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Knee Joint Laxity and Neuromuscular Characteristics of Male and Female Soccer and Basketball Players

ABSTRACT & COMMENTARY

Synopsis: *Decreased joint proprioception could render knees less sensitive to forces and hence at greater risk for ligament injury.*

Source: Rozzi SL, et al. Knee joint laxity and neuromuscular characteristics of male and female soccer and basketball players. *Am J Sports Med* 1999;27(3):312-319.

In an effort to further explore the role of joint proprioception and muscle activity in knee joint stability, Rozzi and colleagues compared knee joint laxity, joint proprioception, lower extremity balance, the amount of time required to generate peak torque of the knee flexor and extensor muscles, and electromyographic (EMG) assessed muscle activity in 17 male and 17 female healthy college athletes. Knee joint laxity was quantified by using a KT-1000 instrumented knee arthrometer to measure anterior tibial translation during application of a 30-pound anterior displacement force and with the subjects tested in the supine position. Using a device specifically designed at the University of Pittsburgh, proprioception was measured by testing threshold to detection passive motion with the subjects seated. The Biodex stabilizing system was used to assess balance and time to generate peak torque of the knee joint flexors and extensors.

Surface electrodes were used to obtain EMG data on each muscle with the data processed and analyzed by Myoresearch software to determine onset time, amplitude, and area of contraction subsequent to landing.

Rozzi et al found that the women tested had greater knee joint laxity, demonstrated a significantly longer time to detect the knee joint moving into extension, possessed superior single-legged balance, and produced greater EMG peak amplitude and area of the lat-

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INSIDE

eral hamstring muscles subsequent to landing after a jump than did the males who were tested. They theorized that the decreased joint proprioception could render the knee less sensitive to forces and hence at greater risk for ligament injury.

COMMENT BY LETHA Y. GRIFFIN, MD, PhD

This article is another excellent addition by the Pittsburgh group to the ever-increasing pool of knowledge concerning neuromuscular influences on knee joint injury and, in particular, as a risk factor for anterior cruciate ligament (ACL) injuries. Women, compared with men, have been found to have a two to eight time increase in ACL injury rates in pivotal sports such as soccer, volleyball, and basketball. However, the cause for this increase in injury rate is not well understood. Approximately 70% of all ACL injuries occur from noncontact mechanisms. Reported risk factors for injury include environmental factors (braces, shoe surface interface, etc.), anatomic factors, hormonal factors, and biomechanical (neuromuscular) factors.

A recent consensus conference on prevention strategies for noncontact ACL injuries held in Hunt Valley, Maryland (June 1999), examined available data on these risk factors and concluded that at the present time neuromuscular factors appear to be the most important reason for the differing ACL injury rates between males and females.

Although the neuromuscular risk factors for injury have not been fully defined, as illustrated by this article, several prevention programs based on altering neuromuscular risk factors have been developed.[1-4] Early data on initial trials of these programs demonstrate impressive decreases in injury rates. Hence, the Hunt Valley conference attendees felt that until specific predictive and protective factors for noncontact ACL injuries are definitively determined, enhanced awareness and continued implementation of these existing neuromuscular preventive programs were reasonable. However, the attendees stressed the need for continued assessment and improvement of such programs. ❖

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Partial ACL Tears

ABSTRACT & COMMENTARY

Synopsis: *Partial ACL ruptures involving less than 50% of the ligament have a good prognosis over the long term.*

Source: Messner K, Maletius W. Eighteen- to twenty-five-year follow-up after acute partial anterior cruciate ligament rupture. *Am J Sports Med* 1999;27:455-459.

Partial anterior cruciate ligament (acl) tears occur less frequently than complete ruptures, and there is uncertainty surrounding their long-term significance. As one would expect, the amount of instability that develops appears proportional to the degree of initial injury. However, little is written concerning the natural history of partial ACL tears over the long term.

Messner and Maletius have followed a group of 22

consecutive patients with a partial ACL tear for a mean of 20 years (range, 18-25). All patients but one, who died, were available for evaluation, which is truly remarkable after such a long period. In each case the diagnosis of a partial ACL tear was made by arthroscopy and an examination under anesthesia within 10 days of injury. No patient had greater than 1+ anterior laxity or greater than 50% damage to the ligament.

Three patients had suture repair of the partially torn portion of the ACL, while all other partial ACL injuries were treated nonoperatively. Nine patients with greater than 2+ valgus laxity underwent primary repair of the medial collateral ligament (MCL), a procedure commonly performed 25 years ago. All patients had concomitant acute injuries in the knee. The period of initial immobilization of the knee depended on these concomitant injuries rather than the ACL and ranged from one to six weeks.

Patients were evaluated at 12 and again at 20 years post-injury by physical exam, instrumented arthrometry, weight-bearing X-rays, Tegner score for activity level, and Lysholm score for knee function. At the latest follow-up, quadriceps strength was assessed and quality-of-life issues were measured by SF-36 health survey.

During the entire follow-up period, no patient underwent ACL reconstruction. Two patients had arthroscopy for meniscal tears and one patient had a late MCL injury. At the latest follow-up, 17 of 21 patients had Lysholm scores in the excellent range, and quality-of-life scores were generally better than those of a reference sample in the general population. Although only 13 of 22 patients were able to initially return to their preinjury activity level, the Tegner scores did not deteriorate between the 12- and 20-year time points.

At 20 years, 10 knees had a 1+ Lachman exam, two knees a 2+ Lachman, and one knee a positive pivot shift. Instrumented laxity measurements were less than 3 mm, which is considered normal, for 20 of 21 knees. About half the knees developed mild arthritis by X-ray, with little progression between 12 and 20 years. Four patients had more advanced changes.

COMMENT BY DAVID R. DIDUCH, MS, MD

From this excellent longitudinal prospective study by Messner and Maletius, we can conclude that partial ACL ruptures involving less than 50% of the ligament have a good prognosis over the long term. No patient underwent late ACL reconstruction over a 20-year follow-up period. However, because these were major knee injuries with concomitant damage to other structures in every case, few patients returned to the same level of preinjury sports activities. Given that the vast majority of patients developed only mild ACL laxity by exam or arthrometry, we might conclude that these other injuries were more significant over the long run.

Therefore, we can advise our patients with partial ACL injuries involving less than 50% of the ligament to not develop progressive laxity and to remain reasonably active. The difficulty clinically can be in determining whether the ACL is truly only partially torn with less than 50% ligament involvement. Magnetic resonance imaging (MRI) can be helpful in this regard and can be confirmed by instrumented laxity measurements. Arthroscopy, together with an exam under anesthesia, can be added when the diagnosis and treatment are in doubt. Some objective information is encouraged because patient guarding during the physical exam can confuse the picture and underestimate the degree of laxity. Of course, even partial tears by MRI that demonstrate clinical laxity by history and exam are functionally complete tears and should be treated as such.

Thus, this paper, despite the small numbers of patients, is an important addition to the ACL literature given the extremely long follow-up in nearly all patients. True partial ACL tears do well over the long term. The major limiting factor appears to be associated injuries. Just as with complete ACL tears, preserving the meniscus appeared to have the greatest influence on late arthritic changes. These findings will be helpful in the future as we counsel patients regarding optional treatment. ❖

ACL Injury Patterns Among Collegiate Men and Women

ABSTRACT & COMMENTARY

Synopsis: *Female collegiate athletes participating in basketball or soccer tear their ACLs at significantly higher rates than males involved in the same sports. No distinct intrinsic and extrinsic factors can be attributed to this difference in injury rates.*

Source: Arendt EG, et al. Anterior cruciate injury patterns among college collegiate men and women. *J Athletic Training* 1999;34:86-92.

Arendt and colleagues present an outstanding review and thoughtful study evaluating the increased anterior cruciate ligament (ACL) injury rate in female collegiate athletes as compared to male athletes in the sports of soccer and basketball. In an earlier paper,[1] they used the NCAA Injury Surveillance System (ISS) to evaluate knee injury patterns and occurrences from 1989 to 1993. In that original study, Arendt et al

noted the ACL injury rate in women's soccer (0.3%) was more than double that of the men (0.13%). Interestingly, in the women's injuries, no apparent contact was the primary mechanism (63%) as compared to player contact (37%). In men's soccer games, the reverse was noted, in which 52% of ACL tears involved player contact and 48% of the tears involved no contact. In NCAA basketball, Arendt et al found a similar difference such that the women's ACL injury rate was more than four times that of men.

The current paper is a follow-up study from 1994 to 1998 using similar NCAA ISS data in an attempt to evaluate whether training or exposure to the sport possibly was involved in the increased incidence of ACL injury in the female athlete. Arendt et al found continued similar injury rates that were increased both in women's basketball and women's soccer as compared to men's basketball and soccer. In this second five-year period, they also investigated women's volleyball, which had a significantly lower ACL injury rate than women's basketball. Arendt et al also report on a pilot study that looked at the participants' athletic profiles to try to evaluate extrinsic or intrinsic causes for the increased ACL tear in basketball and soccer.[2] Interestingly, females were more likely to be injured just before or after their menses and not in midcycle.[3] No other factors were identified concerning mechanism injury, health, sports participation, treatment, or physical attributes.

COMMENT BY ROBERT C. SCHENCK, Jr., MD

Increased ACL injury rates in the female athletic population in collegiate sports such as basketball have been documented by several authors. Many hypotheses have been proposed in an attempt to explain this difference from men. Most commonly the authors describe mechanical differences between the female knee and lower extremity alignment: increased knee valgus, increased tibial external rotation, and differences in femoral notch width and ACL diameter. Nonetheless, no author has been able to elucidate the exact cause of this increased rate and, in all likelihood, as Arendt et al note, it is multifactorial.

This descriptive report allows us an in-depth view of injury rates in NCAA female and male same-sport athletes. It should be used to understand the differences in collegiate athletic injuries. Education of our athletes, coaches, and parents continues to be lacking with regard to the patterns of ligament injury and this education should be improved. Recently other authors have attempted to prospectively identify factors related to this increased injury rate, such as menstrual cycle and jump training. Our next step in orthopedic sports medicine is to identify causes and make attempts to decrease these injuries using preventive measures. ❖

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The Effect of Foot Structure and Range of Motion on Musculoskeletal Overuse Injuries

ABSTRACT & COMMENTARY

Synopsis: *The methods used in this study may be useful in identifying high-endurance athletes at risk for lower extremity overuse injury.*

Source: Kaufman KR, et al. The effect of foot structure and range of motion on musculoskeletal overuse injuries. *Am J Sports Med* 1999;27:585-593.

Four hundred forty-nine volunteer trainees at the Naval Special Warfare Training Center, candidates for Navy SEAL training, were enrolled in this prospective study. The purpose of the study was to determine if there was an association between foot structure and musculoskeletal overuse injuries developing during the extremely intensive training program. The program is in three phases, lasting 25 weeks, probably the most rigorous physical training anyone can experience.

Before the training began, a variety of biomechanical characteristics of the subjects' feet were defined. The arch characteristics of both feet were studied both statically and dynamically. The dynamic assessment was performed in a motion analysis laboratory, with the subjects walking both barefoot and wearing military footwear. A "dynamic arch index" was calculated to define the ratio of the area of contact to the midfoot to the total contact area of the foot to quantify the degree of cavus or planus. In addition, ankle range of motion was measured, both with the knee fully extended and flexed to 90°. The recruits then underwent

training and all injuries were tracked prospectively. Particular overuse injuries that were identified were stress fractures, periostitis, iliotibial band syndrome, patellofemoral syndrome, and Achilles tendinitis. A high incidence of overuse injuries was found, with 149 of the 449 subjects (33.2%) sustaining 348 lower extremity overuse injuries during the training period. The most common problems encountered were stress fractures, iliotibial band syndrome, and patellofemoral syndrome. Less commonly, Achilles tendinitis and periostitis without stress fracture also occurred. The most common sites for stress fractures were the lower leg (49%), the foot (39%), and then the femur (12%).

A distinct relationship was found between foot structure and the development of a stress fracture, with an increased relative risk of developing a stress fracture occurring either with pes planus or pes cavus. Interestingly, the increased risk of injury with pes planus was only identified when the deformity was assessed dynamically. Restricted hindfoot inversion increased the risk of developing a femoral stress fracture, while increased hindfoot inversion led to more frequent tarsal and metatarsal stress fractures. Achilles tendinitis occurred more commonly in those individuals with a tight gastrocnemius or increased hindfoot inversion. Despite the fact that the recruits to the SEAL program are healthy, fit individuals who almost uniformly report to training in extremely good physical condition, one-third of these recruits developed significant overuse injuries. Kaufman and colleagues conclude that the methods they employed in this study can be used to identify those high-endurance athletes at risk for lower extremity overuse injury and recommend further research be done to develop specific footwear modifications to prevent these problems.

COMMENT BY JAMES D. HECKMAN, MD

This study was done in a thorough and thoughtful manner. Biomechanical data were collected prospectively and then the incidence of overuse conditions was measured precisely in this well-controlled population. This is a highly motivated group of individuals and they may have tended to ignore or under-report some injuries because of the fear of washing out of the program. Otherwise, it can be assumed that a complete registry of injuries has been recorded. Certainly the more serious injuries are documented in this study. While few athletes will ever be stressed to the level of Navy SEAL training, the study demonstrates the importance of foot structure in the development of lower extremity overuse injuries. Kaufman et al do not tell us if any of the participants wore orthotic devices in their shoes or had other shoewear modifications that might have affected the mechanics of running. It is assumed that all recruits wore standard issue military boots without specialized inserts.

Of particularly curious note is the fact that despite most subjects coming into the program quite fit and athletically active, one-third still developed overuse problems. Kaufman et al point out that this is an incidence that is not particularly different from the incidence of overuse problems in civilian runners which has been reported to range from 14% to 48% in various studies. This persistently high overuse injury problem may be attributable to foot shape rather than preconditioning, as the study showed that subjects with either pes planus or pes cavus had nearly twice the incidence of stress fractures compared to subjects with normal arch height.

One of the more interesting findings of the study is the high incidence of stress fractures in subjects with flatfoot because other studies of military recruits have shown a protective effect of low arches. Kaufman et al correctly conclude that the techniques used in this study may be useful in identifying at least high-endurance athletes who may be at risk for lower extremity overuse injuries, particularly stress fractures. ❖

Examination of a Clinical Method of Assessing Postural Control During a Functional Performance Task

ABSTRACT & COMMENTARY

Synopsis: *A test was developed that could be used to determine how much postural control an athlete has. A difference existed between balance scores but not landing scores.*

Source: Riemann BL, et al. Examination of a clinical method of assessing postural control during a functional performance task. *J Sport Rehabil* 1999;8:171-183.

Functional testing uses such skills as the single-leg hop. This type of testing has become quite prevalent in orthopedics and sports medicine, particularly for athletes returning from a lower extremity injury. These tests mimic conditions inherent in sports, perhaps better than many other clinical tests. The purpose of this study was to assess a "multiple single-leg-hop stabilization test" (modified Bass test). Specifically, Riemann and colleagues wanted to develop a test that could be used clinically to determine how much postural control

an athlete has during this test.

As implied in the title of the test, it used a numbered floor pattern, with each of the 11 positions marked by white tape and numbered. The athlete was instructed to jump from number to number, in sequence. Based on a pilot study, the marks were separated by 45% of the subject's height.

Thirty recreational athletes were used—19 males and 11 females (mean age 21.23; mean height, 173.37 cm; mean weight, 73.36 kg). In addition, three separate testers were trained during a one-hour training session. Error scores were given for two categories: landing and balance. Landing errors were: not covering tape mark with foot, stumbling on landing, foot not facing forward "with 10° of inversion or eversion, and hands off hips." Balance error entailed: touching down with nondominant limb, nondominant limb touching dominant limb, nondominant limb moving into excessive flexion, extension, abduction, and hands off hips. The subjects were divided into two groups of 15 each. No descriptive data were given for each group. Group one performed the test three times, 48 hours apart. Group two performed the test only once. Interrater reliability was measured.

Results were mixed. A significant difference existed between balance scores but not landing scores. In addition, Riemann et al concluded that there was interrater reliability. Finally, the study indicated that a learning curve was occurring across the three sessions.

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

This study is an important attempt to identify a functional test that could be used in a clinical setting. In addition, the criteria designed are such that, with minimal skill acquisition, the test can be performed. Unfortunately, the only finding that was demonstrated was a learning curve across three sessions, which would be expected. Other findings are not compelling due to either poor design issues or analysis issues. For example, Riemann et al report that an *a priori* power level calculation was performed in order to determine sample size. Unfortunately, this depends on knowing a standard deviation for the population, which was clearly not available. In addition, it is not clear why the two groups were divided. Also, the study did not address interrater reliability. It is assumed that differences are related to learning effect. Clearly, it is impossible for one to determine interrater reliability until interrater has been addressed.

These flaws notwithstanding, the description of a functional test is elegant. This is the type of functional test that demands further research because of its ease of administration and potential to evaluate an athlete's functional status. ❖

Examination Under Anesthesia for Evaluation of Anterior Shoulder Instability

ABSTRACT & COMMENTARY

Synopsis: *Examination under anesthesia is a valuable adjunct to assess shoulder instability and it is important that the shoulder be evaluated in multiple directions.*

Source: Oliashirazi A, et al. Examination under anesthesia for evaluation of anterior shoulder instability. *Am J Sports Med* 1999;27(4):464-468.

For this study, oliashirazi and colleagues chose 30 patients who represented a homogeneous group, all with a diagnosis of recurrent unilateral traumatic anterior shoulder instability. Patients were examined preoperatively in a clinic setting and then evaluated under anesthesia. The purpose of the study was to attempt to correlate the value of an examination under anesthesia with the pathological findings.

The role of rotational position of the arm during the exam was also critically assessed. Oliashirazi et al found that when the affected shoulder was placed in 40°-80° of external rotation, there was a significant increase in the humeral head translation in an antero-inferior direction. A grading system was used as follows: grade I, no abnormal translation; grade II, mild translation up and toward the glenoid rim; grade III, the humeral head has a moderate degree of translation in the glenoid and moves up and onto the glenoid rim; grade IV, the humeral head translation is severe and the head rides up and over the glenoid rim and dislocates.

When Oliashirazi et al compared the affected shoulder to the unaffected shoulder, the test sensitivity was 83% and the test specificity was 100%. Strict criteria were used in that the grade of subluxation or dislocation in the involved shoulder had to measure at least two grades higher than the unaffected side. They concluded that the examination under anesthesia is a valuable adjunct to assess shoulder instability and emphasized the necessity of evaluating it in multiple directions, including straight inferior, straight posterior, straight anterior, anteroinferior, and posteroinferior.

COMMENT BY JAMES P. TASTO, MD

Shoulder instability is a complex issue.[1] Cofield and colleagues reported on humeral head translation under

anesthesia in a previous article, but because the selected population in that study was not homogeneous, the assessment was not believed to be that valuable.[2] There have been a number of studies that have either supported or contradicted the value of evaluation under anesthesia.[3,4] Some feel that it is mandatory and quite valuable, while others feel that it has no particular merit.

We have found that it is a difficult physical examination skill to teach as well as to perform. One must do repetitive examinations, not only on patients with pathological conditions but also on normal shoulders, as there is a wide variety of physical findings, particularly with those patients who have inherent general overall laxity.

The evaluation under anesthesia serves as a great adjunct to one's evaluation in the office to try to correlate those findings and also to refine one's technique. I have found, as have Oliashirazi et al, that early on most physicians will attempt to apply too great a force to the shoulder and will not appreciate the instability pattern. A light force is all that is required with varying degrees of rotation. Oliashirazi et al describe performing a variety of tests in a supine position, comparing both shoulders. I would also recommend learning to do a shoulder exam both with the patient in the supine position, comparing both shoulders, and in the decubitus position with the affected shoulder facing upward and the patient's back and torso resting comfortably against the examiner. This has the added advantage of allowing the patient to relax more and has proved to have more reproducible and consistent results in my hands. For those sports physicians who are not orthopedic surgeons, I would encourage you to spend some time in the operating room with your colleagues and refine your skills so you will be prepared to perform these tests in the clinical setting. ❖

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Pediatric Cervical Spine Injuries

ABSTRACT & COMMENTARY

Synopsis: *The RESCI group showed the lateral cervical spinal view to have the highest sensitivity. Sports injury was the most common cause of pediatric cervical spine injury.*

Source: Baker C, et al. Evaluation of pediatric cervical spine injuries. *Am J Emerg Med* 1999;17:230-234.

Baker and colleagues performed a five-year retrospective review of pediatric (age < 18 years) cervical spine injury patients discharged from their tertiary care pediatric hospital and regional trauma center. Data were collected on children with both radiographically evident cervical spine injury (RESCI) and spinal cord injury without radiographic abnormality (SCIWORA). The goal was to analyze features of the history, physical examination, and radiographic evaluation of patients with cervical spine injury.

Seventy-two patients met the study criteria: 40 (56%) had RESCI and 32 (44%) had SCIWORA. Sports injury was the most common cause of injury (34%), followed by motor vehicle accident (23%), fall (20%), trampoline (11%), diving (4%), and miscellaneous (8%). In children younger than 8 years old, motor vehicle accidents and falls were the most common precipitating events. Of the 40 patients with RESCI, younger children tended to have higher cervical spine injuries but the difference was not significant. Of the 61 patients (RESCI and SCIWORA) with data available on neck examination, 51 (84%) had at least one of the following on clinical examination: midline cervical tenderness, paraspinous muscle tenderness, or cervical muscle spasm. Of those patients with one of these three findings, most (36/51, or 76%) had midline tenderness of the cervical spine. Thirty-eight of the 72 patients (57%) had abnormal neurological examinations; by definition all of the SCIWORA patients had them and an additional six patients with RESCI had focal neurological findings. The remaining 18% of patients in the RESCI group who had neither focal neurological findings nor isolated neck findings had both high-risk mechanisms of injury and distracting painful injuries; thus, no child had a truly unsuspected, asymptomatic cervical spine injury.

Radiographic examination data from the RESCI group revealed the lateral cervical spine view to have the highest sensitivity (79%), with the sensitivity increasing

to 94% when considering the standard three-view series (lateral, anteroposterior, and odontoid). The SCIWORA group, which by definition had negative plain x-rays, had 14 patients who underwent MRI examination; 50% of these had abnormalities, including spinal cord contusions and spinal cord hematomas.

COMMENT BY RICHARD A. HARRIGAN, MD, FACEP

The data presented from this study offered few surprises. The finding that sports was the most common cause of injury is at odds with prior studies, wherein motor vehicle accident has traditionally been found to be the most common cause of pediatric cervical spine injury.[1] This discrepancy is likely due to the study location (Utah), as Baker et al hypothesize that urban areas would be associated with more motor vehicle accidents. The incidence of trampoline-related cervical spine injury was strikingly high and should serve as a warning. Cervical spine injuries in children younger than 8 years old usually occur above C4, due to the high location of the anatomic fulcrum of the cervical spine in young children at the C1-C3 level.[2] Although there was a trend toward this, the results were not significant and perhaps can be attributed to a rather small sample size. The poor sensitivity of the lateral view alone was again shown, a point that deserves mention and reminds us that radiographic clearance involves *at least* a three-view series in children as it does in adults.[1] CT adds further sensitivity to the detection of cervical spine injury.

The concept of SCIWORA must be considered when evaluating the pediatric cervical spine. Nearly one-half of the patients in this series had SCIWORA, which is consistent with previous data.[1] SCIWORA is more common in children than in adults due to the greater flexibility of the ligaments, cartilage, and joint capsules in the pediatric population, allowing contusion of the cord from multiple mechanisms of stress. For example, buckling of the ligamentum flavum after hyperextension can cause a central cord syndrome in children without evidence of bony fracture on plain films.[1,2] SCIWORA should be considered in patients with neurological findings despite a negative three-view series of cervical spine films; MRI is helpful in evaluating the ligaments and spinal cord in this circumstance.

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CME Questions

24. Risk factors associated with noncontact ACL injuries include:
a. hormonal, biomechanical, and anatomical factors.
b. nutritional, biomechanical, and environmental factors.
c. environmental, hormonal, and geographic factors.
d. hormonal, biomechanical, and nutritional factors.
e. All of the above

25. Partial tears of the ACL involving less than 50% of the ligament:
a. progress to complete tears in most cases.
b. rarely progress to complete tears.
c. frequently result in late arthritic changes.
d. significantly limit patients' activities over time.

26. Noncontact ACL injury increase in the female athlete appears to be affected by:
a. menstrual cycle timing with injury.
b. narrowed femoral intercondylar notch size.
c. increased valgus angle of the knee.
d. increased tibial external rotation.
e. multiple factors.

27. The multiple single-leg-hop stabilization test is a reliable way to measure:
a. endurance
b. strength
c. postural control
d. fatigability

28. A higher incidence of stress fractures occurs in high-performance military recruits with:
a. cavus foot deformity.
b. cavus and dynamic flatfoot deformity.
c. cavus and static flatfoot deformity.
d. static flatfoot deformity.

29. Which position of rotation consistently demonstrates increased instability in those patients who have a confirmed anteroinferior post-traumatic shoulder instability?
a. Internal rotation 20°
b. External rotation 30°
c. External rotation 70°
d. Neutral rotation

30. Spinal cord injury without radiographic abnormality (SCIWORA) is:
a. more common in adults than in children.
b. responsible for 90% of cervical spine injury in children.
c. associated with trampoline injuries more often than with other sports injuries.
d. an injury that is elucidated by MRI, but not by plain radiography.

In Future Issues: Effect of Wrist Guards on Bone Strain in Distal Forearm