexion ROMs at 60 minutes postactivity as significant, the question we pose is whether or not approximately 73% (tape) to 88% (Swede-O and SubTalar Support) residual postactivity plantarflexion support is still beneficial when compared to preactivity support. The answer may be found in the fact that the initial unsupported preactivity plantarflexion ROM was still significantly reduced by the Swede-O brace (31.3%), tape (27.8%), and the SubTalar Support brace (19.3%) at 60 minutes postac-

CONCLUSIONS AND RECOMMENDATIONS

We conclude that the Swede-O and SubTalar Support braces and tape offer significant preactivity ankle support in all four directions of movement. Given that the three support conditions offered varying amounts of postactivity residual support, we conclude that both braces offer longer postactivity support than tape. In inversion ROM and plantarflexion ROM, prevalent mechanisms for ankle sprains, the Swede-O retained support longer than did the SubTalar Support brace.
We recommend that both braces be tightened within 5 to 10 minutes of the start of activity. This may further enhance the performance of the Swede-O brace in all ROMs, and the SubTalar Support brace in inversion and, possibly, plantarflexion (Fig 4). In a sport setting, an athlete could easily retighten each brace during halftime, between periods, or between shifts. A similar readjustment would not be possible for taped ankles, as shoes and socks would have to be removed, and a trainer and table or bench would have to be readily available. We recommend further study to compare support of braces that have been retightened shortly after the onset of activity to that of tape that has not been adjusted after it was initially administered.

We felt that the 9-kg weight applied to passively move the ankle into respective end ROMs may not have been close enough to normal pressures imparted during activity. We suggest that future research investigating ankle support over prolonged periods of activity have increased forces applied to the brace, and that each subject actively move the ankle to the end ROMs.

The administration of both tape and selected commercial braces offer varying amounts of postactivity ankle support without compromising lower leg strength. However, athletic trainers may consider purchasing specific braces for their athletes, as they appear to offer as much, or more, postactivity residual support to the athlete’s ankle, the use of braces could offer reduced budgetary costs to the team or institution.

ACKNOWLEDGMENTS

This research was supported by grants from the Eastern Athletic Trainers’ Association and the Faculty of Arts and Science General Research Fund, Concordia University, Montreal, Quebec, Canada. The authors thank Swede-O-International, North Branch, MN, and Sport-Mate Services Ltd, Toronto, Ont, for providing the ankle braces, and AVIA (Canada) Athletic Footwear Company, Burlington, Ontario, for the shoes used in the study.

REFERENCES


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It's a game of inches.
Agility Following the Application of Cold Therapy

Todd A. Evans, MA, ATC; Christopher Ingersoll, PhD, ATC; Kenneth L. Knight, PhD, ATC; Teddy Worrell, EdD, PT, ATC

ABSTRACT: Cold application is commonly used before strenuous exercise due to its hypalgesic effects. Some have questioned this procedure because of reports that cold may reduce isokinetic torque. However, there have been no investigations of actual physical performance following cold application. The purpose of this study was to determine if a 20-minute ice immersion treatment to the foot and ankle affected the performance of three agility tests: the carioca maneuver, the cocontraction test, and the shuttle run. Twenty-four male athletic subjects were tested during two different treatment sessions following an orientation session. Subjects were tested following a 20-minute 1°C ice immersion treatment to the dominant foot and ankle and 20 minutes of rest. Following each treatment, subjects performed three trials of each agility test, with 30 seconds rest between each trial, and 1 minute between each different agility test. The order in which each subject performed the agility tests was determined by a balanced Latin square. A MANOVA with repeated measures was used to determine if there was an overall significant difference in the agility times recorded between the cold and control treatments and if the order of the treatment sessions affected the scores. Although the mean agility time scores were slightly slower following the cold treatment, cooling the foot and ankle caused no difference in agility times. Also, there was no difference resulting from the treatment orders. We felt that the slightly slower scores may have been a result of tissue stiffness and/or subject’s apprehension immediately following the cold treatment. Cold application to the foot and ankle can be used before strenuous exercise without altering agility.

Cold application is commonly used in the initial treatment of acute and chronic injuries. It is also used to facilitate rehabilitation. The beneficial effects of cryotherapy include pain relief, muscle spasm reduction, a decrease in cell metabolism,9,14,17,24 and a modification of the inflammatory response.14,24 However, therapeutic cooling decreases nerve conduction velocity,7,8 produces tissue and joint stiffness,11 and prolongs a muscle’s action potential.14 Researchers have attempted to determine if these physiologic responses adversely affect sensory perception,12 proprioception,18,27 dexterity,15 strength,21,25 power,2 and speed.11 It appears that cold does not affect joint position sense or sensory perception,12,18,27 but does decrease isokinetic strength21 and power5 immediately following application. Nerve conduction velocity,7,8 joint stiffness,11 and dexterity15 may also be altered with decreasing tissue temperatures. The results of this research are varied, and, therefore, it is still uncertain if functional performance is altered immediately following cold therapy.

Although therapeutic cooling does affect physiological activity, it is uncertain whether cooling influences functional performance. Agility, the ability to perform skilled and coordinated movements over a specific time, is a measurable indicator of functional performance and is essential for optimal athletic performance.15,20 The purpose of this study was to examine the effects of cryotherapy, in the form of a 20-minute ice immersion to the foot and ankle, on the performance of three agility tests.

METHODS

Twenty-four male Indiana State University students (22.4 ± 2.1 yr) served as subjects. We determined the number of subjects selected a priori from pilot data (δ = 2.8, p = .05). We recruited 32 male students participating in varsity, intramural, or recreational athletics at least twice weekly, as determined by a questionnaire. Athletes with chronic or acute musculoskeletal injuries, cardiovascular illnesses, or a hypersensitivity to cold, were excluded from this study. Eight subjects withdrew from the study. Subjects wore shorts and court shoes. During the cold application and during the control treatment, subjects remained seated on a stool or a chair. Subjects gave informed consent to participate in this study and we obtained approval from the Indiana State University Institutional Review Board.

Instruments

Agility testing is measuring the speed at which coordinated movements can be completed. This can help to determine whether an athlete is functionally capable of returning to athletic competition.20 The agility tests used in this study included: 1) the cocontraction test, 2) the carioca test, and 3) the shuttle run.

The cocontraction test20 was performed by attaching one end of a heavy rubber tube (2.5 cm diameter, 1.23 m long; The Pro Unit, Pro Orthopedic Devices, Inc, Tucson, AZ) to a nylon belt.

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Chris Ingersoll is an associate professor in the Athletic Training Department at Indiana State University.

Ken Knight is a professor and Chair of the Athletic Training Department at Indiana State University.

Teddy Worrell is an assistant professor of Physical Therapy and Director of Research at the Krannert School of Physical Therapy at the University of Indianapolis in Indianapolis, IN.
The co-contraction test.

around the subject's waist and the other end to a hook mounted
on a wall, 1.52 m up from the floor (see Figure). A perpen-
dicular line was drawn from the hook on the wall to the floor.
The point where this line intersected with the floor served as
the origin of a semicircle (2.44 m radius) drawn on the gym
floor. Subjects stood facing the hook with their feet along
the outside of the semicircle, stretching the tube to twice its recoil
length (2.44 m). We instructed subjects to begin on the left side
of the semicircle and complete five wall-to-wall lengths (three
to the right, two to the left) using a shuffle step. This test
reproduced rotational forces, requiring stabilization of the
musculature crossing the ankle joint. Specific instructions to
the subjects for this test included: 1) use a shuffle step only, 2)
do not push off the walls with your hands, 3) stay behind the
arc, 4) grasp the cord with both hands, 5) face the hook at all
times, and 6) keep tension on the cord with your lower back by
bending at the knees; do not pull with your arms.

The carioca test required subjects to move laterally in a
straight line using a crossover step. The test was performed
over 24.4 m, 12.2 m in each direction. Subjects moved from
left to right then reversed direction at the 12.2 m mark. The
carioca step demanded maximal ankle eversion with moderate
inversion. The carioca is initiated with a shuffle-type maneuver
with the leading leg, followed by the trailing leg crossing in
front of the leading leg on the first step, then behind the leading
leg on the second step.

The shuttle run consisted of four 6.1-m sprints (24.4 m
total). Subjects sprinted 6.1 m, stopped, turned around, imme-
diately sprinted back to the starting line, then repeated the
process. They changed direction three times. The shuttle run
reproduced the acceleration and deceleration forces experi-
enced during high-intensity athletics.

For all tests, time was started when we said "go" and
stopped when the subject's foot touched the end line. We
measured elapsed time by hand, using a stopwatch accurate to
0.1 second. We instructed subjects to perform each test as fast
as possible. During each testing session, they performed three
crosses of each test. To minimize fatigue, we allowed 30 seconds
rest between each trial, and a 1-minute rest between each
different agility test. All scores were entered into the data table
and used for analysis. The pilot study demonstrated moderate
intrasession reliability (ICC = .6 to .84) and excellent inter-
session reliability (ICC = 1.0, n = 4) for these tests.

Procedures

Each subject reported to the Sports Injury Research Labora-
.tory on three separate occasions. During the orientation
session, subjects were introduced to the three agility tests and
given an opportunity to practice each one. Subjects performed
four to six cocontraction and carioca trials, and three shuttle
run trials to minimize improvements attributed to learning. The
number of trial runs during the orientation session was based
on learning observed during a pilot study. Following a
5-minute rest, the subjects performed each agility test three
times. These times were used to determine the orientation
scores. The subjects were then instructed to return for the two
treatment sessions. The dominant leg was determined by
having each subject jump off of one leg, as if shooting a lay-up.
The foot which the subject used to jump was treated.

After subjects completed the orientation, they were in-
structed to return on 2 separate days for the two testing
sessions. At least 1 day separated the treatment sessions. The
order in which each treatment session was applied was ran-
domly assigned. Thirteen subjects underwent the control treat-
ment first and 11 subjects underwent the cold treatment first.
Due to subject mortality, the groups were uneven. The order in
which they performed the three agility tests following the
treatment was assigned according to a balanced Latin square.

For the ice immersion treatment, subjects sat in a chair with
their entire foot and ankle immersed in cold water (1°C) for 20
minutes. The water level was approximately 8 cm above the
lateral malleolus. This allowed the ankle to be cooled without
directly cooling the large muscle groups of the lower leg. We
provided toe caps to reduce discomfort. We did not permit
the subjects to talk about the cold sensations during the
treatment, but we did allow them to read or converse on other
topics.

During the control treatment, we instructed subjects to sit
comfortably for 20 minutes. The functional tests were per-
formed immediately following the treatment sessions and were
completed within 9 minutes after the treatment ended. Each
subject had 30 seconds to warm up before the testing. Type of
warm-up was based on each subject's personal preference.
Before and during each agility test, we provided verbal
encouragements to motivate the subjects to complete the test as
fast as possible. Verbal cues included: "don't slow down," "keep
pushing," and "move as fast as you can." Subjects
completed three trials for each agility test, with the average of
the three scores used for analysis. To minimize fatigue, there
was a 30-second rest between each of the three trials and a
1-minute rest between each agility test. Subjects were not
informed of their scores until both testing sessions were
completed.

Statistical Analysis

We used a multivariate analysis of variance (MANOVA)
with repeated measures to determine if an overall significant
difference existed between cold immersion and rest for a linear combination of the agility scores. The MANOVA was also used to determine if the order of the treatment sessions affected the scores. The level of significance was set at .05 for all tests.

RESULTS

Average agility scores for each treatment condition are found in the Table. There was no difference in agility time scores between the ice immersion and the control sessions (overall treatment effects, \( F^{3,21} = .78, p = .59 \); carioca test, \( F^{1,23} = 3.92, p = .06 \); cocontraction test, \( F^{1,23} = 3.60, p = .07 \); and shuttle run test, \( F^{1,23} = 1.24, p = .28 \), or for order (\( F^{1,40} = .99, p = .59 \)). Therefore, a 40% to 50% possibility of a Type II error exists. Consequently, differences may exist, but we did not detect them due to low power. Times recorded following the cold application were consistently slower, but not statistically different from the control treatment times for all three agility tests.

Immediately following the cold treatment, 19 subjects verbally reported some type of altered sensation such as numbness, tingling, stiffness, or feeling awkward. Others mentioned that the ankle felt taped, unstable, unresponsive when pushing off, and heavy. Five subjects stated that their heel felt oversensitive.

DISCUSSION

Cold’s effectiveness in controlling the inflammatory process and its hypalgesic effects make it one of the most commonly used modalities in sports medicine. However, the safety of using cold before vigorous functional exercise has not been determined. The results of this study indicated that a 20-minute cold treatment applied to the foot and ankle does not adversely affect functional agility. However, due to subject mortality and difficulty in recruiting more athletic subjects willing to participate, the power for each of the three agility tests was less than optimal (carioca: \( 1 - \beta = .6 \); cocontraction: \( 1 - \beta = .6 \); shuttle run: \( 1 - \beta = .5 \)). Therefore, a 40% to 50% possibility of a Type II error exists. Consequently, differences may exist, but we did not detect them due to low power. Times recorded following the cold application were consistently slower, but not statistically different from the control treatment times for all three agility tests.

The moderate power presents a conflict. The statistical analysis supports the current research on therapeutic cold and sensory perception, and proprioception. Studies by LaRiviere, using the ankle, and Thieme, using the knee, showed that therapeutic cold treatments did not adversely affect proprioception. Ingersoll et al suggested that sensory perception in the form of two-point discrimination (superficial sensation), topagnosis (deep sensation recognizing the location of touch), and balance were not affected by an ice immersion treatment to the foot and ankle.

As noted by Thieme, most subjects appeared to move slowly and awkwardly immediately following the cold treatment. Subjects’ verbal responses to the cold also suggest that the cold caused some type of sensory alteration, a theory supported through research. Previous literature on cold’s hypalgesic effects also support this claim.

A concern is that this change in sensation may be linked with deficits in proprioception, ultimately leading to injury. However, studies have shown that these alterations in sensation do not appear to be linked with deficits in the sensory information that is vital for coordinated movement. A possible explanation for this occurrence is that the cold is affecting the sensory receptors that interpret pain and thermal changes, but not the sensory receptors responsible for proprioception.

Still, if the analysis failed to detect a difference, then the possibility that cold may affect agility coincides with studies that have shown deficits in strength and power following cold application. However, studies that demonstrated a decrease in strength and power following cold application used large muscle groups and/or a joint and a large muscle group as the treated area. Our protocol involved cooling the ankle joint 8 cm above the lateral malleolus, well below the large muscle mass of the leg. Cold applications are commonly applied exclusively to a joint for pain relief and reduction of the inflammatory process. However, we were unable to find a study that examined strength or power following a cold application to a joint exclusively. When applied to a large muscle group, cold may adversely affect some component of performance, but it is uncertain whether the same response occurs when only cooling a joint. A recommendation for future study would be to examine how cooling a muscle affects agility.

In addition, the majority of studies attempting to determine cold’s effect on strength have used isokinetic strength as the dependent variable. For example, Ruiz et al suggested that cold therapy applied to the quadriceps muscle results in an immediate decrease in concentric and eccentric isokinetic strength. It is still uncertain whether a deficit in isokinetic strength can be related to deficits in functional performance.

We can suggest that the slower times following the cold treatment were due to subject apprehension immediately following the cold application. Some subjects appeared to be testing the ankle to ensure that it would respond to the demands being placed upon it. It is possible that they performed the agility drills more aggressively as they became more comfortable with the altered sensation.

A second suggestion is that a certain amount of joint stiffness was caused by the cold treatment. Research has shown that cold treatments can reduce dexterity and joint laxity. Joint movement (dexterity) speed following cold is slower when a muscle is cooled and the movement requires full range of motion. A third explanation is that the cooling caused an increase in the viscosity of the fluid within the ankle, resulting in more resistance. Assuming that the muscles were working at their maximum, this resistance would have required more force to generate movement.

It should also be noted that of the 24 subjects who participated in this study, only 18 had previous experience with cold

### Average Agility Time for Each Test Condition (seconds)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Carioca</th>
<th>Co-contraction</th>
<th>Shuttle Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation</td>
<td>6.09 ± .66</td>
<td>12.10 ± 1.17</td>
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<tr>
<td>Ice</td>
<td>6.20 ± .64</td>
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</tr>
<tr>
<td>Control</td>
<td>6.10 ± .62</td>
<td>11.76 ± 1.11</td>
<td>6.48 ± .60</td>
</tr>
</tbody>
</table>
immersion treatments to one of their ankles. In addition, only the 13 varsity athletes had undergone some form of cold therapy followed by exercise. Research has shown that habituation takes place if cold treatments, consistent in temperature, are applied to the same limb. From observing the subjects following the cold treatments, it appeared that those who had no previous experience with cold therapy followed by exercise were more apprehensive than those who had experienced it. This may indicate that a psychological (apprehension due to the hypalgesic affects of cold) rather than a physiological change is responsible for the slightly slower times. It may be possible that athletes who have experienced cold therapy immediately followed by exercise are less apprehensive than those who have not experienced it. This possibility requires further investigation.

It should also be remembered that cold application is usually followed by other forms of treatment such as range of motion and strengthening exercises, as well as taping and a thorough warm-up. Therefore, the time between the conclusion of cold application and the beginning of strenuous exercise is often greater than 30 seconds.

Athletic trainers commonly use cold in the treatment of musculoskeletal injuries. Not only does it decrease the potential for secondary hypoxic injury, it also reduces pain, facilitating early exercise. The results of this study indicate that cooling the foot and ankle does not alter functional agility. However, due to an altered sensation and subsequent apprehension, vigorous exercise and athletic competition following cold therapy should begin when athletes feel they are ready. The results also indicate that cooling a joint may not produce the same decrease in power and strength that cooling a muscle only may cause.

ACKNOWLEDGMENTS

This study was partially supported by Pro Orthopedic Devices, Inc, Tucson, AZ.

REFERENCES

The primary objective of acute ankle sprain treatment is edema control. The most effective means for both prevention and removal of lateral ankle edema is the application of focal compression to the soft tissues on the periphery of the fibular malleolus.

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Intertester Reliability of Assessing Postural Sway Using the Chattecx Balance System

Carl G. Mattacola, MEd, ATC; Denise A. Lebsack, PhD, ATC; David H. Perrin, PhD, ATC

ABSTRACT: In this study, we examined intertester reliability of dynamic and static balance using the Chattecx Dynamic Balance System. Ten female and two male subjects were randomly assigned to two testers and completed ten, 10-second preprogrammed double- and single-leg test conditions. Balance was measured as postural sway in centimeters by the Chattecx Dynamic Balance System. Static balance consisted of the platform remaining stable, whereas dynamic balance consisted of the platform tilting in an anterior and posterior direction during testing. The protocols and average postural sway values were:

1. Double-Leg Static Eyes Open (̄x = .28 cm)
2. Double-Leg Static Eyes Closed (̄x = .37 cm)
3. Double-Leg Dynamic Eyes Open (̄x = .86 cm)
4. Double-Leg Dynamic Eyes Closed (̄x = 1.72 cm)
5. Single-Leg Static Dominant Eyes Open (̄x = .99 cm)
6. Single-Leg Static Dominant Eyes Closed (̄x = 1.70 cm)
7. Single-Leg Static Nondominant Eyes Open (̄x = .65 cm)
8. Single-Leg Static Nondominant Eyes Closed (̄x = 1.48 cm)
9. Single-Leg Dynamic Dominant Eyes Open (̄x = .99 cm)
10. Single-Leg Dynamic Nondominant Eyes Open (̄x = .91 cm).

The mean values of postural sway ranged from .28 cm to 1.72 cm for double-leg stance measures and from .65 cm to 1.70 cm for the single-leg stance measures. The intraclass correlations (ICCs) ranged from poor to excellent (ICCs = .06 to .90) and the standard error of measurement (SEM) ranged from .06 to .34 for the 10 trials. We feel that variability exists between subjects and/or testers between trials. The wide range of reliability values suggests that further research should determine both intratester and intertester reliability using a variety of protocols for assessment of static and dynamic balance.

Proprioception (somatosensation) is a distinct component of balance. It is the cumulative neural input from the mechanoreceptors in the joint capsules, ligaments, muscle tendons, and skin to the CNS. When these structures are subjected to mechanical deformation, action potentials are conducted to the CNS where the information can influence muscular response and position sense. The integration of afferent neural input to the CNS contributes to the body’s ability to maintain postural stability.

The Chattecx Dynamic Balance System has been used to assess postural stability. It is a relatively new instrument with a limited amount of published data regarding its use. Relatively few studies have examined the reliability of the Chattecx Dynamic Balance System. Irrgang and Lephart measured postural sway during unilateral stance on a stable platform. Their results indicate reasonable reliability within and between days for stable nonmoving measures of balance.

The purpose of our study was to examine the intertester reliability values for static and dynamic balance using the Chattecx Dynamic Balance System. Testing included double-leg stable and dynamic conditions with the eyes open and closed as well as single-leg stable and dynamic conditions with the eyes open and closed. The study also served to establish more normative data from which clinicians can make comparisons.

METHODS

The statistical design used in our study was a one-between-subject and one within-subject repeated measures ANOVA.
with postural sway as the dependent variable and raters as the independent variable. Twelve healthy university graduate and undergraduate students (10 female, 2 male) participated in this study (age = 24.7 ± 3.3 yr, wt = 62.2 ± 7.5 kg, ht = 164.8 ± 7.1 cm). None of the subjects had sustained an injury to the tested extremity within 1 year before testing. Before testing, each subject read and signed a consent to participate form outlining the potential benefits and risks of the study. Both the dominant and nondominant extremities were tested. We determined dominance by asking each subject to identify the leg he/she would use to kick a ball.

Following the explanation of test procedures, we randomly assigned the subjects to one of two testers. The subjects then performed the 10 testing conditions on the Chattecx Dynamic Balance System. Following a 30-minute rest period, the second examiner retested the subjects.

Postural Sway Assessment

Postural sway is the distance expressed in centimeters that an individual travels away from his/her center of balance. The Chattecx Dynamic Balance System consists of four independent force-measuring transducers that are used to quantify postural stability. Fluctuations in displacement away from the center of balance reflect the amount of postural sway. Center of balance is the point between the feet where the ball and heel of each foot has 25% of the body weight (Figs 2 & 3). Deviation from this center of balance in any direction represents postural sway. A subject’s center of balance is indicated graphically on the monitor screen by a red “+” and numerically by the x and y coordinates. The sway index was used as the measure of postural sway. The sway index, produced by the machine, reflects the degree of scatter of data about the subject’s center of balance. The data from the force platform measurements are interfaced with software that filters and samples the data at approximately 15 cycles per second, and the sway index is calculated by the determining the distance from the subject’s center of balance for each of the data points.

We tested the subjects for a total of ten, 10-second conditions. By adjusting the footplates, we centered the subject’s bare feet on the footplate. The positions of the footplates were recorded using the x and y axis numerical values printed on the base platform. This information was stored for the retest condition. The computer monitor was turned away from the subject to eliminate visual feedback. During each testing condition, subjects focused on an X that was marked on the wall directly in front of them.

Subjects stood with their knees slightly flexed (5° to 15°) and their arms held at their sides. In the single-leg testing conditions, the nonweight-bearing extremity was not allowed to touch the supporting leg. We gave the subjects one practice trial before each testing condition and instructed them to stand as still as they could while being tested. We began recording when each subject indicated that he/she was ready.

In the dynamic phases of the test, the platform was tilted anteriorly and posteriorly 4° in each direction so that ankle plantar and dorsiflexion were necessary to maintain the body in an erect and stationary position.

Separate repeated measures ANOVAs were performed for each testing condition using the SPSS statistical package (SPSS, Chicago, IL). Separate ICCs were calculated from the ANOVA data to determine the reliability of the testing. We used the ICC formula2 because trials were considered random effects.13
RESULTS

The means and standard deviations for each testing condition are presented in the Table. ICCs, standard error of measurement (SEM), and confidence intervals (CI) are also presented in the Table. The mean values of postural sway ranged from .28 to 1.72 cm and from .65 to 1.70 cm for the double- and single-leg stance, respectively. ICCs ranged from poor (ICC = .06) to excellent (ICC = .90).

DISCUSSION

Measurement of balance has numerous potential applications in athletic training, such as determining the effect of injury, surgery, and external devices such as tape and braces on balance. It is important to establish the reliability of postural sway measurements for different testing conditions and testers. When evaluating an athlete for return to play, athletic trainers need to have confidence in the measuring devices used, as well as in the normative measures that are available to assist in these decisions. Our investigation addressed reliability of measurement and adds to the limited pool of normative data for static and dynamic balance testing conditions. The major finding of our study was that a wide range of reliability exists for static and dynamic testing conditions.

Double-Leg Testing Conditions

The lowest ICC was observed for double-leg stable platform with the eyes-closed condition. This may be because this was the first test performed with the eyes closed. The order of testing was not randomized. We intentionally arranged testing in a progression of least difficult, Double-Leg Static Eyes Open, to most difficult, Single-Leg Dynamic Nondominant Eyes Open, according to manufacturer’s protocol.

The double-leg with static platform reliability coefficients for the eyes-open and eyes-closed conditions varied considerably (Double-Leg Static Eyes Open, ICC = .75 vs Double-Leg Static Eyes Closed, ICC = .06). The double-leg with dynamic platform coefficients were considerably better (Double-Leg Dynamic Eyes Open, ICC = .78 vs Double-Leg Dynamic Eyes Closed, ICC = .84). This finding was unexpected because the dynamic conditions would appear to be more challenging than the static conditions. Although we included a practice test before all test conditions, we can only speculate that this finding was related to a learning effect under the static and dynamic conditions.

Single-Leg Testing Conditions

Our ICCs for the single-leg conditions ranged from .41 to .90. ICCs provide unitless estimates of the reliability of measurement. The SEM provides an estimate of the precision of measurement and is useful to determine if differences between scores are due to change or error. For example, if the score for the Single-Leg Static Dominant Eyes Open condition was 0.64 cm with a SEM of .14 cm, we are 95% confident that there exists a band of error of ± .27 cm around this measurement. The .95 CI equals the mean of the sample ± 1.96 multiplied by the SEM (SEM; .95 CI = x ± 1.96 SEM). Likewise, if the score for the Single-Leg Dynamic Nondominant Eyes Open condition was .92 cm with a SEM of .06 cm, we are 95% confident that there exists a band of error of ± .14 cm around this measurement. The .95 CI equals the mean of the sample ± 1.96 multiplied by the SEM (SEM; .95 CI = x ± 1.96 SEM).
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confident that there exists a band of error ± .12 around this measurement. If the sway index was .92 cm on day 1 and .82 cm on day 2, the clinician can be 95% certain that the difference was due to error rather than to true change. In this example, a change greater than ± .12 cm would be necessary to attribute the difference to change rather than to error. Thus, the clinician must be conscious that the differences observed may exist due to measurement variance alone.

Reliability coefficients for eyes-open vs eyes-closed conditions for single-leg testing (dominant leg) were identical (Single-Leg Static Dominant Eyes Open and Single-Leg Static Dominant Eyes Closed, ICC = .57). The coefficients for eyes-open vs eyes-closed conditions for single-leg testing (nondominant leg) were Single-Leg Static Nondominant Eyes Open, ICC = .41 vs Single-Leg Static Nondominant Eyes Closed, ICC = .49). This is important because the values reported above from our single-leg static testing conditions would be comparable to the eyes-open free-stance conditions used by Irgang and Lephart.7 Their protocol consisted of four test conditions that were randomly administered on the right lower extremity and consisted of Eyes Open Free Stance, Eyes Open Controlled Stance, Eyes Closed Free Stance, and Eyes Closed Controlled Stance. During free stance, the subjects were allowed to place their arms and their nonsupporting leg in any position they chose. During controlled stance, the subjects folded their arms across their chests and held their nonsupporting leg with their knees flexed to 90°.7 Eyes-open and closed free-stance ICCs were calculated for within and between days. Within-day correlations were Eyes Open Free Stance, ICC = .82; Eyes Open Controlled Stance, ICC = .66; Eyes Closed Free Stance, ICC = .65; and Eyes Closed Controlled Stance, ICC = .72. Between-day correlation coefficients were Eyes Open Free Stance, ICC = .76; Eyes Open Controlled Stance, ICC = .47; Eyes Closed Free Stance, ICC = .72; and Eyes Closed Controlled Stance, ICC = .63.7 We asked our subjects to refrain from contacting the balancing extremity with the contralateral leg, and we put no restraints on the angle that the ipsilateral knee was held during each test. We found lower reliability coefficients for measures obtained during eyes open and eyes closed compared to those reported by Irgang and Lephart.7 This finding may be due to the influence of interexaminer testing, even though the test procedures were standardized.

Our reliability measures for the dynamic conditions were Single-Leg Dynamic Dominant Eyes Open, ICC = .63 and Single-Leg Dynamic Nondominant Eyes Open, ICC = .90. Although we would have expected the dynamic tests to be more difficult, the continual movement of the platform during the dynamic condition may have helped the subjects to remain centered on the force platform. As with the double-stance testing, the possibility of a learning effect must also be considered as a potential explanation.

RECOMMENDATIONS

Maintaining postural stability involves integrating multiple physical components. The wide range of reliability coefficients in our study is probably related to this multifaceted system. For example, concentration may be compromised due to extraneous factors such as visual or audible disturbances that may be present in the room. Also, variations in mental status may vary from test to test. Controlling for these disturbances may improve the reliability of measurement. Although every effort was made to control the test environment, our test setting was not completely isolated for this investigation.

We strongly recommend that assessment of balance occur in a completely isolated setting, while minimizing external influences. We noticed during the testing procedures that subjects had individual techniques for maintaining balance. For example, some subjects would count to themselves to remain focused on the task. Future research should examine different concentration techniques for maintaining or improving balance.

It has also been suggested that a learning effect may be present during the progression of testing conditions (Lebsack DL, et al; unpublished data, June 1994); our findings seem to support this notion. Future research should examine the learning curve associated with balance performance and determine when, if at all, a plateau occurs. It is unclear whether the ability to perform well on such measures relates specifically to dynamic joint function. Investigation of factors directly related to dynamic joint function offers an exciting challenge for further research.

CONCLUSION

We conclude that variability exists for the measure of postural sway for static and dynamic testing conditions. Athletic trainers need to recognize this variability when assessing the effects of balance deficits following injury. Currently, there is no established system of evaluating dynamic balance using field tests. The potential of incorporating measures obtained with devices such as the Chattecx Dynamic Balance System with future measures obtained using field tests may offer a solution for a more comprehensive evaluation of dynamic joint function. Secondly, the above values provide athletic trainers with a baseline (with respective confidence intervals) for future examination of postural sway parameters.

ACKNOWLEDGMENTS

We would like to thank Dr. Donald W. Ball for his instruction and consultation regarding the use of ICCs and SEM.

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Effect of ACL Reconstruction and Tibial Rotation on Anterior Knee Laxity

Kevin M. Guskiewicz, PhD, ATC; David H. Perrin, PhD, ATC; David E. Martin, PhD, ATC; David M. Kahler, MD; Bruce M. Gansneder, PhD; Frank C. McCue, MD

ABSTRACT: The anterior cruciate ligament (ACL) is the primary restraint to anterior translation of the tibia on the femur. Research suggests that resistance to anterior translation changes as the tibia is rotated internally and externally. This study assessed the degree to which ACL reconstruction and tibial rotation affects anterior knee laxity. Nine subjects with ACL lesions and functional instability participated in the study. Subjects were measured 1 to 10 days before surgery and 6 to 8 months after ACL reconstruction using the KT-1000 knee arthrometer. A mechanical leg stabilizer was used to assess anterior translation at 20° of knee flexion in three positions: internal rotation of 15°, neutral, and external rotation of 15°. Subjects were measured at 89 and 67 N of anterior force. Data were analyzed with a three-factor (test x position x force) repeated measures ANOVA. Following surgery, reduction in laxity (mm) for the three positions (internal rotation, neutral, and external rotation) was 1.9, 2.8, and 3.4, respectively, at 89 N and 1.5, 2.0, and 2.6, respectively, at 67 N. The degree of reduction in laxity (presurgery to postsurgery) was dependent upon rotation and force, and was greatest in external rotation and least in internal rotation pre-to postsurgery. We concluded that ACL reconstruction using a patellar tendon graft significantly decreased anterior tibial translation at all three positions, but a greater amount of reduction was observed postsurgically at the externally rotated position. This supports the theory that mechanical blocks and secondary restraints such as a taut mid-third of the iliotibial tract may interfere with clinical laxity tests in some positions of tibial rotation. Fixing the tibia in an externally rotated position may decrease the effect of secondary restraints and improve sensitivity in testing for ACL laxity.

The anterior cruciate ligament (ACL) plays a vital role in providing functional stability to the knee. The diagnostic tests used to assess its integrity have generated much interest in both clinical practice and research. Clinicians disagree on the involvement of the secondary restraints to anterior displacement of the knee, thus leading to uncertainty in interpreting clinical examinations. Much of the debate surrounds the interaction between tibial rotation and laxity as well as the role of the ACL in restraining tibial rotation.

Tibial rotation appears to play a vital role in properly assessing the ACL. Joint laxity is a result of a complex interaction among all the ligaments. This interaction is altered when a ligament is cut or injured. Therefore, the change in laxity is due not only to loss of the ligament, but also to a change in the interaction among the remaining ligaments.

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David M. Kahler is an assistant professor of Orthopedic Surgery and Frank C. McCue is an Alfred R. Shands Professor of Orthopedic Surgery and Plastic Surgery of the Hand, Both are associated with the Department of Orthopedics at the University of Virginia.
The Lachman test, performed with the knee flexed 10° to 20°, is positive more often than the anterior drawer test because the hamstrings are less able to resist anterior translation near full extension. Furthermore, rollback of the femur on the tibia is not complete at 20° of flexion; therefore, the menisci are less likely to produce a stabilizing effect.

Several researchers have reported anterior displacement of the tibia using instrumented arthrometry in injured and noninjured populations preoperatively,1,15,23 postoperatively,15,20,24 and during nonsurgical management of ACL-deficient patients.17,27,28 Markolf et al17 and more recently, Martin et al18 and Fiebert et al15 established that tibial positioning influences anterior tibial displacement. No study, however, has attempted to determine the extent to which fixed tibial rotation during knee laxity testing at 20° of knee flexion might better isolate the ACL through minimizing the effect of the secondary restraints preoperatively to postoperatively. The purpose of this study was to assess the effect of tibial rotation on anterior knee laxity in the injured knee and to determine the effect of surgical intervention on laxity from three positions of tibial rotation (neutral, 15° internal rotation, 15° external rotation).

METHODS

Anterior translation of the tibia on the femur was measured bilaterally in nine subjects (age = 25.2 ± 9.5 yr, ht = 175.5 ± 8.8 cm, wt = 79.8 ± 14.6 kg) with ACL lesions and functional instabilities. Functional instability was defined as feeling that the knee was going to “give way” and/or being unable to perform normal activities of daily living. Tears of the ACL had been diagnosed through clinical examination (positive Lachman and positive pivot shift) and confirmed through magnetic resonance imaging and/or Telos stress radiography. Before participation in this study, each subject read and signed a consent form approved by the university institutional review board.

Subjects used in this study presented with subacute tears of the ACL. The time between injury and surgery ranged from 1 to 7.3 months (x = 4.9 months). Subjects were evaluated 1 to 10 days before surgery (preoperative) and 6 to 8 months following ACL reconstruction (postoperative) using a modified KT-1000 knee arthrometer (MEDmetric Corporation, San Diego, CA). The arthrometer was equipped with a strain gauge and a processor (Omega Technologies, Inc, Stamford, CT) that permitted continuous readouts of force from a digital diode.23 The built-in dial tones on the standard KT-1000 were not used. Forces were displayed on the diode and/or being unable to perform normal activities of daily living. Tears of the ACL had been diagnosed through clinical examination (positive Lachman and positive pivot shift) and confirmed through magnetic resonance imaging and/or Telos stress radiography. Before participation in this study, each subject read and signed a consent form approved by the university institutional review board.

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The Tibial Fixator Device (patent pending) was used to control tibial rotation (Fig 1). The foot was placed in the ankle-foot orthosis accompanying the Tibial Fixator Device, thus securing the tibia into the mortise and allowing foot positioning to control tibial rotation. The ankle-foot orthosis pivots at the heel and allows the tibia to be fixed in one of three positions: neutral, internally rotated 15°, and externally rotated 15°, as referenced from the head of the second metatarsal of the foot. The Tibial Fixator Device also maintains the knee in 20° of flexion, while stabilizing the thigh.

Anterior translation of the tibia relative to the femur was recorded at both 67 N (15 lbs) and 89 N (20 lbs) on the uninjured legs, followed by the injured legs at all three positions of rotation. The uninjured legs were assessed to establish test-retest reliability. The selected order of testing positions was randomized.

Following surgical reconstruction using a mid-third patella tendon autograft, subjects completed a standard rehabilitation program. They returned 6 to 8 months postsurgery for a follow-up evaluation.

Statistical analyses were performed using SPSS Release 4.1 statistical package (SPSS Inc, Chicago, IL). A three-factor (test × position × force) repeated measures analysis of variance (ANOVA) was performed to test main effects for test, position, and force, as well as any interactions. Tukey post hoc comparisons were performed to determine where significant differences occurred. Intraclass correlation coefficients were calculated for test-retest reliability at each level of rotation using the Shrout and Fleiss formula.25

RESULTS

The tibial displacement measurements obtained for the two forces at each position of rotation are presented in the Table. Main effects for test (F(1,8) = 179.27, p < .05), rotation (F(2,16) = 4.25, p < .05), and force (F(1,8) = 5.19, p < .05), test by rotation by force interaction (F(2,16) = 18.51, p < .05) were all significant; thus the degree of reduction in displacement (presurgery to postsurgery) was dependent upon rotation and force, and was greatest in external rotation and least in internal rotation (Tukey post hoc test p < .05).

Test-retest intraclass correlation coefficients and associated standard error of measurements were established using the normal limb for internal rotation (.94 and .46 mm), neutral (.84 and .50 mm), and external rotation (.72 and .83 mm).
Testing anterior knee laxity in fixed external tibial rotation may be better than in the fixed neutral or internally rotated positions. As expected, ACL reconstruction using a patellar tendon graft significantly decreased anterior tibial translation when measured 6 to 8 months postoperatively; returning to near normal (< 2 mm) postoperatively as defined by Daniel et al.¹ (See Table).

The reduction in anterior displacement at 89 N was greatest from the externally rotated position (3.4 mm) as compared to the other positions (2.8 mm, 1.9 mm). This trend was also observed at 67 N (2.6 mm compared to 2.0 mm and 1.5 mm); however, reductions were not as drastic as those recorded at 89 N. Thus, the three-way interaction is significant, and fixing the tibia in 15° of external rotation, similar to that suggested by Slocum²⁶ and Larson,¹⁴ may decrease the effect of secondary restraints seen when performing the anterior drawer test or even the standard Lachman test.

The need to better define the drawer test in near extension becomes evident in Hughston’s³ description: “The hand grasping the proximal tibia naturally constrains the rotation of the tibia in a neutral position or may allow it to move relatively unconstrained.” We contend this test can be improved by fixing the tibia in 15° of external rotation using the hand that also applies the anterior force to the tibia. Our findings suggest that this may be a better test of ACL integrity.

We believe that the tightness of the mid-third of the iliotibial tract (capsulo-osseus layer) when the knee is fixed in mild (15°) external rotation is crucial to the assessment of the ACL. This portion of the iliotibial tract progresses from the tibial attachment proximally to the lateral femoral condyle and intermuscular septum (Fig 2).⁹ The iliotibial tract is relatively taut with the knee in 20° knee flexion. However, by externally rotating the tibia, the capsulo-osseus layer becomes less taut, allowing for a more accurate test of the ACL.

Secondly, the ACL itself is under tension when the tibia is fixed in the neutral-externally rotated position. Thus, by externally rotating the tibia, the ACL uncoils to a more functional position, again allowing for a more accurate test of the ACL.

Finally, as described earlier by Torg,²⁹ the posterior surfaces of the tibial and femoral condyles provide an anatomical block to anterior tibial motion from the 90° position as a complete rollback or glide occurs beyond 30° flexion. This was resolved by limiting knee flexion to 20° for testing (ie, Lachman position). We further propose that slight external rotation (15°) of the tibia from this position further enhances the joint mechanics. We believe muscle guarding, joint compression, and a complete rollback (glide) of the femur are eliminated from this position, thus allowing for a more isolated assessment of the ACL.

Our findings are consistent with those of Markolf et al.¹⁷ who studied injured vs normal knees at the same three positions of rotation. Although mean values of displacement for the three positions were not reported in this study, extrapolation of data indicates the externally rotated position also demonstrated the greatest difference in anterior displacement when comparing injured and uninjured knees. Based on their graphically presented data, estimated changes in joint laxity at the three positions of rotation were 2.7 mm (internal), 3.2 mm (neutral), and 3.7 mm (external) when a 100 N anterior force was applied.

One of the strengths of our study was that all subjects had isolated complete lesions of the ACL with no associated capsular or collateral ligament involvement. Five of our nine subjects had associated meniscal lesions; however, when anterior translation of the tibia is tested with the knee fixed in 20° of flexion, the menisci are not likely to produce a stabilizing effect. Therefore, we feel that meniscal pathology had no effect on anterior displacement. The results of the anterior displacement tests using the KT-1000 on both injured and uninjured knees are consistent with those of Steiner et al.,²⁸ Staubli and
Jakob,27 and Markolf et al,17 at the neutral position (8.1 mm, injured; 3.9 mm, uninjured).

At followup, the involved knee averaged 1.6 mm more laxity postsurgery than the uninvolved knee. All subjects reported having achieved at least 85% of their original function.

Because our study involved only subjects with isolated ACL lesions, a small sample size was inevitable. However, a study increasing the sample size and therefore the statistical power might provide stronger evidence that external tibial rotation provides the clinician with a more accurate measure of anterior knee laxity.

In summary, our findings suggest that decreases in knee laxity hold true at three levels of tibial rotation presurgery to postsurgery from a position of 20° of knee flexion. Moreover, 15° of external rotation of the tibia during the assessment may provide clinicians with a more accurate measurement of ACL integrity. ACL reconstruction decreased the amount of tibial displacement, but to a different degree depending on the position of the tibia during testing. Our findings are consistent with those of Slocum and Larson26 who described a test for rotary instabilities different from the anterior drawer test or Lachman test. They established the role of tibial rotation in anterior knee laxity after ACL reconstructive surgery. Our study warrants the need for further research in this area.

ACKNOWLEDGMENTS

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Concerns on Little League Elbow

Michael J. Wells, MS; Gerald W. Bell, EdD, PT, ATC,R

ABSTRACT: Little League elbow is a common overuse injury that will become more prevalent as more youths participate in baseball programs and other sports that involve overhead arm activities. The condition is highly treatable if diagnosed early in its development. Symptoms such as swelling and limited range of motion usually indicate an advanced overuse condition. Prevention and treatment should emphasize education of athletes, parents, and coaches about its etiology. Factors involved are proper pitching mechanics, stretching and strengthening programs, improving early recognition, and, most importantly, limiting the number of pitches thrown daily.

The rise of health awareness in the United States has brought with it an increased participation in sporting activities for all ages. Youngsters are commencing rigorous fitness training programs at an earlier age. Twenty million youths between the ages of 8 and 16 are in nonschool, community-sponsored athletic programs.25 Of particular interest is participation in Little League baseball. Injuries occurring in this sport are unique in that the participants are still developing physically, and severe injury at this stage can have long-term consequences.

The elbow is the most frequently reported area of injury in child and adolescent baseball players.11 Specifically, this paper will discuss the overuse injury known as “Little League elbow” (or pitcher’s elbow in older individuals). This condition was defined by Brogden4 in 1960 as “an avulsion of the ossification center of the medial epicondylar epiphysis in pubertal pitchers.” Little League elbow results from repetitive valgus stress on the elbow during overhead throwing. As research into this problem evolved, the term came to encompass all of the stress responses observed in the symptomatic adolescent baseball pitcher. This condition can also result from weight lifting, gymnastics, wrestling, some field events, and other athletic activities.

If you were to take a moment to observe a beginning pitcher, it would not take long to ascertain that the pitching motion is not a natural act. Poor mechanics and a developing elbow complex leave the young, inexperienced pitcher susceptible to Little League elbow. These young individuals possess an elbow complex comprised of epiphyseal plates that continue to develop until the age of 17.2 The problem of Little League elbow is centered around these growth plates in the pitching arm. The epiphyseal line has been identified as the weakest link in the musculotendinous unit in the adolescent (due to the rapid period of growth) which leaves the tendons and ligaments tight on lengthening bones.25

Literature on Little League elbow suggests that the occurrence of this injury is not significant relative to the large number of youth participants in organized baseball. If this is true, why should there be a reason for concern? We offer the following thoughts for consideration:

1. As the number of youths taking part in organized sporting activities grows, the number of sport-related injuries will follow.
2. Basically, baseball is a 3-month sport. There is too much stress placed on the arm in a short time without proper preseason strengthening/conditioning. This leads to overuse injuries.8
3. Little League has age-determined teams. Youths with the skeletal maturity of 12-year-olds can find themselves under the pitching restrictions intended for a 14- to 15-year-old.
4. The young athlete is continually growing and developing. Adolescent growth cartilage is less resistant to repetitive microtrauma than adult cartilage.14 The rapid growth of the bones during this period creates a muscle-tendon imbalance that places additional tension on musculo-tendinous units, decreasing flexibility. These two factors create an enhanced environment for overuse on the still-developing epiphyseal plates at the elbow complex. Damage to the epiphyseal plates at this stage of development can result in permanent cessation or retardation of growth in any bone of the pitching arm.

MEDICAL HISTORY OF LITTLE LEAGUE ELBOW

Before 1972, prior to the major rule changes, accelerated growth and separation of the medial epicondyle was present in 90% of youths between the ages of 9 and 14 playing baseball in Southern California.1 In 1968, Adams1 looked at 162 individuals (aged 9 to 14 years) with varying baseball experience. He studied three groups: 80 pitchers, 47 nonpitchers, and 35 individuals with no previous baseball experience. The conclusion was that “there exist definite changes in direct proportion to the type and amount of throwing, with the pitchers showing the most striking changes.”1 The injury with the highest occurrence was accelerated growth and separation of the medial epicondyle.1

Since then, the literature has reflected attempts to erase or justify the continued fear of the threat of Little League elbow. Micheli and Fehlandt15 looked at 724 cases of tendinitis and apophysitis in 445 patients (aged 8 to 19 years) and found that baseball had the highest occurrence of injury in the upper extremity for males. For females in this study, softball ranked
fourth. Injury at the elbow ranked highest for both sexes. In 1980, Grana and Rashkin evaluated 73 older pitchers with an average age of 17 years. At the time of evaluation, 58% of these individuals reported pain while throwing or developed pain during the season. Grana and Rashkin concluded that “occurrence of pain about the elbow during pitching tends to increase with age,” and stated further that these abnormalities did not occur in large numbers nor were they too severe. Other authors concluded that preadolescents may successfully participate in organized baseball with no worry of developing permanent arm problems. It should be noted, however, that these studies involved younger subjects than those in Adams study and that these individuals possessed a greater potential for the remodeling of injured epiphyses due to their younger age. More longitudinal studies spanning the late teens are needed to establish or disprove any significant relationship between pitching and Little League elbow.

BONE DEVELOPMENT

Three main areas of concern for injury in the elbow complex are: the medial epicondyle, the olecranon epiphysis, and the articular surface at the capitellum-radial junction (Figs 1 & 2). The threat of epiphyseal injuries and Little League elbow begins with the appearance of the secondary growth plates and lasts until the final plate fuses with the long bone. In the elbow complex, the first epiphysis appears in the capitellum around age 2 and the last plate to fuse is the medial epicondyle, which fuses around 17 years for male and 14 years for female adolescents. In the growing child, cartilage is articulated between tendon and bone at the medial epicondyle. Once this apophysis is separated, continued use and stressful activity (eg, the pitching delivery) will prevent normal closure of the damaged growth plate. For this reason, it is pertinent to restrict the activities of a youngster with a sore/swollen elbow. The threat of Little League elbow does not pertain just to youngsters, however. It is a reality for individuals well into high school. High school baseball does not have consistent limitations on pitching appearances and places the individual in a situation that is conducive to overuse/degenerating injuries at the elbow complex. Moreover, the pitching arm of the high school athlete continues to remain at risk of injury beyond the spring baseball season as it extends into summer leagues and camps.

INJURY DESCRIPTION

Four of the most common injuries among children and adolescents are Little League elbow, Osgood-Schlatter disease, Sever’s disease, and stress fracture. Epiphyseal injuries constitute between 6% and 15% of all long bone fractures in individuals under the age of 16. Seventy-five percent of these injuries occur between the ages of 10 and 16. The typical incident of Little League elbow occurs in youths aged 9 through 14 whose enthusiasm for sports and eagerness to participate outweigh their capabilities, which is particularly obvious in poor pitching/throwing mechanics.
The mechanism of injury is the valgus stress placed on the arm during the acceleration phase of the pitching delivery. During this phase at the elbow complex, there are stretching forces medially and compression forces laterally. Injury to the epiphyseal plates occurs either as an acute incident (fracture) or from repetitive stress placed on the area. Many of the injuries incurred during sporting activities in the young athlete refer to the Salter-Harris categorization of fractures (Fig 3), but equal attention should also be placed on microtrauma injuries caused by repetitive motion.

When the vascular supply crosses the physis, a fracture at the physeal-metaphyseal junction may disrupt the blood supply and result in osteonecrosis. Most injuries to adolescents fall under the lower classifications and usually at the onset of a growth spurt. Due to the remarkable remodeling capabilities of developing bone, many injuries incurred at an early age heal with no long-term consequences if recognized early and if activity is restricted. During a growth spurt, however, there is an increase in muscle-tendon tightness about the joint and a decrease in flexibility, which makes the elbow complex susceptible to acute and overuse injury. Even with proper strengthening and stretching, the repetitive motion of pitching can induce debilitating microtrauma in elbow tissues.

PATHOLOGY

As mentioned before, the delivery of a pitch causes traction forces medially and compressive forces laterally. As would be expected, the signs and symptoms of Little League elbow reach their peak during the adolescent growth spurt, in the 13-14-year-old age range. The most common injury is an avulsion fracture of the medial epicondyle. Before epiphyseal closure, strong contraction of the forearm flexors during a pitch is capable of avulsing a medial epicondyle weakened by repetitive microtrauma. Complications that can develop laterally from the compressive and shearing forces involve the radial head and capitellum.

Repetitive compression and shearing forces between the radial head and capitellum can lead to the most serious form of Little League elbow (or pitcher’s elbow), osteochondritis dissecans. Development of osteochondritis dissecans in either of these structures is difficult to treat. Osteochondritis dissecans is a localized area of necrosis that is classified as a Salter-Harris type V fracture and results in fragmentation of bone tissue. Repetitive trauma appears to be responsible for many cases of osteochondritis in the elbow of the child pitcher. An injury of this type might not be realized for months or even years after the injury occurs. Osteochondritis dissecans should not be confused with Panner’s disease. Panner’s disease occurs in much younger individuals (average age, about 8 years) and is a condition brought about by changes in circulation, resulting in avascular necrosis of the capitella. It is characterized by fragmentation of the entire ossific center and no loose bodies are present. Osteochondritis dissecans occurs in individuals from 13 to 17 years and is a localized area of necrosis.

Other complications that can occur are general inflammation, apophysitis, fragmentation, loose bodies, stretching of the ulnar nerve (medially), and degeneration of the elbow joint. Later in life, these conditions can develop into osteoarthritis of the affected elbow. In considering the posterior aspect of the elbow complex, the olecranon slams into its fossa during follow-through. Repetitive action of this nature can prevent closure of the olecranon epiphysis and cause a stress fracture through the growth plate.

PITCHING MECHANICS

Pitching is a complex activity that requires the coordination and interaction of numerous muscles, joints, and body segments to perform in a specific sequence of motions. Any abnormality or inefficiency in this motion will place additional stress on the elbow complex.

Bryan separates the pitching motion into four stages: windup, cocking, acceleration, and follow-through (Fig 4). In the windup phase, the pitcher balances on his/her back foot and
reaches a “gathering point.” Bryan states that young pitchers often rush this stage to start ball release and lose all benefit from their lower extremity. In the cocking phase, the ball is brought behind the head with at least 90° of external shoulder rotation. The front foot contacts the ground midway through this phase and the abdominal muscles prepare to initiate trunk rotation toward home plate.

It is during the third phase, acceleration, that a majority of Little League elbow symptoms develop, caused by the extreme valgus forces produced in the pitching delivery. Also, if the body moves ahead of the arm in this phase, it is known as “opening up too soon” and this places stress on the anterior shoulder. Bryan suggests that the young pitcher should concentrate on keeping the opposite shoulder tucked under the chin to allow arm motion to accelerate before trunk rotation. The last phase is follow-through. In this phase, there is rapid pronation of the forearm which produces a shearing and compressive force between the radial head and the capitellum. Also, at the end of follow-through, the olecranon process slams into its fossa, and this can have consequences over time. If the stride foot is placed short of the midline in this phase, the pelvis will not rotate properly and the body will lose its momentum. The pitcher will “open up” too late and throw mainly with the arm. Things to look for in a young pitcher’s delivery include: balance, body rotation, shoulder rotation, proper stride, and sufficient follow-through.

**Effects of Delivery**

The type of pitching delivery can also affect the forces at the elbow during the throwing motion. Albright et al. discuss three types of delivery: vertical, three-quarter, and sidearm. They found that individuals who incorporated a sidearm delivery had a definite susceptibility to elbow injury. This method involves using the arm in a whipping type motion. The result is increased valgus forces about the elbow and increased incidence of elbow discomfort and pain. Albright et al. state that some of their subjects switched from sidearm to the three-quarter or vertical delivery. After the change, the subjects displayed a drastic decrease in elbow difficulty. It was concluded that an efficient, overhead delivery is not only more effective, but it also causes fewer injuries since there is less abnormal stress placed on the extremity.

**Type of Pitch**

The type of pitch thrown can also affect the forces at the elbow during the throwing motion. In the normal pitch, the arm has a natural inclination to pronate during the throwing motion. The immature pitcher believes that there is a need to forcefully supinate the forearm/wrist to elicit sufficient spin on the ball to make it curve. Repetitive attempts to go forcefully against the natural motion of the arm during a throw may cause irritation of the tendons and flexor muscles. Long-term exposure to this type of trauma may cause widening or separation of the medial epicondyle. Even with a three-quarter or vertical delivery, the repetitive shearing forces of the radial head on the capitellum and the jamming of the olecranon into its fossa may have long-term significance. An experienced coach will alter the young pitcher’s style away from the sidearm throwing delivery and prohibit the curve ball; both have been shown to cause symptoms of Little League elbow.

**PREVENTION**

Prevention of Little League elbow involves preseason stretching and strengthening programs, evaluating and correcting pitching techniques, limiting the number of pitches thrown, and, most importantly, educating coaches, parents, and athletes on the condition.

It has been said numerous times before, “Warm up to throw; do not throw to warm up.” Stretching and general calisthenics allow sufficient warm-up before throwing activity begins. Preseason training should gradually increase the number, distance, and intensity of throws. There should be no pitches thrown by a player from the mound until well into the second week of practice.

Although the Little League has restrictions on the number of innings pitched, tallying the number of pitches thrown is more important to avoid the condition of Little League elbow. This point should be stressed when educating coaches, pitchers, and parents, because more pitches are thrown during the week in practice than in a single game. Congeni sets reasonable limits in the range of 90 to 100 pitches per game or practice, barring elbow or shoulder pain. If discomfort arises, activity should stop and throws should decrease for the following few days. If pain persists, total rest and radiographic studies are recommended. Before returning to competition, the player should display a full recovery of strength, range of motion, and pain-free throwing.

**TREATMENT**

Developing bone is highly tenacious and displays remarkable healing capabilities. If symptoms of Little League elbow are recognized early and activity is restricted, injury can be kept to a minimum. However, enthusiastic children and adolescents have a tendency to postpone seeking medical attention until they are unable to throw because of pain. Unfortunately, swelling and limited elbow motion usually characterize more advanced overuse conditions. Prevention is the best way to “treat” Little League elbow. Radiographs are of little advantage in detecting early changes, but are needed to locate loose bodies, joint abnormalities, avulsions, and osteochondritis dissecans. These findings indicate the need to refer the patient to an orthopedist for evaluation.

Initial treatment involves resting the elbow joint and applying ice to alleviate pain, swelling, and inflammation. Athletic activities should be ceased until elbow tenderness has disappeared and the individual can complete a throwing motion with no pain or discomfort. Treatment should also include stretching and strengthening exercises of the flexor and extensor muscles of the forearm. An isotonic program of light weights and high repetitions decreases stress about the elbow, yet allows an endurance factor. It is important to provide support for the affected elbow at the beginning of rehabilitation. Wrist curls, a baseball curl-up weight, and/or therapeutic putty can also be used for both flexor and extensor muscles. Throwing activities should be commenced gradually and an elbow sleeve can be worn for support.
SUGGESTIONS AND CONCLUSION

We recommend the following for preventing Little League elbow:

1. Increase awareness among coaches, parents, and athletes.
2. Use proper warm-up, stretching, and strengthening.
3. Use proper pitching technique/mechanics.
4. Limit pitches thrown during games and practice (and home).
5. Prohibit breaking balls until the mid- to late-teenage years.
6. Rehabilitate previous injuries.
7. Improve early recognition of signs and symptoms.

Although the pitching rules established by the Little League have definitely decreased the incidence of Little League elbow, concerns on this injury extend well beyond restricting the number of innings pitched. All too often, a team is dependent on a single pitcher, and that individual is used in every possible situation as governed by the rules. Throwing during practice is also a major concern. As Gugenheim et al.11 stated, the problem of abuse of the pitching arm lies not on the baseball diamond, but on the practice field. In warmer climates, baseball is virtually a year-round sport, leaving the individual no recovery time or time for unstressed skeletal growth.

The youngsters involved in sports such as Little League, Junior Tackle Football, etc., are the athletes that athletic trainers will be treating in the future. Establishing lines of communication and relationships with coaches, parents, and athletes when the athletes are young is advantageous to the trainer. It simplifies initiation of future education/prevention programs as the athletes mature. Also, establishing a familiar history with the athletes makes future treatment that much easier. In addition, prevention of Little League elbow should include stretching and strengthening programs and limiting the number of pitches thrown daily. Both of these factors involve community education of the condition.

The type of delivery and pitch thrown is also important in avoiding Little League elbow. A sidearm delivery has been shown to increase the incidence of elbow discomfort or pain.2 A change to a vertical or three-quarter delivery proved to dramatically reduce elbow problems caused by a sidearm delivery.2 Video evaluation of the biomechanical aspects of the delivery and correcting problems will also decrease unnecessary stress on the elbow or shoulder. Throwing curve balls is another stress that can cause Little League elbow. Youngsters should not throw curve balls until the mid- to late-teenage years, giving the epiphyseal plate chance to fuse.

In treating the condition, coaches need to be aware of early warning signs. These include noticeable discomfort while throwing, or swelling and tenderness over the affected area. A gradual return to throwing activities should occur only when there is a full recovery of strength, range of motion, and painless throwing motion.8 Radiographic evidence of loose bodies, joint abnormality, avulsions, or osteochondritis dissecans indicate the need for referral to an orthopedist.8

Little League elbow is an avoidable overuse injury. Community education is an important key in decreasing its occurrence. Permanent injuries that do occur are often a result of late recognition or simply a lack of knowledge on the part of coaches, parents, and athletes. Future studies need to evaluate the effects of rigorous activity at an early age and examine just how tenacious the epiphyseal plates and elbow are in response to these stresses over time. As mentioned previously, longitudinal studies need to assess athletes who begin pitching at an early age and continue into their late-teenage years.

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REFERENCES

Kinematic and Electromyographic Analysis of Elbow Flexion During Inertial Exercise

James E. Tracy, MS, PT, ATC, CSCS; Shuchi Obuchi, MS, PT; Ben Johnson, PhD

Inertial exercise protocols are currently used clinically to improve and restore normal muscle function even though research to substantiate their effectiveness cannot be cited in the literature. The purpose of this study was to compare simultaneous kinematic and electromyographic (EMG) data obtained from 12 subjects during elbow flexion on the Impulse Inertial Exercise System. Testing sessions consisted of inertial exercise performed using phasic and tonic techniques with loads of: a) 0 kg, b) 2.27 kg, c) 4.54 kg, d) 6.80 kg, and e) 9.07 kg. Greater peak angular velocities, peak platform accelerations (change in velocity of platform during elbow flexion), mean and peak triceps brachii muscle EMG activity, and less range of motion were observed during phasic exercise. There was also a general trend for peak angular velocities and peak platform acceleration to increase as the load decreased. No significant difference in mean or peak EMG activity of the biceps brachii muscle was seen between techniques. Clinicians and athletic trainers using inertial exercise should consider both the exercise technique and load characteristics when designing protocols to meet the specific needs of patients.

Inertial exercise is a relatively new and unique form of muscle loading that simulates momentum and velocity changes occurring during functional activities. The Impulse Inertial Exercise System (EMA Inc, Newnan, GA) is an inertial exercise device that allows reciprocal acceleration and deceleration of a platform of variable mass along a horizontal track by a pulley cable system (see Figure). Exercises can be performed in various functional or straight plane patterns to simulate the desired activity, all of which are controlled by the patient.

Even though the clinical rationale for the use of inertial exercise is based on established physiological and mechanical principles, documentation pertaining to kinematic, kinetic, and electromyographic (EMG) measures during inertial exercise is yet to be reported. The literature substantiating the use of inertial exercise is therefore of a secondary nature and uses arguments not founded on research specific to inertial exercise. As a result, there is a need for the quantification of kinematic and EMG data specific to inertial exercise.

The purpose of this study was to biomechanically analyze and compare kinematic and EMG data collected during phasic and tonic elbow flexion inertial exercise with varied loads. Quantification of these variables in a controlled-exercise situation will provide objective data that can be related specifically to inertial exercise and its potential application in the functional training and rehabilitation of athletes and workers. We hypothesized that: 1) peak angular velocities, peak platform accelerations, and EMG activity of the biceps brachii and triceps brachii muscles during inertial exercise would be significantly different between loads; 2) peak angular velocities would exceed those currently attained with isokinetic devices; and 3) greater peak angular velocities, peak platform accelerations, and EMG activity would be attained with phasic exercise as compared to tonic exercise.

METHODS

A 2 × 5 statistical design was used to guide this investigation. Independent variables were exercise technique (phasic and tonic) and load (0 kg, 2.27 kg, 4.54 kg, 6.80 kg, and 9.07 kg). Dependent variables were: 1) peak angular velocity, 2) peak platform acceleration, 3) range of motion, 4 & 5) mean and peak EMG activity of the biceps brachii muscle, and 6 & 7) mean and peak EMG activity of the triceps brachii muscle.

Twelve women (age = 22 ± 1.5 yr) volunteered to participate in this study. Subjects received an upper quarter clearing exam before testing to rule out any previous or current upper extremity dysfunction. We familiarized all subjects with the purpose of the study, testing procedure, and instrumentation, and had each sign an informed consent statement. The Georgia State University Institutional Review Board approved this study.

We collected simultaneous EMG and kinematic data from each subject during maximal effort elbow flexion on the Impulse Inertial Exercise System. We analyzed data extracted from one elbow flexion movement at each load during the testing sessions.

We obtained kinematic data from the WATSMART digital motion analysis system (Northern Digital Inc, Waterloo, Ontario, Canada), which has been shown to be reliable. Sampling frequency was 200 Hz; angular velocity and acceleration data were calculated using differentiation of the marker position data. We used a 6-Hz Butterworth filter while collecting the acceleration data.

We collected EMG data with a Therapeutics Unlimited Model 544 Multichannel Electromyographic System (Thera-
Subject positioning and placement of IREDs during inertial exercise.

peutics Unlimited Inc, Iowa City, IA) using two 8-mm diameter silver/silver chloride electrodes (inter-electrode distance of 22 mm) with an on-site solid-state amplifier embedded in a plastic enclosure. The signals were preamplified, transmitted, and amplified again such that a maximal signal was observed. The common mode rejection ratio is 87 dB at 60 Hz, and the input impedance is greater than 15 M ohms at 100 Hz. For ease of interpretation, we converted raw EMG signals to root mean square values at a time constant of 11.75 m/sec and converted to digital output via the WATSCOPE (Northern Digital Inc, Waterloo, Ontario, Canada) data acquisition system. We viewed the raw signals on a Tektronics storage oscilloscope (Tektronics Inc, Beaverton, OR) to allow observance of the converted signal for determination of proper amplitude settings.

We located the muscle bellies of the right biceps brachii and the lateral head of the right triceps brachii muscles during maximal voluntary isometric contraction of each muscle. We identified and marked the midpoint of each muscle belly with a permanent ink marker. We lightly abraded the marked area with sandpaper to decrease skin impedance, placed electrolyte cream on each electrode, and secured the electrodes over the abraded skin with prefabricated double-sided adhesive tape. Each testing session began with placement of the EMG electrodes. Gain settings as determined by pretesting were set at 1 K (K = 1000 times) for the biceps brachii and 2 K for the triceps brachii. We observed EMG activity on the oscilloscope during isometric muscle contraction of each muscle to verify proper signal amplitude.

We positioned and secured with double-sided adhesive tape, three infrared light-emitting diodes over each of three anatomical landmarks on the subject’s right upper extremity (see Figure): a) 15.25 cm proximal to the elbow, b) over the lateral epicondyle, and c) 15.25 cm distal to the elbow. We also placed one infrared light-emitting diode on the sliding platform of the Impulse Inertial Exercise System to monitor the kinematics of the platform during testing. We used two cameras specifically designed to sense the infrared light emitted from the diodes during motion and integrated with the WATSMART system. The cameras were separated by a distance of 3 m, and positioned at a height of 2.5 m at a distance of 4 m from the Impulse Inertial Exercise System. The angle between the two cameras’ central line of view as measured from their convergence point at the Impulse Inertial Exercise System’s center was 29.

Before testing, we instructed each subject in the correct technique for phasic and tonic elbow flexion exercise and allowed time to practice each technique. When performing the phasic exercise, the subjects were instructed to move the platform as fast as they could, causing slack in the pulley cable. Pretesting showed that this task could be best accomplished if the subject performed the exercise through a limited range of motion. We instructed subjects to maintain constant tension on the pulley cable during exercise and to move the elbow through a larger range of motion than during phasic exercise. We seated subjects in a wooden chair with a backrest and secured their trunks with a waist belt. The elbow rested on a cushioned armrest to minimize shoulder activity (see Figure). Elbow and shoulder positioning before beginning testing were similar for all subjects. We did not position the shoulder or elbow in a standard position, based on the assumption that each subject would adapt to her optimum power production zone during the dynamic testing. Since peak kinematics of elbow flexion and extension were desired, positional postural requirements were less important than ensuring the subjects’ attained maximal kinematic values.

We taped infrared-emitting diode markers to the anatomical landmarks described above. Testing consisted of one session of both phasic and tonic exercise separated by at least 1 day using randomly ordered loads of: 1) 0 kg, 2) 2.27 kg, 3) 4.54 kg, 4) 6.80 kg, and 5) 9.07 kg (plus weight of the sliding platform = 1.47 kg). Each session began with a 30-second warm-up with a 4.54-kg weight followed by a 3-minute rest. The subject then performed voluntary maximal effort elbow flexion/extension for 20 seconds at each load setting with a 3-minute rest interval between trials. During the exercise bout, we collected data during a 5-second interval when it was determined by the test administrator that the subject was performing the exercise according to the previously stated directions.

We obtained kinematic and EMG data on all 12 subjects during testing, and generated group means for the previously determined biomechanical variables. We extracted one complete cycle (flexion/extension) from the 5 seconds of data collected. This cycle reflected a dynamic state of maximal elbow flexion to extension and back to full flexion at each load setting, verified by analyzing the linear displacement of the platform during exercise.

We analyzed the data using a multivariate analysis of variance (MANOVA) for the effects of the factors, technique, load, and the technique by load interaction on all dependent variables. MANOVA significance using Wilks’ criterion was determined at the p <.05 level. We further analyzed the data using univariate analysis to determine the effects of the factors on each dependent variable with significance being determined at the p <.05 level. We used Tukey’s multiple comparison testing to further identify differences in means between different levels of the dependent variables in which there was univariate significance.
RESULTS

Means and standard deviations of the dependent variables obtained from tonic and phasic exercise techniques are shown in Table 1. The kinematic variable peak platform acceleration is seen to increase as the load decreases for both tonic and phasic exercise. During tonic exercise, peak angular velocity also increased as the load decreased. Phasic exercise did not show consistent findings except for increases in peak angular velocity from 0 kg to 4.54 kg. Mean and peak biceps brachii EMG activity increased as the load decreased for both tonic and phasic exercise. During tonic exercise, peak angular velocity is seen to increase as the load decreases for both tonic and phasic exercise. Mean triceps brachii EMG activity decreased as the load increased during tonic exercise, while EMG activity increased as the load increased during phasic exercise. Phasic exercise did not show consistent findings except for increases in peak angular velocity.

There were overall significant differences between technique (F(8,92) = 22.85, p < .0001), load (F(32,340) = 5.47, p < .0001), and a technique by load interaction (F(32,340) = 1.60, p = .0236). The results of univariate analysis for each dependent variable for each of the factors are found in Table 2. Greater peak angular velocities and peak platform accelerations were significantly greater between loads of 0 kg, 2.27 kg, and 6.80 kg, but not between 6.80 and 9.07 kg. Range of motion was significantly greater in tonic versus phasic exercise. Mean and peak biceps brachii EMG muscle activity was not significantly different between exercise techniques but significantly greater mean and peak biceps brachii EMG activity was seen with a load of 9.07 kg versus 0 kg. The only significant difference reported for the mean and peak EMG activity of the triceps brachii was an increased activity during phasic exercise.

Table 1. Dependent Variables Measures for Tonic and Phasic Exercise Techniques (mean ± SD)

<table>
<thead>
<tr>
<th>Load</th>
<th>Tonic (°s⁻¹)</th>
<th>Phasic (°s⁻¹)</th>
<th>Tonic (°)</th>
<th>Phasic (°)</th>
<th>Tonic (mV)</th>
<th>Phasic (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak ang vel</td>
<td>392 ± 108</td>
<td>490 ± 177</td>
<td>43 ± 13</td>
<td>43 ± 8</td>
<td>.87 ± .36</td>
<td>1.19 ± .55</td>
</tr>
<tr>
<td>Platform acc</td>
<td>348 ± 85</td>
<td>421 ± 126</td>
<td>51 ± 16</td>
<td>41 ± 11</td>
<td>1.05 ± .47</td>
<td>1.11 ± .55</td>
</tr>
<tr>
<td>Range of motion</td>
<td>51 ± 16</td>
<td>49 ± 16</td>
<td>36 ± 12</td>
<td>43 ± 12</td>
<td>1.25 ± .64</td>
<td>1.47 ± .67</td>
</tr>
<tr>
<td>Mean biceps EMG</td>
<td>.87 ± .36</td>
<td>1.19 ± .55</td>
<td>.31 ± .31</td>
<td>.57 ± .29</td>
<td>4.34 ± 1.25</td>
<td>4.15 ± .8</td>
</tr>
<tr>
<td>Peak biceps EMG</td>
<td>1.05 ± .47</td>
<td>1.11 ± .55</td>
<td>.31 ± .25</td>
<td>.49 ± .22</td>
<td>3.83 ± 1.8</td>
<td>3.83 ± 1.96</td>
</tr>
<tr>
<td>Mean triceps EMG</td>
<td>1.25 ± .64</td>
<td>1.47 ± .67</td>
<td>.34 ± .33</td>
<td>.44 ± .24</td>
<td>6.48 ± 2.67</td>
<td>5.44 ± 2.43</td>
</tr>
<tr>
<td>Peak triceps EMG</td>
<td>1.43 ± .58</td>
<td>1.35 ± .62</td>
<td>.33 ± .27</td>
<td>.41 ± .15</td>
<td>5.08 ± 1.98</td>
<td>4.44 ± 1.9</td>
</tr>
<tr>
<td>F values: F(1,99) technique, F(4,99) load, F(4,99) interaction.</td>
<td>.0001</td>
<td>.0001</td>
<td>.0001</td>
<td>.0001</td>
<td>.0001</td>
<td>.0001</td>
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</table>

DISCUSSION

The basic principles of inertial exercise can all be related to Newton's three laws of motion. The load placed on the sliding platform acts as the mass, while force corresponds to muscular forces which initiate and accelerate a mass through a pulley cable system. The momentum and acceleration/ deceleration forces change as the velocity and direction of motion of the sliding platform are altered. By definition, inertia refers to the resistance an object offers to a change in its momentum, while moment of inertia refers to the resistance of a lever arm to a change in angular motion. Impulse refers to summation of forces associated with the accelerations and decelerations during exercise that are absorbed by the muscle during a specified period of time. When performed properly, inertial exercise enhances the power generated in the muscle by using stored elastic energy in the series elastic component of the muscle and

Table 2. Univariate Analysis for Kinematic and EMG Variables (p-values) Presented in Table 1

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Technique*</th>
<th>Factors load**</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak ang vel</td>
<td>.001</td>
<td>.0001</td>
<td>.87</td>
</tr>
<tr>
<td>Platform acc</td>
<td>.0001</td>
<td>.0001</td>
<td>.0001</td>
</tr>
<tr>
<td>Range of motion</td>
<td>.001</td>
<td>.81</td>
<td>.60</td>
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<tr>
<td>Mean biceps EMG</td>
<td>.39</td>
<td>.005</td>
<td>.30</td>
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<tr>
<td>Peak biceps EMG</td>
<td>.95</td>
<td>.007</td>
<td>.20</td>
</tr>
<tr>
<td>Mean triceps EMG</td>
<td>.0004</td>
<td>.74</td>
<td>.28</td>
</tr>
<tr>
<td>Peak triceps EMG</td>
<td>.0001</td>
<td>.71</td>
<td>.32</td>
</tr>
</tbody>
</table>

* Statistical difference between means p < .05 (see Table 2).
** Tonic & Phasic data combined.
by excitation of muscle spindles during the quick muscle stretch (myotatic reflex) experienced at the end of the deceleration or eccentric phase.\textsuperscript{1,4,5,7,13} The enhancement of these neurological and viscoelastic properties can be used to generate acceleration for the next concentric muscular contraction.\textsuperscript{1,19}

The ability to use the elastic and neurophysiological properties of muscle is theorized to facilitate increased muscle recruitment in a minimal amount of time and is interpreted clinically as increased power.\textsuperscript{1,4} Komi et al\textsuperscript{13} showed that stored elastic energy in the muscle was recovered most effectively when the amortization phase (the amount of time between a muscle's transition from an eccentric contraction to the initiation of a concentric contraction) was short. The ability to use this elastic energy in the muscle is also affected by time, magnitude of stretch, and velocity of stretch, all of which can be controlled during inertial exercise by changing either the load or exercise technique.\textsuperscript{4,13}

Albert\textsuperscript{1} described two specific inertial exercise techniques: phasic and tonic. The phasic exercise technique is characterized by cyclic bursts of muscular co-contraction, which allows slack in the pulley cable during contraction and would theoretically constitute more muscle spindle feedback and function to recruit dynamic joint stability. The tonic exercise technique is characterized by muscle contractions, which maintain a constant tension in the pulley cable throughout the exercise, emphasizing optimal joint stability.

Albert also studied the influence of inertial exercise on muscle torque in the biceps brachii. A pilot study done in 1987\textsuperscript{1} found no significant increase in concentric isokinetic peak torque at 90°/sec or 300°/sec in subjects who trained on the Impulse Inertial Exercise System three times a week for 5 weeks. Albert postulated that the lack of increases was because angular velocities during training sessions exceeded the velocities used during isokinetic testing. In a second study, Albert\textsuperscript{2} found increased concentric and eccentric torque at 60°/sec and eccentric torque at 120°/sec after a 5-week inertial exercise training program.

The results of our study support the hypothesis that significantly greater peak angular velocity, peak platform acceleration, and mean and peak EMG activity in the triceps brachii muscle occur with phasic exercise. Our hypothesis that greater range of motion occurs with tonic exercise was also supported, as was the hypothesis that peak angular velocities and peak platform accelerations would be different for the different loads with a general trend for these variables to increase as the load decreased. The increases in angular velocity and platform accelerations as load decreased is consistent with the typical force velocity curve.\textsuperscript{14} The findings of this study did not support the hypothesis of increased mean or peak EMG activity in the biceps brachii muscle during phasic exercise.

Maximum peak angular velocity averaged 490°/sec with a standard deviation of 177°/sec during phasic exercise with a 0-kg load. These values indicate that velocity values greater than 600°/sec are attainable in some subjects and support Albert's clinical hypothesis\textsuperscript{1} that exercise on the Impulse Inertial Exercise System is capable of exceeding velocities associated with most isokinetic devices. These peak elbow angular velocities are, however, still considerably lower than those reported in baseball pitchers, 2200°/sec\textsuperscript{23} and 4595°/sec\textsuperscript{20} and in water polo players, 1200°/sec\textsuperscript{23}.

The significantly greater peak angular velocities and peak platform accelerations during phasic exercise suggest the clinical use of this technique, particularly in patients or athletes involved in dynamic activities.\textsuperscript{1,16,21} The large accelerations observed during phasic exercise are likely to cause more stretch on the series elastic component and greater musculospindle feedback. The long-term effect of this type of high dynamic training may be increased dynamic stabilization of the joint.\textsuperscript{1} In contrast, tonic exercise resulted in significantly lower peak angular velocities and peak platform accelerations through a larger range of motion, which may indicate that this type of exercise is better suited for training programs designed for joint stability.\textsuperscript{1}

The EMG activity during inertial exercise was significantly greater in the triceps brachii muscle during phasic exercise. No significant differences were observed in the EMG activity of the biceps brachii muscle between the two exercise techniques, although significantly more biceps brachii activity was seen for exercise using a load of 9.07 kg, versus 0 kg. Triceps brachii muscle EMG activity showed a consistent decrease in EMG activity as load increased during both tonic and phasic exercise, while the biceps brachii muscle showed a general increase in EMG activity during tonic exercise as the load increased and no trend in EMG activity as the load increased during phasic exercise.

One possible explanation for the EMG activity observed in this study could be related to the orderly recruitment of motor units in human muscle from the smaller slow twitch to the larger fast-twitch fibers as the demands for more powerful actions are required.\textsuperscript{6} This seems to be true for the biceps brachii muscle, which, in this study, is the prime mover responsible for initiating movement along the horizontal track. During tonic exercise, the biceps brachii muscle generally showed increased activity as mass increased, indicating more motor unit recruitment as the load increased.\textsuperscript{6} This relationship was probably not observed in the phasic exercise because larger bursts of muscle activity may recruit all muscle types. The more powerful ballistic nature of this exercise was likely to cause more synchronous activation of all available motor units, violating the normal recruitment sequence.\textsuperscript{10} The limited activity in the triceps brachii muscle during tonic exercise is likely related to the slower nature of this exercise and the fact that the triceps brachii muscle did not have to overcome a substantial amount of resistance during extension of the elbow. During phasic exercise, the triceps brachii muscle was required to move more quickly in a more ballistic manner, which may account for the greater EMG seen with phasic exercise.\textsuperscript{10}

Clinically, we know that many shoulder injuries are a result of the deceleration forces imparted to the shoulder tissues during the follow-through phase of throwing, while most elbow injuries are attributed to forces created during the acceleration phase.\textsuperscript{18,20} High-velocity joint rotations, combined with factors such as muscle imbalances, inadequate coordination of the muscles surrounding a joint, decreased flexibility, or fatigue can alter the body's ability to properly
absorb the acceleration and deceleration forces directed into the joint area.3,18

Inertial exercise, because it more closely simulates the normal acceleration/deceleration forces created around a joint during functional and sport-specific activities,17,22 may prove a more useful training tool to prevent injury than currently used protocols. Training of the neural component of the neuromuscular system attained through the practice of specific skills appears to be as important as muscle strength in perfecting certain skills and preventing injury.18,24 Inertial exercise, therefore, offers advantages over current isokinetic devices which are limited by: 1) a fixed plane of motion, 2) a lack of specific functional or closed chain testing modes, 3) maximal velocities up to 600°/sec, and 4) constant velocity settings with minimal acceleration and deceleration.1 As a result, inertial exercise more realistically replicates the true kinematics and kinetics present in most sport- or work-related activities that involve significant joint accelerations and decelerations.1

More research is needed to fully understand the potential and application of inertial exercise in rehabilitation and in specific sports training programs. Specific factors, such as changes in the length of the amortization phase as described by Komi et al,13 need to be quantified at different load settings and before and after training. More detailed EMG analysis related to specific timing of EMG activity relative to the position of the moving platform and to the stretch-shorten cycle needs to be examined. This type of information would add credibility to, or refute the many untested theories associated with inertial exercise and EMG activity. Specific points such as the catch phase described by Albert1 also need to be quantified to actually describe the biomechanical factors at play when significant changes in joint velocity occur during inertial exercise. The implications for work and sport-specific training programs need further investigation, especially as to the possible improvement in these tasks as documented by improved performance. The use of inertial exercise as a training device in which subjects are given ample time to perfect the exercise skill may also result in even greater angular velocity values.15

CONCLUSION

The data collected in this study provide objective kinematic and EMG data for elbow flexion motion during inertial exercise performed at five different loads. 1) There were significant differences between the phasic and tonic exercise technique and between different loads. 2) There was a general trend for peak angular velocity and peak platform accelerations to increase as the load decreased. 3) There was significantly greater mean and peak triceps brachii muscle activity (EMG) during the phasic exercise and significantly greater mean and peak EMG activity in the biceps brachii muscle between the loads of 9.07 kg and 0 kg. 4) Significantly greater range of motion occurred during the tonic exercise. 5) Athletic trainers using inertial exercise should therefore consider both the exercise technique and load parameters when designing protocols to meet the specific demands of their patients and athletes.

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Glenoid Dysplasia

Terry Randall, MS, PT, OCS, ATC

ABSTRACT: Athletic trainers evaluate many athletes with acute and chronic shoulder problems such as rotator cuff pathology, impingement syndromes, and inflammatory conditions. They also need to be aware of more obscure reasons for shoulder pain and dysfunction. The purpose of this paper is to describe a rare congenital abnormality called glenoid dysplasia, which can be responsible for a variety of shoulder complaints in athletes. Characteristics of glenoid dysplasia are seen on radiographs and include a shallow glenoid fossa and a hypoplastic scapular neck. This case study depicts an athlete who functioned at a very high level for many years before developing symptoms. This athlete was able to continue an active lifestyle but some limitations were recommended.

T he shoulder is commonly injured in athletic endeavors. Athletic trainers must be knowledgeable in the evaluation and rehabilitation of common shoulder injuries and also be aware of the more obscure causes of joint dysfunction. The consideration of alternate diagnosis may lessen the chance of delayed or inappropriate treatment.

Common shoulder problems that athletic trainers may need to evaluate include rotator cuff pathology, impingement syndromes, and symptoms related to instability. These problems may be acute or chronic. An example of a rare cause of shoulder dysfunction in an athlete is glenoid dysplasia. Other rare causes of shoulder pain that must be considered include: injuries to the brachial plexus during birth, which may lead to abnormal development of the glenohumeral joint; avascular necrosis of the humerus, which is usually unilateral; and epiphyseal dysplasia, which can affect many joints simultaneously.7

Glenoid dysplasia is rare, but there are reported cases in the orthopedic literature. A review of 50 cases showed that glenoid dysplasia is usually detected in late adolescence, presumably during a period of high activity, or during the fifth or sixth decade of life, when degenerative changes may be occurring.4 Some authors believe that glenoid dysplasia is due to autosomal dominant inheritance.1 This may be true in the presence of multiple anatomic anomalies, but the cause of isolated glenoid dysplasia is unknown. The purpose of this paper is to increase the awareness of athletic trainers toward this rare, congenital abnormality that may mimic other types of shoulder pathology.

CASE REPORT

A 28-year-old male active duty soldier was referred to the physical therapy clinic with a diagnosis of a left shoulder rotator cuff injury. He was a right-hand dominant, former linebacker for an NCAA Division II conference championship football team. He had recently developed left shoulder pain while lifting weights. While bench-pressing 420 lb, he felt a sudden pain in the posterior aspect of his shoulder as he was lowering the bar. He was able to continue his workout despite discomfort, although he did lower his weight to 300 lb. The pain intensified over the next few days and he was unable to continue his normal weight-training routine. He was also forced to stop doing any overhead work with his left upper extremity and could not do push-ups without pain. He had no limitations or pain with activities of daily living. It should be noted that he had only recently returned to a strenuous weight-training routine following a hiatus of several years.

On physical examination 3 weeks following injury, the patient had normal range of motion at the shoulder with normal scapulohumeral rhythm and no tenderness to palpation. There was no noted asymmetry or muscle atrophy in the shoulder girdle. Manual muscle testing of internal and external rotation produced shoulder discomfort, but his strength graded 5/5. No instability was detected with manual stress tests in multiple joint positions. The apprehension sign and the drop arm test were negative. Impingement signs were negative.3,6 No other musculoskeletal abnormalities were detected in the left shoulder girdle. No cervical spine pathology was present.

Due to the traumatic onset, continued pain with strenuous activity, and the inability of the athlete to return to his previous level of function, radiographs of the left shoulder were obtained. They showed a deformity involving the glenoid fossa, scapular neck, and the humeral head (see Figure). The glenoid fossa was poorly formed and appeared to have an irregular surface. The scapular neck was hypoplastic and the portion of the humeral head in contact with the glenoid was flattened. These are common radiographic findings with glenoid dysplasia.2 Radiographs of the other shoulder showed similar findings to a lesser degree. Magnetic resonance imaging revealed a flattened glenoid fossa with a scalloped appearance on the articular surface consistent with glenoid dysplasia. Since there were minimal limitations in function, further invasive testing, such as arthrography or arthroscopy, was not recommended.

The athlete’s history was significant in that he was able to function at a very high level for many years in the presence of a congenital abnormality without complaints of shoulder pain or dysfunction. During 3 years of successful intercollegiate football competition and training, he reported no shoulder injuries or pain.

His rehabilitation program emphasized strengthening of the scapular stabilizers and rotator cuff musculature and began upon confirmation of the diagnosis. Exercises such as rowing, press-ups, and push-ups with a plus have been found to have high EMG activity in the trapezius, rhomboid major, and serratus anterior muscles.5 High EMG activity has been noted

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AP view of the shoulder and glenohumeral joint demonstrating a deformity involving the glenoid fossa, scapular neck, and the humeral head. The scapular neck is incompletely developed or hypoplastic. The glenoid surface does not have a normal contour and has an irregular surface area in contact with a flattened humeral head. These findings are common with glenoid hypoplasia.

in the rotator cuff muscles with a military press, scaption (elevation in the scapular plane) with internal rotation, and horizontal abduction. The athlete was followed over a 3-month period, and activities such as heavy resistance training and overhead work were restricted. During this time, he developed no additional symptoms relating to shoulder dysfunction and had no limitations with his job. He was able to do push-ups without significant limitations but could not perform them on a daily basis, as shoulder discomfort would gradually increase.

DISCUSSION

Although no specific rehabilitation guidelines exist for this condition, this patient’s exercise program addressed the probability of future impingement due to the decreased mechanical advantage of the rotator cuff and the medial positioning of the glenohumeral joint secondary to the hypoplastic scapular neck. Progression of the degenerative process of the glenoid surface was another concern.

Lintner provides arthroscopic documentation of progressive deterioration of an already abnormal joint surface in a Division I football player. This observation led Lintner to recommend a decrease in stressful activities while maintaining the integrity of the shoulder girdle musculature. Similarly, the patient in this case study was advised to continue a general weight training program for the left shoulder to include the rotator cuff musculature, but more stressful activities, such as heavy weight training and repetitive throwing, were discouraged.

All athletic trainers will deal with rare injuries or unusual disorders during their careers. This case illustrates the importance of the differential diagnosis in the evaluation of musculoskeletal problems. In this case, the evaluation provided by the athletic trainer was instrumental in the development of the proper diagnosis. Athletic trainers should develop and use their expertise in the evaluation of sports injuries to assist in the diagnostic process.

While delayed or misdiagnosis is inevitable for some rare conditions, it is hoped that, by presenting this case, awareness of glenoid dysplasia as a possible cause of shoulder pain will be increased.

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Improving Rehabilitation Effectiveness by Enhancing the Creative Process

William A. Pitney, MS, ATC; Edwin E. Bunton, MS, ATC, CSCS

ABSTRACT: Creativity is a tacit component of a rehabilitation program that must be exercised by a clinician to avoid stagnation of rehabilitative innovation. Enhancing creativity can improve rehabilitation effectiveness but requires a conscious effort on the part of a clinician. There are many components to encouraging the creative process, but few authors have grouped them into a single step-by-step process. The authors of this paper have developed the CLEAR method to enhancing creativity. This method represents a summation of various strategies offered in the literature and comprises five steps: 1) challenging old routines, 2) learning new attitudes, 3) enlisting idea-generation exercises, 4) assessing the new idea for safety, and 5) revising the idea so that it is safe and suitable for rehabilitation.

The topic of creativity has been investigated in many professions. Although it is viewed as a significant component of many tasks, there is a paucity of literature discussing creativity in athletic rehabilitation. Despite this lack, creativity is a tacit element of an athletic rehabilitation program. Creative thinking is critical for disseminating technology, managing resources, and solving problems. Because creative care is viewed by injured clients as being very individualistic and problem-specific, it may also help improve athlete compliance. Moreover, when activated, the creative process can facilitate a dynamic and challenging program that makes the rehabilitation process enjoyable for both the athlete and the clinician. The purpose of this paper is to examine creativity and its relevance to athletic rehabilitation and to discuss strategies to enhance the creative process, specifically the CLEAR method, which we have developed to help facilitate creative thinking.

CREATIVITY

Creativity is simply showing imagination, combining concepts into new compilations or procedures, and finding new avenues to accomplish the same result. Too often, people believe that others are inherently creative and that they themselves do not possess this given ability. Thus, they seemingly give up trying to be creative or innovative because they feel that an idea has already been created or performed. Creativity, however, is an omnipresent characteristic manifested in every individual to some degree. Furthermore, an idea or innovation only needs to be new to that individual to be creative.

Although many athletic trainers may learn to be very creative, aspects of rehabilitation can offer us many challenges. Clinicians are often faced with protocols that can cause a habit of executing tasks the same way time after time. Moreover, these standards and custom procedures become frozen to the point that creativity or innovation ceases. These habits or standards may save time and be more comfortable for the clinician, but, unfortunately, the athlete may grow tired of doing the same things the same ways time after time.

From a rehabilitation perspective, if the creative process is not exercised, it will start to decline, leading to stagnation of ideas or innovations. Therefore, clinicians have a responsibility to challenge themselves to seek creative avenues. Furthermore, problem solving is an integral part of clinical practice and improving creativity can allow us to become better problem solvers. Quite often we need to expand our thinking and gather information before we can adequately develop a solution, and creativity is especially important when we are exploring different solution strategies.

As clinicians, we should be compelled to be inventive during the rehabilitation process, because functional rehabilitation is only limited by our imagination. Moreover, determinants of rehabilitation programs not only include the patient and the type of injury sustained but also the innovation of the clinician. We must use our creative processes in the rehabilitation environment to foster excitement for the athlete, protect our own welfare, and continually strive to be innovative, thus contributing to quality practice. Additionally, practitioners can use their creative resources to cope with health care changes.

ENHANCING THE CREATIVE PROCESS

Enhancing individual creativity takes effort and persistence. Although there is no one strategy or technique that is guaranteed to make an individual more creative, there are many techniques to help enhance the creative thought process. We have developed the CLEAR method to help an individual enhance his/her creative process (Fig 1). The CLEAR method represents a summation of various strategies and concepts offered in the literature and may benefit clinicians as they strive to make creativity an important link in the chain of rehabilitation. The CLEAR method consists of five steps: 1) challenging old routines; 2) learning new attitudes; 3) enlisting idea-generation exercises; 4) assessing the new idea for safety; and 5) making revisions so that the new idea is suitable for use during the rehabilitation program.

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The CLEAR Method for Enhancing Creativity

Challenge old habits and routines as well as rigid thinking and hardened thought.

Learn new attitudes such as mental flexibility and optimism.

Enlist specific exercises to help generate clinical ideas and innovations.

Assess the new ideas for relevance and safety. Assess the new innovations to assure they will help meet your goals.

Revise any innovations and ideas to help achieve your goals.

Fig 1. The CLEAR method for enhancing creativity.

Challenging Old Routines

Challenging old routines refers to the clinician’s ability to unlearn old habits and obstacles that interfere with the creative process. There are many obstacles or barriers that limit professional creativity, including hardened thoughts, intolerance of ambiguity, conformity, and ridiculing new ideas. These particular characteristics, especially hardened attitudes, are not conducive to a quality rehabilitation service. It is well documented that challenging the typical way of thinking is an important step to enhancing creativity. By challenging our old habits and comfortable surroundings, we allow new information to become integrated into our programs. The creative process may not grow to new avenues if these aforementioned obstacles cannot be unlearned.

Learning New Attitudes

Learning new attitudes or characteristics is essential to the creative process. Challenging or unlearning old habits and learning new concepts can foster creative thinking and enhance idea development as well as problem-solving ability. If the clinician chooses to maintain “old” habits and new frames of mind are not incubated, innovations or ideas may never be fully developed. Creative attitudes that need to be learned include positive thinking, being dissatisfied, rearranging thinking patterns, and combining existing concepts of rehabilitation.

Enlisting Idea-Generation Techniques

Enlisting the use of techniques refers to using specific cognitive exercises to help generate ideas of quality as well as quantity. These specific techniques can be used by an individual or group whose main focus is to generate new and exciting ideas for rehabilitation procedures. Techniques for idea generation are abundant in the literature and, hence, only a few selected techniques will be offered here. Some specific techniques for generating ideas include Cournoyer’s One Minute Creator, brainstorming, and the Gordon technique. The One Minute Creator, developed by Cournoyer, is a series of questions that may work well in a rehabilitation setting, especially when one is focusing on functional exercises. Cournoyer suggests taking 1 minute to ask yourself questions about a problem or, considering rehabilitation, a specific exercise. The questions he suggests include but are not limited to: What can you combine?; What can you rearrange?; What if you examine both extremes?; What can you adapt?; What if you turn it upside down?; What if you invert the cause and effect?; What if you omit some steps?; and What if you negate it as a problem?

The brainstorming technique for idea generation is perhaps the most widely used and is excellent for developing a large quantity of ideas. Brainstorming is performed by simply stating a problem and submitting multiple suggestions to help solve it. Von Fange offers four guidelines to conducting a brainstorming session: 1) the problem should be stated in basic terms; 2) do not find fault with any idea; 3) reach for any idea no matter how remote it may seem; and 4) provide the necessary support to help free restricted attitudes. Remember that, when brainstorming, every idea is important because often they can be useful after being cultivated and refined.

The Gordon technique may be well suited for generating ideas in a rehabilitation setting. This particular technique investigates underlying concepts rather than trying to generate ideas for a specific problem. For example, if a clinician is trying to create a new knee exercise to help an individual control function in the transverse/frontal plane, he/she would become a group leader and ask other clinicians to devise new lower extremity exercises using any available equipment. By examining exercises of the lower extremity instead of the knee, early closure to the problem is prevented and insurgent applications are encouraged.

Assessing the New Idea for Safety

The fourth step of the CLEAR method is assessing the idea or innovation for clinical relevance and safety. Safety during rehabilitation is paramount. When working with individuals and creating new avenues to restore function, we must assess the safety of an exercise before use and respect normal biomechanics. The rules of rehabilitation, as stated by Gray, include: 1) Create an environment for optimal healing; 2) Above all else, do no harm; and 3) Be as aggressive as you can without breaking rule number two. The author suggests that a fourth rule is often necessary that states: Be as innovative as possible without causing harm.
Fig 2. In this instance, the use of a slide board can be altered to move the left knee into the transverse/frontal plane.

Revise

Revising a new idea for an exercise may be necessary, especially if it is not biomechanically safe. Many ideas are not used because the practical application is not easily recognized. Cultivate your ideas and revise them as necessary to make them safe, effective, and feasible in the rehabilitation process.

IMPLEMENTING CREATIVITY INTO A REHABILITATION PROGRAM

Creativity can improve our clinical problem-solving ability and allow us to invent better solutions to rehabilitation problems. Many exercises are used to address various functional deficits. As clinicians, we may have several techniques that we continually use because we are comfortable with them and have achieved past results. As stated earlier however, the creative process can become frozen if it is not used, and having athletes performing the same exercises time after time may lead to noncompliance. Therefore, the following includes a typical clinical deficit and traditional methods used to help resolve the deficit and restore function. These traditional exercises will be contrasted with alternative, creative exercises (products of the CLEAR method) to illustrate new and innovative avenues for achieving results. We consent that there may be several readers who have developed similar exercises to achieve clinical goals. It is the process that should be considered here and not necessarily the exercise presented.

The problem of knee instability or sensations of “giving way” is a common clinical deficit. Knee collapse typically occurs in the transverse/frontal plane and, therefore, function in this plane should be addressed under clinical control. Unfortunately, standard treatment of knee collapse often consists of general lower extremity strengthening and proprioceptive exercises. Alternative exercise would need to focus on challenging movement into the transverse/frontal plane emphasizing eccentric control.

Using the steps of the CLEAR method, common exercises can be evaluated and challenged to see what can be altered or combined to develop effective exercises. The slide board is one such piece of equipment that can be used in alternative creative ways to facilitate safe movement into the transverse/frontal plane (Fig 2). A step and resistive tubing can also be combined to promote control and function in the transverse/frontal plane in a safe manner (Fig 3). These exercises can range from simple to complex and can be performed on a variety of terrains. Furthermore, external stimuli can be used to remove the conscious task of the movement (Fig 4) and to make the exercise more enjoyable for the athlete. These exercises are...
CONCLUSION

Clinicians can realize many benefits from enhancing their inventive capabilities. These benefits might include: a more exciting and dynamic work place, improved compliance on behalf of the athlete, enhanced problem-solving ability, and innovative creations that may lead to better therapeutic results. Functional rehabilitation is only limited by our imagination. Therefore, we must cultivate our ideas and attempt to enhance our creativity to minimize our shortcomings. Although using creative ideas on inanimate objects is very feasible, employing innovative techniques in a rehabilitation program must never compromise an athlete’s safety. Hence, our development of the CLEAR method, which offers individuals a step-by-step process for enhancing their clinical creativity and allows for assessment of clinical relevance and safety.

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A Modified Low-Dye Taping Technique to Support the Medial Longitudinal Arch and Reduce Excessive Pronation

Shane S. Schulthies, PhD, PT, ATC; David O. Draper, EdD, ATC

The low-dye arch support is a common taping technique used in athletic training. The tape on the bottom of the foot is pulled from a lateral to a medial direction to support the medial longitudinal arch of the foot. This medial support may reduce excessive subtalar joint pronation that accompanies the lowering of the medial longitudinal arch. Many authors have reported the relationship that exists between subtalar joint pronation and lowering of the medial longitudinal arch. While anecdotal evidence suggests that the low dye arch support taping technique may be effective in relieving many of the symptoms accompanying lowered medial longitudinal arches, a more in-depth understanding of the mechanics of weight-bearing foot pronation may lead to a more effective method to apply the low-dye arch support.

A description of weight-bearing foot pronation while the foot is flat on the ground may be made as follows. When the subtalar joint pronates, the calcaneus everts, while the talus moves medial, plantar flexes, and internally rotates (Fig 1). This results in dorsiflexion and abduction of the midtarsal joint on its oblique axis and inversion of the midtarsal joint along its longitudinal axis (Fig 2). This motion of the midtarsal joint is the primary mechanism in lowering of the medial longitudinal arch. If pronation of the subtalar joint is excessive, or if the motion of the midtarsal joint is limited, pronation of the subtalar joint will cause dorsiflexion of the first tarsal-metatarsal joint. This is the secondary mechanism producing the lowering of the medial longitudinal arch.

Naturally, to support the medial longitudinal arch, you must reduce the motions that cause it to lower, namely: subtalar joint pronation; midtarsal joint longitudinal axis inversion; midtarsal joint oblique axis dorsiflexion, and abduction; and first tarsal-metatarsal joint dorsiflexion. We have described a modified low-dye taping technique that attempts to support the medial longitudinal arch in such a manner.

Place the athlete either sitting or supine with the lower leg supported by a table and the foot extending past the table. After applying an anchor around the metatarsal heads, place figure-eight strips on the sole of the foot, similarly to a longitudinal arch support taping technique. This is accomplished by attaching the tape to the dorsomedial aspect of the first metatarsal head, encircling the posterior aspect of the calcaneus, pulling the tape obliquely along the plantar aspect of the foot, and attaching the tape again to the dorsomedial aspect of the first metatarsal head. When attaching the tape to the first metatarsal head, passively evert the forefoot and plantar flex the first metatarsal (Fig 3). This is accomplished by simply twisting the forefoot so that the sole of the foot is turned out. Take care not to passively pronate the subtalar joint (evert the calcaneus) during this procedure. This is accomplished by keeping tension on the tape while applying the figure-eight strip around the posterolateral aspect of the calcaneus. Visually monitor the calcaneus during this procedure to ensure that it does not evert. Then apply three to five figure eights to the first metatarsal head while twisting the forefoot each time to evert, plantar flex, and adduct the forefoot on the rearfoot. You may also apply alternating figure eights to the fifth metatarsal head, but do not attempt to evert the forefoot during their application.

Then apply lateral to medial strips of tape to the plantar aspect of the foot, beginning on the calcaneus and moving toward the forefoot until reaching the first cuneiform. At this point, reverse the direction of the tape and pull from medial to lateral to further evert the forefoot and plantar flex the first metatarsal (Fig 4). Take care not to excessively evert the

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Fig 2. Movement of the foot with closed chain pronation of the subtalar joint. Note: as the rearfoot everts (calcaneus), adducts, internally rotates, and plantar flexes (talus), the forefoot must invert (longitudinal midtarsal joint axis), dorsiflex, and adduct (oblique midtarsal joint axis). (Reprinted from: Kapandji JA. The Physiology of the Joints. London: E & S Livingstone; 1970-74:227 with permission from IA Kapandji.)

Fig 3. Application of the figure-eight strips. The forefoot is passively everted and the first metatarsal is plantar flexed by the athletic trainer’s left hand. The pull of the tape on the lateral calcaneus provides a counterforce to allow the subtalar joint to remain in the neutral position.

forefoot and plantar flex the first metatarsal. This may cause the first metatarsal head to strike the ground first during early midstance which may cause abnormally high pressures under the first metatarsal head. This may also cause the subtalar joint to supinate excessively during weight bearing.3

Complete the taping technique by applying strips of tape around the transverse plane of the foot (from the dorsomedial aspect of the first metatarsal head around the posterior aspect of the calcaneus to the dorsolateral aspect of the fifth metatarsal head). Then apply strips of tape over the dorsum of the forefoot. This will secure the tape previously applied to the plantar surface of the foot. When the taping technique is complete, evaluate the foot for a reduction of excessive pronation while the athlete is standing (Fig 5, a & b). Question the athlete about discomfort due to tightness and/or overcorrection. The toes will often slightly splay as the forefoot is everted and this is generally not a concern if it is not excessive (Fig 6).

We have described a modified low-dye arch support in order to more effectively reduce excessive subtalar joint pronation. The medial longitudinal arch is supported by stabilizing the first metatarsal in plantar flexion and stabilizing the midtarsal joint in adduction, plantar flexion, and eversion. This taping technique differs from the traditional arch support by manually everting the forefoot on the rearfoot and plantar flexing the first metatarsal during application of the figure-eight strips and reversal of direction of the lateral strips halfway up the plantar aspect of the foot. In performing this technique, remember the adage “tape is medicine, tension is dose.”9 It is imperative that the subject be evaluated for a decrease in pronation, and/or a change in symptoms upon completion of the procedure. If
results are unsatisfactory, the procedure should be revised, either increasing or decreasing the tension of the tape until the patient is satisfied.

We have also explained the relationship between lowering of the medial longitudinal arch and subtalar joint pronation. Many authors have stated the importance of controlling abnormal subtalar joint pronation in the treatment of overuse injuries including: medial shin splints, posterior tibial tendonitis, plantar fasciitis, and patellofemoral pain syndrome.\textsuperscript{1,2,4,5,8,9} We believe the modified low-dye taping technique described above is effective in the short-term management of overuse injuries, secondary to abnormal pronation. Additionally, the taping technique may be used to evaluate the effect of reducing pronation on the athlete’s symptoms; this may serve as a tool to predict the effectiveness of future foot orthotic intervention.

The authors believe that, as with many taping techniques, cost, skin breakdown, and the possible creation of new overuse injuries preclude the long-term use of this technique. If one desires a long-term reduction of subtalar joint pronation or a long-term arch support, foot orthotic intervention is the indicated treatment.

REFERENCES

Students will master basic principles with this hands-on workbook.

The Kinesiology Workbook, 2nd Edition, links theory with reality. It reinforces the basic principles of kinesiology and biomechanics and relates these principles to the evaluation techniques of manual muscle testing and goniometry. An array of exercises covers each major joint, gait, and posture evaluation—making this workbook a great value to all rehabilitation students!

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- Chapter 6, Foot and Ankle, has been significantly expanded
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Lower extremity closed kinetic chain exercises are commonly performed by athletes during rehabilitation of knee injuries and are often integrated early in the rehabilitation progression. The standing terminal knee extension using resistance is a closed kinetic chain exercise often used in knee rehabilitation programs. Einhorn et al describe this exercise using an elastic band for resistance. Other authors describe the exercise using surgical tubing for resistance. When a Theraband (The Hygenic Corporation, Akron, OH) elastic band is used to perform the terminal knee extension exercise, it often rolls or bunches behind the knee in the popliteal space (Fig 1) causing discomfort. This makes performing the exercise more difficult. I have found that applying a foam pad to the Theraband reduces the bunching behind the knee and allows the athlete to perform the standing terminal knee extension more comfortably. Anecdotal reports from athletes indicate that using the padded elastic band is more comfortable than using the elastic tubing alone when performing this exercise.
Step 1: Select the appropriate resistance (color) Theraband and cut a 60-inch piece.
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Step 3: Tie the band securely to a treatment table leg.
Step 4: Have the athlete position the foam pad behind the knee and perform the exercise (Figs 3 & 4).

Protocols should be determined according to the athlete’s stage of rehabilitation and should be modified as the athlete progresses. The closed kinetic chain terminal knee extension can easily be incorporated into an athlete’s home rehabilitation program. To make the exercise more challenging, you can increase the number of repetitions, increase the tension on the elastic band, and/or use a higher resistance Theraband color.

ACKNOWLEDGMENTS

Thanks go to Melissa Marcus, ATC, who helped inspire this tip, to Lisa Mattea for being a patient model, and to Carolyn Jimenez, ATC, for the photographs.

REFERENCES

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Open rotator cuff repair has shown reliable results in terms of pain relief and improved shoulder function. Recently, however, arthroscopically assisted rotator cuff repair has shown promising preliminary results. We compared the results of these two procedures with regard to pain, function, range of motion, strength, patient satisfaction, and return to previous activity. Thirty-seven rotator cuff repairs were evaluated in 36 patients with a minimum follow-up of 2 years. The open repair group comprised 20 shoulders with an average follow-up of 3.3 years; the arthroscopically assisted repair group comprised 17 shoulders with an average follow-up of 3.2 years. Overall, the open repair group had 80% good-to-excellent results and 88% patient satisfaction, and the arthroscopically assisted repair group had 85% good-to-excellent results and 92% patient satisfaction. Shoulder flexion and abduction strength, the size of the tear repaired, and the functional outcome did not differ significantly between the two groups. In general, however, small and moderate-sized tears (< 3 cm) had better functional outcome with arthroscopically assisted repair. The arthroscopically assisted repair group was hospitalized 1.2 days less and returned to previous activity an average of 1 month earlier. In the surgical treatment of symptomatic complete rotator cuff tears, arthroscopically assisted rotator cuff repair is as effective as open repair.

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The detachment of the superior labrum from anterior to posterior has variously been reported. This lesion has been classified into four types. It was our impression that not all superior labrum abnormalities fit into such a classification system and that the mechanism of injury was distinctly different. During a 5-year period, 84 of 712 (11.8%) patients had significant labral abnormalities; 52 of 84 patients (62%) had lesions that fit within the classification system (Type II, 55%; III, 4%; IV, 4%), but 32 of 84 patients (38%) had significant findings that could not be classified. These unclassifiable lesions fit into three distinct categories. Two of three patients described a traction injury to the shoulder. Only 8% sustained a fall on an outstretched arm; 75% had a preoperative diagnosis of impingement based on consistent history and provocative testing; however, when examined under anesthesia, 43% of the shoulders were considered to have increased humeral head translation when compared with the other shoulder. Recognition of superior labrum-biceps tendon detachment should prompt the surgeon to investigate glenohumeral instability as the source of a patient’s complaints.

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We report four cases of acute midsubstance rupture of the patellar tendon that were treated with primary surgical repair, with semitendinosus autograft augmentation. The goal of this treatment was to allow immediate mobilization of the knee with a single operative procedure. We also demonstrate a technique for determining patellar position intraoperatively. Patients were tested for functional performance at an average final follow-up of 40 months (range, 20 to 66) including hamstring and quadriceps muscle strength evaluation, completion of a functional questionnaire, functional test performance, range-of-motion assessment, and patellar tendon length measurement. In evaluating the results, all cases were essentially identical to the
nonoperated side, except one knee that had multiple associated ligament injuries. The multitude of injuries to this knee are likely the cause of the discrepancy. Immediate midsubstance patellar tendon repair with semitendinous augmentation allowed immediate mobilization, which decreased the recovery period and improved the outcome of rehabilitation. Furthermore, a second surgery for hardware removal was not needed. These two factors—early and improved rehabilitation and the decreased chance of a second surgery—affect the cost of treatment of this injury. All isolated patellar tendon injuries in the study had excellent function at follow-up. For these reasons, we recommend this procedure for acute patellar tendon ruptures.

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In a previous study we used technetium-99 m bone scans to show that cooling a knee for 20 minutes with a standard ice wrap will decrease soft tissue blood flow by a mean of 26%, and skeletal blood flow and metabolism by 19%. The present study examined the effects of shorter and longer icing periods to determine minimum cooling time for a measurable and consistent decrease, and time to produce maximal decrease within a safe period of icing (< 30 minutes). Thirty-eight subjects were studied. An ice wrap was applied to one knee for an assigned time (5, 10, 15, 20, or 25 minutes). Triple-phase bone scans of knees were obtained; mean percentages of decrease in the iced knee for each of the five time groups at each of the three phases of the bone scan were calculated and compared. Mean decreases of 11.1% in soft tissue blood flow, and 5.1% in skeletal metabolism and blood flow were measured at 5 minutes; maximums of 29.5% and 20.9%, respectively, were obtained at 25 minutes. A small but consistent decrease in soft tissue blood flow and skeletal blood flow and metabolism in a knee appear to be obtained with as little as 5 minutes of ice application. This effect is time-dependent and can be enhanced three- to four-fold by increasing the ice application time to 25 minutes.

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This study sought to compare the effects of morphine, bupivacaine, and saline injected into the knee after arthroscopic surgery. In a double-blind, randomized trial, 124 patients received either bupivacaine, morphine, bupivacaine and morphine, or saline at the completion of surgery. Postoperative pain was assessed with a 100-mm visual analog pain scale. Analgesic requirements were calculated, and weight-bearing status was recorded. We found that morphine alone injected intra-articularly at the completion of arthroscopic knee surgery had no significant effect on postoperative pain, need for supplemental analgesia, or weight-bearing status. Patients receiving morphine alone injected intra-articularly had no significant effect on postoperative pain, need for supplemental analgesia, or weight-bearing status. Patients receiving morphine in combination with bupivacaine did not demonstrate any statistically significant improvement over those receiving bupivacaine alone. Therefore, our results failed to show any beneficial effect of morphine used for postoperative analgesia, either alone or in combination with bupivacaine. The overall pattern in all patients demonstrated decreased pain scores, decreased analgesic use, and increased weight-bearing status as the observation period progressed. Finally, preoperative pain was correlated with pain at discharge, indicating that the most significant predictor of postoperative pain was preoperative level of discomfort.

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Before studying the biomechanical effects of rehabilitation exercises on the reconstructed knee, it is important to understand their effects on the normal anterior cruciate ligament. The objective of this investigation was to measure the strain behavior of this ligament during rehabilitation activities in vivo. Participants were patient volunteers with normal anterior cruciate ligaments instrumented with the Hall effect transducer. At 10° and 20° of flexion, ligament strain values for active extension of the knee with a weight of 45 N applied to a subject’s lower leg were significantly greater than active motion without the weight. Isometric quadriceps muscle contraction at 15° and 30° also produced a significant increase in ligament strain, while at 60° and 90° of knee flexion there was no change in ligament strain relative to relaxed muscle condition. Simultaneous quadriceps and hamstrings muscle contraction at 15° produced a significant increase in ligament strain compared with the relaxed state but did not strain the ligament at 30°, 60°, 90° of flexion. Isometric contraction of hamstrings muscles did not produce change in ligament strain at any flexion angle. Exercises that produce low or unstrained ligament values, and would not endanger a properly implanted graft, are either dominated by the hamstrings muscle (isometric hamstring), involve quadriceps muscle activity with the knee flexed at 60° or greater (isometric quadriceps, simultaneous quadriceps and hamstrings contraction), or involve active knee motion between 35° and 90° of flexion.

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To describe the role of the scapular muscles in the golf swing, we studied 15 competitive male golfers. Four muscles were studied bilaterally using dynamic
electromyography and cinematography. In the trailing arm, the levator scapulae elevates while the rhomboid muscles retract the scapula during takeaway; both then stabilize the scapula through the remainder of the swing. In the leading arm, these muscles retract the scapula during forward swing and acceleration. The trapezius muscle in the trailing arm also demonstrates high activity during takeaway to aid in scapular retraction. In the leading arm, trapezius activity is high in forward swing and through the remainder of the swing to promote scapular retraction. The serratus anterior muscle activity is high in the trailing arm during forward swing and through the remainder of the swing to maximize scapular protraction. In the leading arm, the serratus anterior muscle has constant activity through all phases of the swing, which may explain the clinical scenario of muscle fatigue in high demand golfers. The golf swing and uncoiling action requires that the scapular muscles work in synchrony to maximize swing arc and clubhead speed. This study demonstrates the importance of the scapular muscles in the golf swing and the need for specific strengthening exercises.

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We treated painful bipartite patella with a modified lateral retinacular release technique in 15 patients (16 knees). Bony union of the separated fragment and the patella was obtained in 15 of 16 knees within 8 months of surgery. Sustained traction acting on the patella laterally and proximally is presumed to cause the pain. The surgical technique to reduce this force proved effective not only in relieving the pain but also in achieving bony union. Painful bipartite patella can lead to excessive lateral pressure syndrome or patellar compression syndrome, these complications can be effectively treated by this surgical technique. In contrast to conventional treatments, such as excision of smaller fragments or osteosynthesis to achieve bony union, the modified lateral retinacular release technique is easy to perform and provides an effective means for relieving patellofemoral pain and achieving bony union.

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We know it is important to avoid excessive strain on reconstructed ligaments, but we do not know how individual muscles affect cruciate ligament strain. To answer this, we studied the effect of muscle forces and external loads on cruciate ligament strain. Nine cadaveric knee joints were tested in an apparatus that allowed unconstrained knee joint motion. Quadriceps, hamstring, and gastrocnemius muscle forces were simulated. Additionally, external loads were applied such as varus-internal or valgus-external rotation forces. Cruciate ligament strain was recorded at different knee flexion angles. Activation of the gastrocnemius muscle significantly (p < .05) strained the posterior cruciate ligament at flexion angles larger than 40°. Quadriceps muscle activation significantly strained the anterior cruciate ligament when the knee was flexed 20° to 60° (p < .01) and reduced the strain on the posterior cruciate ligament in the same flexion range (p < .05). Activation of the hamstring muscles strained the posterior cruciate ligament when the knee was flexed 70° to 110° (p < .05). Combined varus and internal rotation forces significantly increased anterior cruciate ligament strain throughout the flexion range (p < .05). The results suggest that to minimize strain on the ligament after posterior cruciate ligament surgery, strong gastrocnemius muscle contractions should be avoided beyond 30° of knee flexion. The study also calls into question the use of vigorous quadriceps exercises in the range of 20° to 60° of knee flexion after anterior cruciate ligament reconstruction.

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Eight cadaveric lower extremities were examined by three experienced knee surgeons in blinded fashion. The knees were examined with intact anterior cruciate ligaments, sectioned anterome-

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dial bundles, and completely sectioned anterior cruciate ligaments to evaluate detectable laxity changes. Lachman, anterior drawer, lateral pivot shift, and KT-1000 arthrometer testing were performed. Optimized biplanar radiography using a defined spatial coordinate reference system was performed with a 30-lb anterior force at 30° of flexion to confirm clinical findings. Physical examination and arthrometer testing detected no difference between intact and partially sectioned anterior cruciate ligaments; these ligaments were significantly different than completely sectioned ligaments, with the Lachman test being the most sensitive. Despite consistent clinical detection of complete sectioning of the anterior cruciate ligament by both physical examination and arthrometer testing, neither method proved accurate in the diagnosis of isolated tears of the anterior-medial bundle, but both did show that partially sectioned anterior cruciate ligament closely resembled intact ligament and differed significantly from completely sectioned ligament, as confirmed by radiologic data. Clinically diagnosed partial tear is likely to be complete rupture of the anterior cruciate ligament. Historically, clinically diagnosed partial tears of the anterior cruciate ligament have tended to progress to symptomatic instability. Our data imply these patients may have had functionally incompetent ligaments from time of injury and, in fact, were demonstrating the expected natural history of an anterior cruciate ligament-deficient knee.


The purpose of this investigation was to determine the performance and physiologic characteristics of a successful American high school football team, and to compare the present values with values reported for other groups of high school, college, and professional players. For descriptive purposes, players were divided into two groups: backs (n = 8) and linemen (n = 10). Maximal aerobic power (VO₂ max) was determined from a maximal treadmill test, and body composition was evaluated by hydrostatic weighing. Maximal strength values were evaluated by one-repetition maximum bench press and squat test; the sit-and-reach test was used to measure flexibility. Speed and power were evaluated by a vertical jump and a 36.6-meter sprint. Results indicate that compared with other groups of college and professional players, as the level of competition increases so do height, weight, and fat-free weight of the players. Similar maximum oxygen consumption values were found for the present group when compared with other groups of these players. From the strength and power standpoint, football players at all levels are becoming stronger. Incorporation of strength training programs has greatly improved strength and performance profiles of football players at all levels of competition.


We have developed a noninvasive ultrasound technique that may be used to differentiate complete and incomplete acute tears of the anterior talofibular ligament. Direct visualization of the ligament will demonstrate the lesion in most cases and can be supplemented by an anterior drawer test with the ligament under direct vision. Seventeen athletes involved in sports and work that put high-demand pressure on their ankles underwent ultrasonic examination of their acute lateral ankle ligament injuries before surgical exploration. Fourteen scans demonstrating a complete lesion of the anterior talofibular ligament were confirmed at operation. Three scans were equivocal; two of these patients had incomplete lesions of their anterior talofibular ligaments and one patient had a complete tear that was not detected. We have found that the dynamic ultrasound test is a simple and reliable examination. We suggest that this technique is indicated where the extent of an acute lateral ligament injury requires further definition. Ankle ultrasonography may reduce the need for ankle arthrography.
Sports Injury Management
Anderson MK, Hall SJ
Williams & Wilkins, A Waverly Company, Baltimore, MD
1995
712 pages
Price: $45.95

*Sports Injury Management* would be a valuable text for any clinical athletic training program. The primary objective is to incorporate basic medical concepts and scientific knowledge so that the reader can acquire a strong background in the areas of injury prevention, recognition, assessment, management, disposition, and rehabilitation. The major focus is to improve the problem-solving skills of the reader.

The organization of the text includes:

**Section 1:** Foundations of sports injury management (2 chapters). Topics include responsibilities of the sports medicine team, standards for professional practice, legal liabilities, medical records, and career opportunities in athletic training; injury mechanisms, soft tissue, bone, and nerve injuries, and pain are discussed.

**Section 2:** Sports injury management (4 chapters). Topics include emergency procedures that may be encountered during athletic training duties, anatomical foundations, injury assessment, history of the injury, observation and inspection, palpation, special tests, injury recognition, SOAP notes, an overview of various therapeutic exercises and modalities used in athletic training, and principles of protective equipment for the head, face, and the upper and lower body.

**Section 3:** Injuries to the lower extremity (3 chapters); **Section 4:** Injuries to the upper extremity (3 chapters); **Section 5:** Injuries to the axial region (3 chapters). The content of the chapters include: 1) an anatomical and biomechanical overview of the body region or joint, 2) injury prevention, 3) specific sports injuries and management, and 4) an injury assessment using the HOPS format (history, observation and inspection, palpation, and special tests).

**Section 6:** Special conditions related to sports (2 chapters). Topics include injuries and conditions of the genitalia, sexually transmitted diseases, menstrual irregularities, and sports participation concerns for birth control and pregnancy, environmental considerations, respiratory tract conditions, gastrointestinal tract, diabetic athlete, contagious viral diseases, epilepsy, hypertension, anemia, substance abuse, and eating disorders.

Each chapter in the text includes: 1) learning objectives, 2) thought questions, 3) marginal definitions and tips, 4) tables, 5) field strategies, and 6) a summary section. These features supplement the text and enhance the learning process. Each chapter is well organized allowing for easy reading. I would like to see key terms at the beginning of each chapter, icons to highlight NATA competencies required by athletic training education programs, and color photos of various skin diseases. These features would supplement the text allowing for better comprehension.

The interview with one of six athletic trainers at the beginning of each section is an interesting addition to the text. It allows the student to get various perspectives on athletic training, see how these individuals started, and what it takes to be an athletic trainer today. The thought questions throughout each chapter are also an interesting addition to the text. They require the reader to critically analyze information in an attempt to solve the problem. The correct response is supplied at the end of the specific section.

The instructor's manual and the computerized test bank are available to the instructor. The computerized test bank (Macintosh and IBM compatible) supplies the instructor with 700 test questions that supplement the text. The student manual is designed to move the student through the injury evaluation, address proper vocabulary, and techniques to assess and manage each injury.

This text is very similar to the 8th edition of Arnheim and Prentice's *Principles of Athletic Training*, or the 3rd edition of Booher and Thibodeau's *Athletic Injury Assessment*. What differentiates this text from them is its problem-solving approach to learning (thought questions and case studies). Various pedagogical features allow the reader to become more involved in the text (learning objectives, marginal definitions, and field strategies). The text is well written and has elaborate illustrations that catch the reader's attention. These features invoke comprehension and retention, thus enhancing the learning process. I highly recommend this text to supplement any clinical athletic training program. It would also be an excellent reference text for the practitioner.

*Mark R. Casterline, MS, ATC*
USOC Training Center
Colorado Springs, CO
McDavid Introduces New Hinged Knee Brace

The #428 Pro Stabilizer™ Deluxe Hinged Knee Brace with condyle pads is a professional quality, bilateral design for advanced knee support and protection. This long-sleeve knee support features 3/16-inch thick thermal neoprene and geared polycentric hinges with contoured rubber pads to enhance the fit as well as support the medial and lateral condyles. It also features hyperextension stops and a patellar buttress. Its superior design lends itself to knee protection for all types of sports and activities. It fits left or right knee, has nylon on two sides, and comes in black or beige.

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1994 Outstanding Manuscript Awards

Congratulations to the following authors. The Editorial Board selected the following seven manuscripts for special merit from among those published in the *Journal of Athletic Training* during 1994. Good work, folks!

**Outstanding Research Article:**
- **Winner:** Myrer JW, Draper D, Durrant E. Contrast therapy and intramuscular temperature in the human leg. 1994;29:318.
- **First Runner-up:** Rimington SJ, Draper DO, Durrant E, Fellingham G. Temperature changes during therapeutic ultrasound in the precooled human gastrocnemius muscle. 1994;29:325.
- **Second Runner-up:** Zemper ED. Analysis of cerebral concussion frequency with the most commonly used models of football helmets. 1994;29:44.

**Outstanding Clinical Article:**
- **First Runner-up:** Pitney WA, Bunton EE. The integrated dynamic exercise advancement system technique for progressing functional closed kinetic chain rehabilitation programs. 1994;29:297.
- **Second Runner-up:** Nellis SM. Leadership and management: techniques and principles for athletic training. 1994;29:328.

### 18th Annual NATA Student Writing Contest

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

1. The contest is open to all undergraduate members of the NATA.
2. Papers must be on a topic germane to the profession of athletic training and can be case reports, literature reviews, experimental reports, analysis of training room techniques, etc.
3. Entries must not have been published, nor be under consideration for publication by any journal.
4. The winning entrant will receive a cash award and the paper will be published in the *Journal of Athletic Training* with recognition as the winning entry in the Annual NATA Student Writing Contest. One or more other entries may be given honorable mention status.
5. Entries must be written in journal manuscript form and adhere to all regulations set forth in the “‘Authors’ Guide’” of the *Journal of Athletic Training*. We suggest that, before starting, you read: Knight KL. Tips for scientific/medical writers. *J Athl Train.* 1990;25:47–50. NOTE: A reprint of this article, along with other helpful hints, can be obtained by writing to the Writing Contest Committee Chairman at the address below.
6. Entries must be received by March 1, 1996. Announcement of the winner will be made at the Annual Meeting and Clinical Symposium in June.
7. The Writing Contest Committee reserves the right to make no awards if, in their opinion, none of the entries is of sufficient quality to merit recognition.
8. An original and two copies of the paper must be received at the following address by March 1, 1996.

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(DEADLINE FOR ABSTRACT SUBMISSION: JANUARY 5, 1996)

INSTRUCTIONS FOR SUBMISSION OF ABSTRACTS AND PROCESS FOR REVIEW OF ALL SUBMISSIONS

Please read all instructions before preparing the abstract. Individuals may submit more than one abstract, but no individual may be the primary (presenting) author on more than one paper. All abstracts will undergo blind review.

I. SPECIFIC CONTENT REQUIREMENTS: FREE COMMUNICATIONS ABSTRACTS

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

- BASIC SCIENCE - includes controlled laboratory studies in the subdisciplines of exercise physiology, biomechanics, and motor behavior, among others, which relate to athletic training and sports medicine.
- CLINICAL STUDIES - includes assessment of the validity, reliability, and efficacy of clinical procedures, rehabilitation protocols, injury prevention programs, surgical techniques, and so on.
- EDUCATIONAL RESEARCH - a broad category ranging from basic surveys to detailed athletic training/sports medicine curricular development. An abstract in this category will generally include assessment of student learning, teaching effectiveness (didactic or clinical), educational materials, and curricular development.
- SPORTS INJURY EPIDEMIOLOGY - includes studies of patterns of injury among athletes. These studies will generally encompass large-scale data collection and analysis. Surveys and questionnaires may be classified in this category but are more likely to come under the Observational/Informational Studies category.
- OBSERVATIONAL/INFORMATIONAL STUDIES - includes studies involving surveys, questionnaires, and descriptive programs, among others, which relate to athletic training and sports medicine.

II. INSTRUCTIONS FOR PREPARING A FREE COMMUNICATIONS ABSTRACT:

1. Provide all information requested on the Abstract Author Information Form. Abstracts are to be typed or word processed using a LETTER QUALITY printer with no smaller than elite (12 cpi) or 10-point typeface. Do not use a dot-matrix printer.
2. Top, bottom, right, and left margins should be set at 1.5" using a standard 8.5" x 11" sheet of paper. Type the title of the paper or project in all CAPITAL letters on the left margin.
3. On the next line, indent 3 spaces and type the names of all authors with the author who will make the presentation listed first. Type the last name, then initials (without periods), followed by a comma; continue with the other authors (if any), ending with a colon.
4. Indicate the institution where the research or case report was conducted on the same line following the author(s) names.
5. Double space and begin typing the text of the abstract flush left in a single paragraph with no indentations. Do not justify the right margin.
6. The abstract should not exceed 500 words.

III. SPECIFIC CONTENT REQUIREMENTS: CLINICAL CASE REPORTS

This category of abstracts involves the presentation of unique individual athletic injury cases of general interest to our membership. Abstracts in this category must include the following information. This year, no form is provided so that authors may use their own word-processing software to format and submit the following information using...
IV. INSTRUCTIONS FOR PREPARING A CLINICAL CASE REPORT ABSTRACT:

1. An individual may submit only one clinical case report abstract as primary (presenting) author; however, there is no limit to the number of abstracts (free communications or case reports) listing an individual as co-author.
2. Clinical case report abstracts are to be word-processed or typed using a letter-quality printer with no smaller than elite (12 characters per inch) or 10-point font. Do not use a dot-matrix printer.
3. Top, bottom, right, and left margins should be set at 1.5" using a standard 8.5" × 11" sheet of paper. Type the title of the paper or project in all CAPITAL letters on the left margin.
4. Provide all information requested on the information form below. Please note that the institution where the clinical case occurred should be cited, not the author(s)' current address, if different.
5. The title of the clinical case report should not contain information that may reveal the identity of the individual nor the specific nature of the medical problem to the reader. An example of a proper title for a clinical case report is, "Chronic Shoulder Pain in a Collegiate Wrestler".
6. Complete the six different categories of information as required for a clinical case report abstract. These categories are:
   a. PERSONAL DATA/PERTINENT MEDICAL HISTORY (provide the age, gender, sport/occupation of individual, their primary complaint, and pertinent aspects of their medical history),
   b. PHYSICAL SIGNS AND SYMPTOMS (a brief summary of the physical findings),
   c. DIFFERENTIAL DIAGNOSIS (array of possible injuries/conditions),
   d. RESULTS OF DIAGNOSTIC IMAGING/LABORATORY TESTS,
   e. CLINICAL COURSE (eg, diagnosis, treatment, surgical technique, rehabilitation program, final outcome),
   f. DEVIATION FROM THE EXPECTED (a brief description of what makes this case unique).

V. INSTRUCTIONS FOR SUBMITTING ABSTRACTS (EITHER FREE COMMUNICATIONS OR CASE REPORTS)

1. Complete the form and mail it, the original abstract, two photocopies of the original abstract, six (6) blind copies (showing no information about the authors or institution) of the Abstract and a labeled 3.5" DISKETTE copy (preferably in WordPerfect or ACSII format; if you must send it in MacIntosh format, please use a high-density diskette) of your abstract and the following author information to:
   NATA-REF Free Communications
   2952 Stemmons Freeway
   Dallas, TX 75247

   MAILING ADDRESS OF PRESENTING AUTHOR (Please type; provide full name rather than initials)
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   KEY WORDS (2-6 words that identify your abstract): __________________

   Indicate the most appropriate TYPE for the presentation (check one only):
   ____________________________________________ Free Case Report Communication
   __ Clinical Communication

   If FREE COMMUNICATION, indicate the most appropriate CATEGORY for your presentation (check one only):
   Basic Science Clinical Studies
   Educational Sports Injury Research Epidemiology
   Observational Studies

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

2. Abstracts POSTMARKED AFTER JANUARY 5, 1996 WILL NOT BE ACCEPTED.
The NATA Board of Certification accepts this continuing education offering for .5 hours of prescribed CEU credit in the program of the National Athletic Trainers’ Association, Inc, provided that the test is used and completed as designed.

Please note the new procedure for participating in this program. Read the material in this issue carefully, photocopy this page, and record your test answers on this page. It is no longer necessary to photocopy the test. Fill in your name, address and other information and mail with $15 for processing to the address below. FOR CREDIT, the form must be postmarked by December 15, 1995.

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

### June ’95 CEU Quiz Answers

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### INSTRUCTIONS

1. Carefully read the articles in this issue.
2. Photocopy this page.
3. Record your answers below by darkening the appropriate letter of your answer.
4. Mail with $15 fee (check or money order only payable to Indiana State University) postmarked by December 15, 1995 to:

JAT— CEU Quiz

Athletic Training Department

Indiana State University

Terre Haute, IN 47809

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### CEU Quiz Evaluation

1. Questions challenging enough? □Yes □No
2. Presented clearly? □Yes □No
3. Material covered well? □Yes □No
4. Will information be useful to you in your work? □Yes □No

Please add any suggestions on how to improve the CEU Quiz on the back of this form when you are finished.

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

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| 5 | a | b | c | d | e | 10| a | b | c | d | e| 15| a | b | c | d | e |
1. A biological waste mailing system:
   a. requires a long-term contract with the company.
   b. requires mailing waste disposal kits to an approved facility for disposal.
   c. protects against hazardous dumping and contamination of the environment.
   d. does little to reduce unnecessary risk of exposure to the general public.
   e. Both b and c.

2. Athletic trainers who are responsible for developing educational programs with respect to blood-borne pathogens should provide appropriate information concerning:
   a. the risk of transmission or infection during competition.
   b. the risk of transmission or infection generally.
   c. the availability of HIV testing.
   d. the availability of HBV testing and vaccinations.
   e. All of the above.

3. Inertial exercise offers advantages over current isometric devices that are limited by:
   a. a fixed plane of motion.
   b. maximal velocities up to 3000°/sec.
   c. too many specific functional or closed chain testing modes.
   d. None of the above.
   e. All of the above.

4. A study of the effects of cryotherapy on agility indicated:
   a. athletes with a hypersensitivity to cold were adversely affected.
   b. a significant difference in agility time between ice immersion and no ice sessions.
   c. subjects experienced altered sensations and subsequent apprehension and had trouble participating in vigorous exercise after ice immersion.
   d. cooling the foot and ankle does not affect functional agility.
   e. All except b.

5. The modified low-dye arch support taping technique differs from the traditional arch support by manually everting the forefoot on the rearfoot and plantar flexing the first metatarsal during application and reversal of direction of the tape halfway up the plantar aspect of the foot.
   a. True
   b. False

6. In assessing postural sway,
   a. athletic trainers should be aware that variability can exist between testers and subjects for static and dynamic testing conditions.
   b. there is an established system of evaluating dynamic balance using field tests.
   c. devices such as the Chattecx Dynamic Balance System can help provide athletic trainers with a reference for comparison.
   d. many studies have examined the reliability of the Chattecx System and indicate good reliability.
   e. a and c only.

7. While physiological evidence indicated that the "Breathe-Right" device did not enhance exercise performance, all subjects believed that the device in some way opened up their nasal passages.
   a. True
   b. False

8. Which of the following should not be a factor in deciding whether athletes infected with blood-borne pathogens should be allowed to participate in athletic competitions?
   a. The nature and intensity of the athlete's training.
   b. The potential risks of the infection being transmitted.
   c. The desires of the athlete.
   d. The administrative and legal needs of the competitive program.
   e. None of the above. All should be considered.

9. Advantages of ankle braces over tape might include:
   a. reduced budgetary costs to the team or institution.
   b. more postactivity support to the ankle.
   c. more preactivity support to the ankle.
   d. All of the above.
   e. a and b only.

10. Common findings with glenoid dysplasia include:
    a. radiographs showing a poorly formed glenoid fossa with an irregular surface.
    b. radiographs showing a hypoplastic scapular neck and the portion of the humeral head in contact with the glenoid flattened.
    c. magnetic resonance imaging revealing a flattened glenoid fossa with a scalloped appearance on the articular surface.
    d. All of the above.
    e. None of the above.

11. "Little League elbow" is:
    a. an avulsion of the ossification center of the lateral epicondylar epiphysis in pubertal pitchers.
    b. not significant relative to the large number of youth participants in organized baseball.
    c. a concern because damage to the epiphyseal plate at this stage of development can result in permanent cessation or retardation of growth in any bone of the pitching arm.
    d. traumatic to younger baseball players, but readily disappears by the time they enter high school.
    e. Both a and c.

12. A study of the effect of ACL reconstruction using a patellar tendon graft on anterior knee laxity indicated that:
    a. degree of reduction in laxity (presurgery to postsurgery) was dependent on rotation and force.
    b. degree of reduction in laxity (presurgery to postsurgery) was greatest in internal rotation.
    c. anterior tibial translation was significantly reduced postsurgery for internal and external rotation, but not in the neutral position.
    d. anterior tibial translation was not significantly reduced postsurgery for internal or external rotation or for the neutral position.
    e. None of the above.

13. A comparison of four techniques to manage the airway in a cervical spine injury with the least amount of cervical spine movement showed:
    a. tissue compliance, especially between the scalp and the skull, renders the comparison invalid.
    b. the pocket mask insertion technique required less time than the other three techniques, but did not produce less extraneous cervical spine motion than the manual or power screwdriver methods.
    c. the use of bolt cutters was the quickest and safest technique for removing the face mask with minimal spine movement.
    d. the use of an electric screwdriver was faster and produced less cervical spine motion than the manual screwdriver.
    e. the Trainer's Angel was by far safer and faster than any of the other techniques with no rebound effects.

14. Wearing the Breathe-Right nasal dilator:
    a. increases nasal gas conduction and improves performance.
    b. increases VO₂ and peak VO₂/kg, but not respiratory exchange ratio or onset of VO₂ max.
    c. may give athletes a psychological edge if not a physiological one.
    d. increases VO₂ and VO₂ max, but not peak VO₂/kg.
    e. increases max WATT output.

15. Enhancing creativity in the rehabilitation program:
    a. is something that anyone can do; an idea or innovation only needs to be new to that individual to be creative.
    b. is something that only a few can do; most do not believe that they are inherently creative.
    c. is especially important when we are exploring different solution strategies.
    d. probably is unimportant in most instances because standard time-tested protocols are usually the best.
    e. a and c only.
Submit one original and three copies of the entire manuscript (including photographs, artwork, and tables) to the editor.

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The Journal of Athletic Training uses a double blind review process. Authors should not be identified in any way except on the title page.

Manuscripts are edited to improve the effectiveness of communication between the author and the reader and to aid the author in presenting a work that is compatible with the style policies found in the AMA Manual of Style, 8th ed. (William & Wilkins 1989). The author agrees to accept any minor corrections of the manuscript made by the editors. Galleys are sent to the author for proofreading when the article is typeset for publication and it is important that they be returned within 48 hours. Important changes are permitted, but authors will be charged for excessive alterations.

Published manuscripts and accompanying work cannot be returned. Unused manuscripts will be returned when submitted with a stamped, self-addressed envelope.

STYLE POLICIES

The active voice is preferred. Use the third person for describing what happened. "I" or "we" (if more than one author) for describing what you did, and "you" or the imperative for instruction.

Each page must be typewritten on one side of 8.5 × 11 inch plain paper, double spaced, with one-inch margins. Do not right justify pages.

Manuscripts should contain the following, organized in the order listed below, with each section beginning on a separate page:

a. Title page
b. Acknowledgments
c. Abstract and Key Words (first numbered page)
d. Text (body of manuscript)
e. References
f. Tables—each on a separate page
g. Legends to Illustrations
h. Illustrations

Begin numbering the pages of your manuscript with the abstract page as #1; then, consecutively number all successive pages.

Titles should be brief within descriptive limits (a 10-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.

The title page should also include the names, titles, and affiliations of each author, and the name, address, phone number, and fax number of the author to whom correspondence is to be directed.

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.

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.

Begin the text of the manuscript with an introductory paragraph or two in which the purpose or hypothesis of the article is clearly developed and stated. Tell why the study needed to be done or the article written and illuminate with a statement of the problem (or controversy). Highlights of the most prominent works of others as related to your subject are often appropriate for the introduction, but a detailed review of the literature should be reserved for the discussion section. In the one to two paragraph review of the literature, identify and develop the magnitude and significance of the controversy, pointing out differences between others' results, conclusions, and/or opinions. The introduction is not the place for great detail; state the facts in brief specific sentences and reference them in the discussion. The detail belongs in the discussion. Also, an overview of the manuscript is part of the abstract, not the introduction.

The body or main part of the manuscript varies according to the type of article (examples follow); however, the body should include a discussion section in which the importance of the material presented is discussed and related to other pertinent literature. Liberal use of headings and subheadings, charts, graphs, and figures is recommended.

The body of a Review of the Literature article should be organized into subsections in which related thoughts of others are presented, summarized, and referenced. Each subsection should have a heading and brief summary, possibly one sentence. Sections must be arranged so that they progressively focus on the problem or question posed in the introduction.

The body of a Case Study should include the following: a statement of the personal data (age, sex, marital status, and occupation when relevant—but not name), chief complaint, history of present complaint (including symptoms), results of physical examination (e.g., x-ray, laboratory findings), factors related to the rehabilitation program (e.g., injuries or medical findings in the rehabilitation program were...), medical history (surgery, laboratory results, exam, etc.), diagnosis, treatment and clinical course (rehabilitation until and after return to competition), criteria for re-turn to competition, and deviation from the expected (what makes this case unique). NOTE: It is mandatory that the Journal of Athletic Training receive, with the manuscript, a release form signed by the individual being discussed in the case study. Case studies cannot be reviewed if the release is not included.

The body of a Technique Article should include both the how and why of the technique, a step-by-step explanation of how to perform the technique, supplemented by photographs or illustrations; and why the technique should be used. The discussion of why should review similar techniques, point out how the new technique differs, and explain the advantages and disadvantages of the technique in comparison to the other techniques.

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.

The manuscript should not have a separate summary section—the abstract is 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.

Citations in the text of the manuscript take the form of a superscripted number, which indicates the number assigned to the citation. It is placed directly after the reference or the name of the author being cited. Referen­ces should be used liberally. It is unethical to present others' ideas as your own. Also, use references so that readers who desire further information on the topic can benefit from your scholarship.

The reference page(s) accompanying a manuscript should list authors numerically in alphabetical order, should be in the following form: a) articles: author(s) (list all) with the family names then initials, title of article, journal title with abbreviations as per Index Medicus (italized or underlined), volume, year, inclusive pages; b) books: author(s), title of book (underlined), city, state of publication, publisher, year, inclusive pages of citation. Examples of references to a journal, book, presentation at a meeting are illustrated below. See the AMA Manual of Style for other examples.

D. Behnke R. Literature for athletes' problems: solutions and prevention. Presented at the 29th Annual Meeting and Clinical Symposium of the National Athletic Trainers' Association; June 15, 1978; Las Vegas, NV.

Tables must be typed. See references cited in #5 or #19a for table formatting.

Type legends to illustrations on a separate page followed by Xerox copies of the illustrations. Photographs should be glossy black and white prints. D or not use paper clips, write on photos, or attach photos to sheets of paper. Carefully attach a written label to the back of each photograph so that the photograph is not damaged. Graphs, charts, or figures should be of good quality and clearly presented on white paper, 3½" or 7½" wide, with black ink to 10 point san serif typeface, no box, and printed on laser printer—no dot matrix.

All artwork to be reproduced should be submitted as camera-ready black and white line art. If artwork is to be reproduced in black, please send a second (or proof) color. It should be submitted as black and white line art. Clearly mark each area of color, or areas of shading or screening (a percent or tint of black or a color), on a separate photocopy. Authors will pay for color.
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Certification from BCP is the highest endorsement received in the pedorthic field. BCP is a national association that sets the standards for certification and credentialing of certified pedorthists and pedorthic facilities. BCP administers an annual certification exam for pedorthic candidates, and has recently revised its stringent guidelines for pedorthic facility accreditation.

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