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Effectiveness of a Polyurethane Football Helmet Cover on the Repeated Occurrence of Cerebral Concussions

ABSTRACT & COMMENTARY

Synopsis: *The natural history of recurrent concussions may not be affected by the use of this helmet cover.*

Source: Torg JS, et al. Retrospective report on the effectiveness of a polyurethane football helmet cover on the repeated occurrence of cerebral concussions. *Am J Orthop* 1999; 28(2):128-132.

Concussion, and particularly recurrent concussion, is a serious and not uncommon consequence of playing football. The ProCap polyurethane helmet cover, manufactured by the Protective Sports Equipment Company of Erie, PA, has been used for the last five years or so as a means to try to decrease the incidence of concussive episodes, particularly among competitors who have a history of concussion. The ProCap is a lightweight polyurethane pad that conforms to and attaches snugly to the outside of the helmet. Laboratory studies using the standardized "drop test" show that this device reduces the G-forces transmitted through the helmet to the head by approximately 30% when compared to the helmet alone.

To test the clinical effectiveness of this helmet cover, Torg and associates surveyed 245 individuals who have been identified as having purchased the device. One hundred fifty five purchasers returned the survey, which provided a detailed history of concussions occurring both prior to and during the period that the device was used. All respondents to the survey used the device because they had previously sustained at least one concussion. The rate of concussion recurrence was then calculated and compared to the number of previous concussions sustained by the players. It was found that the rate of concussion recurrence increased proportionate to the number of previous concussions that had been incurred. Torg et al concluded, "The range appeared to reflect a parallel relationship between pre- and post-device concussion experiences: the more concussions experi-

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enced prior to adopting the device, the higher the rate of concussion reoccurrence while using the device." Torg et al concluded that the natural history of recurrent concussions may not be affected by the use of this helmet cover. They recommended that further scientific study be conducted in a prospective, randomized manner to see if the device actually does prevent either initial concussions or recurrent concussions. The limited anecdotal evidence currently available led Torg et al to conclude that the Pro-Cap device should not be routinely used prophylactically and that its effectiveness has not been conclusively shown. Because it does not seem to cause any problem, they still recommended that because of the objective evidence of decreased G-forces in the drop-test studies, the device could "…be considered for use in individuals with one or two prior concussion injuries."

COMMENT BY JAMES D. HECKMAN, MD

Torg et al bring to our attention the experience of a large number of players who used a polyurethane helmet cover to reduce recurrent concussive episodes while playing football. This anecdotal evidence is not very conclusive with regard to effectiveness. While there are some objective biomechanical studies that show that impact loading of the head can be decreased somewhat by use of this device, there is not a clear, direct relationship defined between impact loading and the cause of concussion. Indeed, concussion can be caused either by impact loading or, as Torg et al state, impulsive loading. Impulsive loading is more related to shear, tensile, and compressive strains within the brain as opposed to direct impact. Because the exact mechanism of concussion in a football player is not entirely clear, it cannot be assumed that a helmet cover or similar devices will eliminate the problem. Indeed, wearing such a protective helmet cover may give the player a false sense of security, causing him to ignore sensible tackling techniques that have clearly been shown to decrease the incidence of severe head injury among football players. It certainly is clear that more studies need to be conducted to determine the specific mechanisms of concussion in football players and to demonstrate the value of the helmet cover to prevent repeated occurrences of cerebral concussions in these athletes.

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Prospective Evaluation of the Ottawa Ankle Rules in a University Sports Medicine Center

ABSTRACT & COMMENTARY

Synopsis: *Use of the Ottawa Ankle Rules could limit the need for x-rays in patients without increasing the risk of missing a significant ankle injury.*

Source: Leddy JJ, et al. Prospective evaluation of the Ottawa Ankle Rules in a university sports medicine center. *Am J Sports Med* 1998;26(2):158-165.

In an attempt to develop a clinical decision rule to screen emergency room patients, Stiell and colleagues[1] developed a set of clinical evaluation guidelines for patients who present with an acute ankle injury. Using their "Ottawa Ankle Rules," they were able to limit the frequency of x-rays taken in the emergency department without increasing the risk of missing a significant ankle injury. The current study was designed to evaluate the effectiveness of the Ottawa Ankle Rules in a university sports medicine center, where the predicted incidence of a clinically significant fracture is lower (about 8%) than in an emergency department (where it is 13-20%). Leddy and colleagues evaluated all persons (children and adults) who presented to their office with

an acute ankle or midfoot injury. The only individuals excluded were those with injuries more than 10 days old, an obviously deformed ankle or foot, or altered sensorium, or an individual who returned for a second evaluation for the same injury.

The evaluating physicians were instructed in the use of the "Ottawa Ankle Rules," which require radiography of the ankle if, and only if, there is bony tenderness along the last 6 cm of the posterior aspect of the medial or lateral malleolus or tenderness to palpation over the base of the fifth metatarsal or over the tarsal navicular or if there is inability to bear weight both immediately after injury and during the examination (four steps, regardless of limping). When none of these signs is present, x-rays are not obtained. When any one sign was present, x-rays were taken.

Two hundred ten patients were enrolled in the study. Eleven clinically significant fractures (8.3%) were identified. Application of the Ottawa Ankle Rules was 100% sensitive in identifying these significant ankle fractures, and Leddy et al conclude that use of the "Ottawa Ankle Rules" could significantly reduce the need for radiography in patients with acute ankle and midfoot injuries in this setting (ambulatory sports medicine clinic) without missing clinically significant fractures.

COMMENT BY JAMES D. HECKMAN, MD

Ankle injuries are the most common reason for lost time from participation in athletic activities. In a busy sports medicine practice, a clinical decision rule that can be applied with 100% sensitivity can be used to improve the cost-effectiveness of the practice. The authors in this study and in the emergency room studies previously reported have found the rules both easy to use and valid. They are a cost-effective screening tool that can be used to identify those ankle injuries that are not associated with a significant fracture and, thus, can be treated effectively with rest, ice, compression, and elevation. In this series of 210 patients, Leddy et al were able to forego ankle x-rays in 34% of the patients who presented with an acute injury without missing any clinically significant fractures. It should be pointed out that these rules should be applied only to acute injuries (those less than 10 days old) and, thus, do not apply to chronic or repeat ankle injuries. The patients must be able to comply and so must be alert and cooperative with the examination. One of the critical phases of the evaluation is a weight-bearing test. Leddy et al found that while many patients were reluctant to try to put weight on the affected ankle, with some gentle encouragement they were often able to do so. Clinical decision rules, such as the Ottawa Ankle Rules, can facilitate our medical decision-making and can conserve important resources without compromising the care of our patient athletes. ❖

Reference

1. Stiell IG, et al. A study to develop clinical decision rules for the use of radiography in acute ankle injuries. Ann Emerg Med 1992;21(4):384-390.

The Effect of Knee Bracing After Anterior Cruciate Ligament Reconstruction

ABSTRACT & COMMENTARY

Synopsis: *While bracing may have some minimal effect on the patient's performance on a functional scale three months after surgery, the long-term benefit remains in question.*

Source: Risberg MA, et al. The effect of knee bracing after anterior cruciate ligament reconstruction. A prospective, randomized study with two years' follow-up. *Am J Sports Med* 1999;27(1):76-83.

For years, the inclusion of knee braces in post-op rehabilitation programs after anterior cruciate ligament (ACL) reconstruction has been considered standard of care. These braces have been designed to "protect against excessive motion and excessive loading on the healing ACL graft." However, controversy exists regarding the use of these post-op braces. There is a paucity of evidence concerning their effectiveness. The purpose of this study was to perform a prospective, randomized clinical trial to determine if the braces are effective. The subjects had an ACL injury that was either isolated or combined with a meniscus or MCL injury. All candidates had undergone a bone-patellar tendon-bone ACL reconstruction.

There were 60 subjects with a mean age of 28 years (range, 15 to 50 years). There were 28 women (47%) and 32 men (53%). The mean time from injury to operation was 31 months. All patients underwent the same rehabilitation program, which included CPM acutely. Isometric and passive extension exercises were also started immediately and continued. All subjects progressed following "closed kinetic chain principles." The patients were randomized into two groups, with and without braces. The brace group "utilized the DonJoy rehabilitative range of motion brace" (DonJoy, Smith & Nephew, Carlsbad, CA) for the first two weeks. They were instructed to wear the "DonJoy gold point func-

tional knee brace" (DonJoy, Smith & Nephew) for the next 10 weeks. After 10 weeks the patients were instructed to use braces on an "as needed" basis.

Outcome measurements included knee joint laxity as measured by the KT-1000, range of motion, cross-sectional area of the thigh as measured by computer tomography and functional testing.

Data were recorded within 48 hours preoperatively and postoperatively at six weeks, three months, six months, one year, and two years, with the exception of knee laxity and function, which were measured at all times except six weeks. Preoperatively, there were no significant differences between the two groups. While there were some differences in associated pathologies between the two groups with respect to meniscal injuries, overall the groups were comparable. There were no significant differences between the two groups with regard to knee laxity or range of motion measurements at the follow-up visits. Cross-sectional area of the thigh was significantly decreased in the braced group at three months; however, this difference disappeared by six months. There were no significant differences with regard to isokinetic measures at each follow-up. Finally, there were no significant differences between the braced and nonbraced groups with respect to the functional knee test, except at three months after surgery, when the "Stairs Hopple Test" indicated that the braced group was significantly better functionally. In addition, follow-up MRIs revealed three new meniscal injuries in the braced group while the nonbraced group had none. There was also an increased number of degenerative changes in seven subjects of the braced group while the no-braced group had none.

COMMENT BY CLAYTON F. HOLMES, EdD, PT, ATC

This study is an attempt to determine the effectiveness of post-op bracing for ACL patients. Perhaps the most important finding relates to knee ligament laxity. Specifically, at no time, including two-year follow-up, was there an increase in knee joint laxity in patients who did not wear the brace postoperatively as compared with those who did. It should also be pointed out that early motion, early full-weight bearing, and an emphasis on closed kinetic chain exercises in the rehabilitation program have been reported as effective.[1,2] These results regarding postoperative bracing may be different if a more conservative post-op rehabilitation approach is used. It is also important to note that at three months, bracing resulted in significantly more thigh atrophy while nonbraced subjects were more "functional" at three months. However, by six months there was no difference relative to thigh atrophy or function. Perhaps patients who have the brace "feel" more confident in their function despite having increased thigh atrophy. This study effectively dispels some of the myths concerning the possible benefits of bracing. Ultimately, while bracing may have some minimal effect regarding the patient's performance on a functional scale at three months after surgery, the long-term benefit of post-op bracing remains in question. Furthermore, when cost is factored in, any benefit probably is not worth pursuing. ❖

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Muscle Cramps and Nitric Oxide

ABSTRACT & COMMENTARY

Synopsis: *A link is shown between increased levels of nitric oxide, strenuous exercise, and severe muscle cramps.*

Source: Maddali S, et al. Postexercise increase in nitric oxide in football players with muscle cramps. *Am J Sports Med* 1998; 26(6):820-824.

Nitric oxide, a free radical functioning as an intracellular and intercellular messenger molecule, has been shown to have important roles in vasodilatation, platelet aggregation, cardiac contractility, and host defense against infection.1 The enzyme, nitric oxide synthase, is abundant in skeletal muscle, and nitric oxide appears to have important functions for this tissue as well.

Maddali and colleagues analyzed detailed blood chemistries for members of the New York Giants football team before and during rigorous preseason "two-a-day" practices. They found that nitrite, the stable breakdown product of nitric oxide, increased nearly 300% in those players suffering severe, generalized muscle cramps and symptoms of heat exhaustion requiring intravenous rehydration. Other serum chemistries showed much smaller variations consistent with dehydration.

Maddali et al also determined that players with a greater mean weight and percentage of body fat tended to lose more weight during each practice and were at greater risk of cramps requiring rehydration.

Because the dramatic, threefold increase in nitrite did not correlate statistically with the other serum

chemistries, and because other values increased to a much smaller degree (16% for albumin, 102% for lactate dehydrogenase), the nitrite increase appeared specific to muscle cramps rather than just dehydration. Compared with only a 51% increase in creatinine from the expected rhabdomyolysis, the 300% increase in nitrite reflects increased nitric oxide synthesis.

COMMENT BY DAVID R. DIDUCH, MS, MD

Maddali et al have clearly demonstrated a link between increased levels of nitric oxide, strenuous exercise, and severe muscle cramps. The precise relationship between nitric oxide and cramps remains unclear and requires further research. Without further data from players without cramps, it is also unclear whether the cramps, the exercise, or both generated the increase in nitric oxide.

This study, combined with others in the literature, can lead to a plausible explanation for the role of nitric oxide in muscle cramping. Extreme exercise induces vasodilatation to increase blood flow to muscles and dissipate body heat.[2] Nitric oxide is released from endothelial cells and skeletal muscle cells.[3] This increased nitric oxide enhances further vasodilatation, skeletal muscle contractility, and increases in body temperature. Hyperemia adds to the problem of dehydration. The contribution of nitric oxide and its metabolites to skeletal muscle cramps may be related to increased contractility but needs further exploration.[4]

There has been a recent surge in the use of nutritional supplements such as creatine that are known to promote dehydration. Creatine increases intracellular skeletal muscle water in response to increased protein levels within the cells. Severe, generalized muscle cramps are becoming extremely common with less strenuous exercise because of the increased propensity to dehydration. The sports medicine physician must be aware of this relationship between creatine and dehydration and be alert to the need for prompt rehydration should symptoms occur. Further research is needed to better understand these relationships, optimize treatment, and minimize potential consequences. ❖

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4. Kobzik L, et al. Nitric oxide in skeletal muscles. *Nature* 1994;372:546-548.

Cardiovascular Risks to Young Persons on the Athletic Field

ABSTRACT & COMMENTARY

Synopsis: *An American Heart Association consensus panel agreed that inclusion of noninvasive tests in the routine screening of all young athletes is impractical.*

Source: Maron BJ. Cardiovascular risks to young persons on the athletic field. *Ann Intern Med* 1998;129:379-386.

Sudden death in young athletes is rare, occurring in only approximately one out of every 200,000 high school athletes per academic year. Its major causes are hypertrophic cardiomyopathy and congenital coronary anomalies. These abnormalities infrequently result in premonitory signs or symptoms and, therefore, are difficult to diagnose during a preparticipation physical examination. Nonetheless, a preparticipation cardiovascular screening exam consisting of a targeted personal and family history as well as a physical examination is recommended for every competitive athlete. Although echocardiography and electrocardiography are helpful in identifying life-threatening cardiac abnormalities in young people, an American Heart Association (AHA) consensus panel agreed that inclusion of such noninvasive tests in the routine screening of all young athletes is impractical, given the considerable size of this population, which is estimated to be 8 to 10 million.

Other causes of sudden death in young athletes discussed by Maron include ruptured aortic aneurysm associated with Marfan syndrome, idiopathic dilated cardiomyopathy, aortic valve stenosis, the long QT syndrome, and myocarditis secondary to viral disease or drug use. Cardiac arrest may also occur from a relatively modest nonpenetrating chest blow, which occurs during the vulnerable phase of cardiac repolarization. This phenomenon has been called commotio cardis and has been most commonly described following blows to the chest from batted baseballs.

COMMENT BY LETHA Y. GRIFFIN, MD, PhD

The AHA's statement on preparticipation cardiac screening of competitive athletes recommends such

screenings for all young athletes by a health care worker knowledgeable in cardiovascular evaluations.[1] This evaluation should include a cardiovascularly targeted personal and family history with key questions designed to determine 1) prior occurrence of exertional chest pain or syncope, shortness of breath, or exertional fatigue; 2) history of heart murmur or increased blood pressure; and 3) family history of premature cardiovascular death or severe cardiac disease. The physical examination should emphasize 1) precordial auscultation in both the supine and standing positions, 2) assessment of femoral artery pulses, 3) recognition of stigmata of Marfan syndrome, and 4) a seated brachial blood pressure.

Although the AHA initially recommended a complete examination every two years, it modified this recommendation in 1998 to include a formal cardiovascular evaluation upon entrance into an athletic program with annual updates of the medical history and blood pressure measurement. If the history reveals any pertinent changes in the athlete's medical status, a full cardiovascular examination must be done. Two important symptoms that should trigger more extensive cardiovascular evaluations are exertional syncope and intense chest pain or discomfort brought on by exercise. ❖

Reference

1. American Heart Association. Cardiac preparticipation screening of competitive athletes. *Circulation* 1996; 94:850-856.

Snowboarding and Skiing Injuries

ABSTRACT & COMMENTARY

Synopsis: *As compared to skiing, snowboarding presents a relatively high risk for injuries, especially serious injuries. This study specifically documents the risk scenario for first-time skiers and snowboarders.*

Source: O'Neill D, McGlone M. Injury risk in first-time snowboarders versus first-time skiers. *Am J Sports Med* 1999;27:94-97.

O'Neill and McGlone studied the incidence of injuries in first-time skiers and snowboarders at two major ski resorts in New Hampshire between 1994 and 1996. They recorded a comparative risk profile among beginner (first-time) participants in both sports. The incidence of injuries was equal in the two groups (4%), but the incidence of injuries requiring emergency treatment was significantly higher in the snowboarders (42% vs 16%). Also, upper extremity injuries occurred more commonly in snowboarders than in skiers (53% vs 21%). They conclude not only that snowboarding poses a greater threat for serious injury but also that "this rate should diminish with the use of helmets and wrist guards."

COMMENT BY STEPHEN B. GUNTHER, MD

The rising popularity of snowboarding has brought with it a new source of musculoskeletal injuries. O'Neill and McGlone present a well-controlled cohort study in which all participants were beginners in a "learn to" program with rental equipment and a certified lesson. It is valuable to document the incidence of injuries in each sport (4%) for beginners, and the relatively greater risk for "serious" injuries in snowboarders. The injury profile for intermediate and advanced participants is another important variable. There is also a need to document specific injury patterns and fractures as well as to further delineate the severity of injury.

Injury prevention is the most important corollary to epidemiological studies. Physicians, participants, and members of the ski industry must carefully evaluate these types of data. The use of helmets may decrease the risk of serious injuries, but education and awareness are equally important. Clinical studies in the future should aim to test the efficacy of protective equipment as well as to further document injury patterns. Biomechanical studies are also helpful. The take-home point from this study is that injuries occur even in beginners, and that safety is an important issue. ❖

EMG of Elbow Function in Tennis Players with Lateral Epicondylitis

ABSTRACT & COMMENTARY

Synopsis: *Abnormal mechanics were isolated in the wrist and elbow during the single-handed backhand tennis stroke. These abnormalities were thought to lead to increased stress in the wrist extensors that could lead to repetitive injury at the lateral epicondyle.*

Source: Kelly JD, et al. *Am J Sports Med* 1994;22(3): 359-363.

Kelly and colleagues did an extensive analysis of electromyographic (EMG) changes in five separate muscles about the wrist and elbow during

the single-handed backhand tennis stroke. They used fine wire electrodes in five separate muscles and then recorded the backhand stroke on high-speed film and synchronized it with the EMG signal. Two groups of volunteer patients used were (a) those who had never experienced tennis elbow in the past, and (b) those who had experienced tennis elbow in the past but were in the subacute phase and, therefore, had minimal symptoms. Kelly et al found that the injured players had greater activity in their wrist extensors and pronator teres muscle during ball impact and early follow-through. Kelly et al thought this might have been caused by abnormal mechanics, and they were able to document these on film. Abnormalities included a "leading elbow," wrist extension, open racket face at the time of impact, and ball impact on the lower half of the strings. Kelly et al believed that the abnormalities they isolated would not only lead to a poor level of play but also to increased stress in the wrist extensors and the pronator teres that could lead to repetitive injury at the lateral epicondyle.

COMMENT BY JAMES P. TASTO, MD

Lateral epicondylitis is a frequently encountered injury in sports medicine. Not only do we see this in a high percentage of tennis players, but also in golfers, industrial workers, people who carry a great deal of baggage, and, often, people who do normal household activities and gardening. Conservative treatment is usually sufficient to overcome most symptoms. Treatment includes concentric and eccentric exercises, counterforce bracing, nonsteroidal anti-inflammatories, and judicious use of corticosteroidal injections. Surgical procedures vary considerably but are generally focused around releasing and reattaching the extensor carpi radialis brevis, removal of inflammatory tissue, and, on occasion, creating an osseous bed for increased vascularity and better reattachment of the extensor mechanism. This article points out the importance of isolating the cause of all tennis elbow complaints. We are familiar with many of the entities that contribute to lateral epicondylitis in the tennis population, such as those mentioned above, as well as racket handle size, string tension, and racket head size. These should all be looked at carefully by the athlete. It is important to isolate etiology for all of your patients whether they are tennis players or golfers. Have them work specifically on appropriate mechanics, avoid provocative situations that give rise to this inflammatory condition, and choose proper equipment. ❖

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Posterior Cruciate Ligament Surgery: The Debate Continues

ABSTRACT & COMMENTARY

Synopsis: *Long-term follow-up studies of arthroscopic reconstruction of the completely torn posterior cruciate ligament have found results to be fair, at best, with continued evidence of tibial drop-back often seen clinically.*

Sources: Burks RT, Schaffer JJ. A simplified approach to the tibial attachment of the posterior cruciate ligament. *Clin Orthop Rel Res* 1990;254:216-219; Berg EE. Posterior cruciate ligament tibial inlay reconstruction. *Arthroscopy* 1995; 11(1):69-76.

Long-term follow-up studies of arthroscopic reconstruction of the completely torn posterior cruciate ligament (PCL) have found results to be fair, at best, with continued evidence of tibial drop-back often seen clinically.

Surgical technique, isometry of the tunnels, and graft selection have all been cited as causes of the poor results. Furthermore, the arthroscopic techniques that use an anterior to posterior tibial tunnel create a sharp turn posteriorly ("the killer turn"), which is believed to lead to graft failures. Passage of PCL grafts through this tunnel is also fraught with difficulty, and such a sharp turn on the tibial side frequently complicates even the most smoothly running procedure. In 1990, Burks published a simplified technique for the tibial attachment of the PCL. This approach stimulated Berg to describe his technique of "tibial inlay reconstruction" using a posterior approach to the

knee joint with attachment of the medial head of the gastrocnemius and placement of the tibial bone plug (ideally a bone/tendon/bone autograft patellar tendon) directly into a tibial trough. Berg positions the patient in the lateral decubitus position with the injured knee side up. The knee is first examined by arthroscope with the knee flexed and the leg externally rotated. Graft harvest, arthroscopy, and femoral tunnel preparation are performed using the standard arthroscopic methods. The leg is then extended and abducted to expose the back of the knee and a posterior S-shaped incision is made across the knee flexion crease. Careful dissection allows access to the posterior aspect of the joint, after release of the medial head of the gastrocnemius. The neurovascular bundle is retracted gently. The tibial stump of the PCL is debrided and a cortical window is made in the posterior tibia, approximating the size of the graft bone plug. The femoral side of the reconstruction is fixed with an interference screw, and the tibial inlay portion is fixed with a standard cancellous screw and washer. The results of treatment in Berg's four patients showed fairly good clinical function, but the patients had some measurable instability at the two-year follow-up point.

COMMENT BY ROBERT C. SCHENCK, Jr., MD

The tibial inlay technique, while solving the problem of the "killer turn," creates new problems with access to the posterior knee and its complex anatomy. The term "onlay" has been used by some to describe this technique, but most surgeons feel the graft plug can be placed into the tibia to create a flush surface and thus "inlay" is probably a more accurate term. Some surgeons feel this technique requires positioning the patient prone for one portion of the procedure. Prone positioning complicates the operation and is less attractive in trauma patients, the population in which the PCL is frequently injured. While in his four patients, Berg noted no loss of postoperative extension, an incision in the flexion crease carries the risk of creating a postoperative flexion contracture and limitation of knee motion. This inlay technique will require evaluation in a larger number of patients prior to its universal acceptance; however, it is becoming a popular approach in many sports surgeons' hands. ❖

CME Questions

23. The major causes for sudden death in athletes are:
a. congenital coronary artery disease and commotio cardis.
b. commotio cardis and Marfan syndrome.
c. Marfan syndrome and acute myocarditis.
d. hypertrophic cardiomyopathy and congenital coronary artery anomalies.
e. Marfan syndrome and aortic valve stenosis.

24. In professional football players experiencing muscle cramps after "two-a-day" practices, threefold increases in serum levels were found for:
a. nitric oxide.
b. creatinine.
c. albumin.
d. lactic dehydrogenase.

25. A polyethylene helmet cover:
a. decreases the incidence of new concussions in football players.
b. decreases the incidence of recurrent concussions in football players.
c. reduces direct G-forces transmitted to the head by 30% when compared to the helmet alone.
d. is especially effective at reducing shear forces on the brain.

26. PCL reconstruction has had varying success rates. The most widely accepted reason for graft failure is:
a. graft selection.
b. tibial inlay technique.
c. bundle differences.
d. tunnel placement.

27. According to the current study, the incidence of injuries in first-time skiers and snowboarders is:
a. 40% and 10%.
b. 10% and 40%.
c. 10% and 10%.
d. 4% and 4%.
e. 4% and 10%.

28. Which of the following muscles is not implicated by EMG in the tennis elbow syndrome?
a. extensor carpi radialis brevis.
b. extensor carpi radialis longus.
c. extensor digitorum communis.
d. pronator teres.

29. According to the current study, at two years post-op, knee bracing after ACL reconstruction affected which of the following variables positively?
a. Knee joint laxity
b. Thigh atrophy
c. Function
d. a, b, & c
e. None of the above

30. In an ambulatory sports medicine clinic practice, the Ottawa Ankle Rules can be used to:
a. identify osteochondral lesions of the talar dome.
b. identify those ankle ligament injuries requiring immediate surgical repair.
c. screen acute ankle injuries prior to obtaining x-rays.
d. guide rehabilitation of ankle injuries.

In Future Issues:

Muscle Cramps and Nitric Oxide

Cardiovascular Risks to Young Persons on the Athletic Field