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Sports Medicine in Primary Care

Introduction

The benefits of regular physical activity are well known. Encouraging individuals to be active through recreational and competitive athletics while preventing and treating injuries is the role of the sports medicine physician. Participation in organized sports is increasing. More than 7.6 million high school students participated in high school sports in 2010-2011, compared with an estimated 4 million in 1971-1972.[1] With this, the field of sports medicine is also rapidly advancing. This review will discuss new methods to prevent injuries, further understanding of concussions, the use of platelet rich plasma and prolotherapy to accelerate healing, and the use of musculoskeletal ultrasound to evaluate soft tissue injuries and aid in injections.

Physical Activity Among Americans

Physical activity can improve the health and quality of life of Americans of all ages, regardless of the presence of chronic disease and disability. Physical activity among adults can lower the risk of:

- Early death
- Coronary heart disease
- Stroke
- High blood pressure
- Type 2 diabetes
- Breast and colon cancer
- Falls
- Depression.

Among children and adolescents, physical activity can:

- Improve bone health
- Improve cardiorespiratory and muscular fitness
- Decrease levels of body fat
- Reduce symptoms of depression.[2,3]

In 1995, the Centers for Disease Control and Prevention (CDC) and American College of Sports Medicine (ACSM) published physical activity recommendations for public health. The report stated that adults should accumulate at least 30 minutes a day of moderate-intensity physical activity on most, and preferably all, days per week. To track the percentage of adults who meet this guideline, CDC specified that "most" days per week was 5 days. Since 1995, the common recommendation has been that the adults obtain at least 30 minutes of moderate-intensity physical activity on 5 or more days a week, for a total of at least 150 minutes a week. The 2008 Physical Activity Guidelines for Americans (PAG) are the first government-published national guidelines for physical activity. PAG reaffirmed the CDC/ACSM recommendations. However, according to the advisory committee report, existing scientific evidence does not allow researchers to say whether the health benefits of 30 minutes of activity on 5 days a week are different from health benefits of 50 minutes of activity on 3 days a week.[3] As a result, new guidelines allow a person

Executive Summary

The recent news of Junior Seau's death added to the speculation of repeated head trauma being associated with depression and suicide and has renewed the interest in sports-related injuries. With the increasing emphasis on physical activity (and perhaps due to the well-publicized salaries of professional athletes), more than 7.6 million high school students are participating in sports. The field of sports medicine has grown concomitantly with established training fellowships across the country. The primary care physician is expected to be more involved with the management of these injuries along with the "weekend warriors."

- The 2008 Physical Activity Guidelines for Americans, the first government-published national guidelines, recommend 150 minutes cumulative per week.
- More than 80% of adults do not meet the guidelines for both aerobic and muscle-strengthening activities and 80% of youths do not meet the guidelines for enough aerobic physical activity.
- In the United States, approximately 7 million children and adults receive medical care for sports injury each year.
- Ankle sprains are the most frequent injuries sustained in sports and often lead to chronic pain. Functional treatment is preferred to immobilization.
- Anterior cruciate ligament injury can occur without any application of external force to the knee joint. Female athletes have a higher incidence of injury. Injury prevention programs have been successful in reducing the risk.
- An estimated 300,000 concussions occur in sports every year. A Modified Maddock's Sideline Assessment Score is a more sensitive tool.
- New modalities of management include platelet-rich plasma therapy and prolotherapy.
- Musculoskeletal ultrasound has emerged as an important interventional modality in sports medicine.

to accumulate 150 minutes a week in various ways. Children should do 60 minutes or more physical activity daily. As a part of their daily physical activity, children and adolescents should include muscle-strengthening activities at least 3 days a week and bone-strengthening physical activity at least 3 days a week.[3]

Unfortunately, more than 80% of adults do not meet the guidelines for both aerobic and muscle-strengthening activities. More than 80% of youths do not do enough aerobic physical activity to meet the guidelines for youths. The estimated annual health care cost associated with obesity is about $209 billion[4] and an additional $183 billion is spent on heart disease, cancer, diabetes, and arthritis.[2]

Acute Injuries in Sports Medicine

Although a significant number of American adults and youth do not meet the recommendations set by PAG in general population, there has been a steady increase in sports and recreational activity over the last decade. In the United States, sports has evolved into a major component of everyday life. American youth are involved in scholastic, club, collegiate, and recreational sports. In addition to the 7.6 million students who participate in high school sports annually,[1] more than 30 million athletes participate in club and recreational sports.[5-6] In fact, every fifth unintentional injury in typical communities in industrialized parts of the world is associated with sports and physical exercise.[7] In the United States, an estimated 7 million children and adults received medical care for sports injury each year.[8] The highest rates occur in children ages 5-14 years (59.3/1000 persons) and in the 15-24 age group (56.4/1000 persons). The rate of injury in males is more than twice that in females. In a 1999 study, sports injuries among high school athletes' resulted in approximately 2 million injuries, 500,000 doctor visits, and 30,000 hospitalizations annually.[9,10] Most common injuries in sports medicine are sprains, strains, fractures, and concussions, but less common injuries include eye injuries, dental injuries, neck and cervical injuries, dehydration, and heat illnesses.[8,11] According to a 2001 CDC report, sports-related injuries result in about 2.6 million emergency room visits annually. The most common reasons for sports-related emergency department visits for children and adolescents are injuries associated with basketball and pedal cycling (almost 900,000 a year), football and baseball injuries (250,000 visits per year), and soccer injuries (100,000 visits per year). The findings do not suggest that these sports are necessarily more dangerous; there may be more people engaging in these activities. In addition, ice or roller skating and skate boarding result in 150,000 visits, gymnastics and cheerleading in 146,000 visits, and water and snow sports in 100,000 visits each year. Injuries on the playground account for about 137,000 emergency department visits yearly.[8,12]

Principles of Acute Injury Prevention

The traditional injury prevention program in sports involves four stages:

1. Establishing the extent of the sports injury problem.
2. Establishing the etiology and mechanism of injury.

Table 1: Principal Components of a Functional Ankle Rehabilitation Program[26]

Rehabilitation Mode	Goal/Methods
Price	Reduce swelling, inflammation, and pain. Use of ice massage, ice packs, ankle cryo-sleeve, compressive sleeves/elastic ankle wraps, and short-term use of braces.
ROM	Reduce swelling, inflammation, and pain. Use of ice massage, ice packs, ankle cryo-sleeve, compressive sleeves/elastic ankle wraps, and short-term use of braces.
Strengthening	Primary emphasis on ankle evertor strengthening. Begin with low-level strengthening such as restoring appropriate invertor/evertor strength ratios, sub-maximal isometric exercises, and progress in a pain-free fashion to isotonic strengthening. Use a combination of open and closed kinetic chain strengthening.
Proprioception	Restore dynamic ankle balance and stability. Use ankle disks/wobble boards, single-leg stance on uneven surface or with eyes closed.
Functional	Restore dynamic strength, balance and power jogging, running, double-leg jumping, single-leg jumping.

3. Introducing the preventive measures.

4. Assessing the effectiveness of the preventive interventions by repeating the first step.[7,13]

More complex socioenvironmental health promotion frameworks have been used to visualize the injury mechanism and relate them to structures of the environment. Various "modifying conditions" such as sports person factors (age, sex, ethnicity), physical environment (climate, air, soil and water quality, urbanization level), and social environment (family roles, winning pressure, financial resources) may have a role in resulting injury. Modifying conditions represent the sports person factors, social factors, and environmental factors that are independently involved in sport injury mechanism. Modifying conditions normally cannot be influenced by the intervention programs. On the other hand, the "mediating mechanisms" are factors that are regarded as modifiable and are targeted within planned interventions. Mediating mechanism may include factors such as sports person factors (sports specific skills, equipment, fatigue, substance abuse), physical environment (condition of sports facilities, floor/turf surface), and social environment (mass media, health care resources, access to organized sports, fair play policies).[7,14-16]

Bracht et al introduced a five-stage process that can be applied for organization of safety programs in sports communities: [16]

1. Analysis of community structure, resources, injury "modifying factors" and "mediating mechanisms."

2. Design of safety program addressing identified mechanism and conditions.

3. Implementation of structural changes, information campaigns, and educational interventions.

4. Program maintenance and consolidation.

5. Evaluation and dissemination of the results.

The first stage is establishing the baseline for the program and priorities. This involves constructing a profile for specific sports that includes the incidence of the injury, assessing ongoing safety activities, and identifying modifying factors and mediating mechanisms associated with occurrence of the sports injury. The second stage involves setting up an organizational structure, defining safety goals, and designing safety interventions (e.g., structural changes and information campaigns in mass media or safety education). In the third stage, a timeline is established and interventions are implemented. The fourth stage involves the maintenance and sustainability of intervention efforts, for example, the integration of interventional activities into sports community structures and establishing a positive organizational climate to retain staff and volunteers. In the final stage, the interventions are evaluated and the results are disseminated.[16]

The intervention programs have been helpful in identifying preventable causes of sports injury and also have helped in designing guidelines in injury prevention. For example, in baseball, strict guidelines have been developed to determine safe pitch counts, rest period required, and age recommendations for various pitches. According to these guidelines, a 12-year-old athlete should have a maximum pitch count of 85 per game, should rest for at least 3 days if he throws more than 61 pitches, and should not be engaged in throwing sliders, forkballs, or screwballs to minimize the risk of shoulder and elbow injury.[17]

Prevention of Acute Ankle Injury

Ankle sprains are the most frequent injuries sustained in sports and often lead to chronic pain,

swelling, and functional instability. In the United States, there are approximately 2 million moderate-to-severe ankle sprains every year, which accounts for an estimated 14-33% of all sports-related injuries. Up to 40% of individuals who sustain acute ankle sprains have been found to have symptoms of chronic ankle instability and recurrent injury.[18,19] A 1983 study estimates the annual aggregate cost for moderate-to-severe ankle sprains in the United States is about $2 billion. Adjusted for inflation, this figure equates to $4.5 billion in today's economy (consumer price index, 2012). These data suggest that considerable morbidity and unnecessary medical cost potentially may be averted with effective ankle injury prevention and treatment programs.[18,20-24]

In a review of 22 studies, Kerkhoffs et al found that functional treatment was preferable to immobilization for the initial treatment of acutely injured ankles.[25] Rehabilitation can begin when the pain and swelling are under control. A review of clinical trials supports the use of NSAIDs in the early phase of ankle sprains (less than 2 weeks). Functional ankle rehabilitation starts by normal joint range of motion (ROM), followed by gentle stretching and progressive weight-bearing exercises. Resistance exercises can begin when there is no pain through the available ROM with full weight bearing. (*See Table 1.*)[26]

Proprioceptive exercises are an integral part of acute ankle sprain rehabilitation. Patients with functional ankle stability following an acute ankle sprain have been found to have a significant deficit in balance compared with the controls. Proprioceptive training using ankle disks/wobble boards has been shown to significantly improve balance testing and decrease the symptoms of functional instability.[27-30]

The use of ankle support and taping has been found helpful in preventing recurrent ankle injury. This benefit is related to enhancement of proprioceptive function of an injured ankle with taping or bracing. Following a review of 113 studies, Thacker et al recommended the use of ankle orthosis for 6 months after an athlete sustains moderate-to-severe ankle sprain.[31-32]

Prevention of ACL Injury

Most ligament injuries are the result of excessive external forces applied to the limbs, while meniscus injuries are more likely secondary to torsional force generated within the limbs. However, anterior cruciate ligament (ACL) injury can occur without any application of external force to the knee joint. There are approximately 200,000 ACL and posterior cruciate ligament (PCL) injuries annually in the United States alone. When combined, the cost of MRI, ACL reconstruction surgery, and post-operative rehabilitation translates into an average annual cost exceeding $3 billion. Typically, an ACL injury is considered a season-ending injury for an athlete, with average recovery time and return to sports taking about 6 to 9 months. In addition, the psychological impact of such an injury can be tremendous.[33]

Multiple studies and randomized controlled trials have shown the usefulness of an ACL injury prevention program among athletes. Female athletes have two- to 10-fold higher incidence of ACL injury compared with their male counterparts.[34] The difference in anatomy — including greater Q angle, increased femoral anteversion, excessive tibial torsion, and excessive subtalar pronation compared with male equivalents — have been noted.[35,36] In addition, women typically have a narrower A-shaped intercondyler notch compared with wider U-shaped notch in males of same height and weight.[37] The role of hormones, biomechanical factors, and neuromuscular factors has been studied.[33,38,39] The details of these studies are beyond the scope of this paper, but it is worth mentioning that irrespective of various risk factors, injury prevention programs have been successful in reducing the risk of lower limb injuries, including ACL injury. Most of these programs have emphasized proper landing techniques, which includes landing softly on the fore foot and then rolling back on the

Table 2: Definition of Concussion from 3rd International Conference on Concussion[61]

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.

Several common features that incorporate clinical, pathologic, and biomechanical injury constructs that may be utilized in defining the nature of a concussive head injury include:

1. Concussion may be caused either by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head.

2. Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously.

3. Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury.

4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however, it is important to note that in a small percentage of cases, post-concussive symptoms may be prolonged.

5. No abnormality on standard structural neuroimaging studies is seen in concussion.

rear foot, avoiding excessive genu valgum at the knees on landing and squatting, and engaging hip and knee flexion on landing and with lateral maneuvers. In addition, increasing strength and flexibility of hamstrings, gluteus medius, and hip abductors has been utilized in most ACL prevention protocols.[33,40-46] The use of prophylactics and the functional knee brace has not been able to demonstrate statistically significant injury reduction and is not currently recommended.[33,47]

Concussions

Participation in school sports can benefit children, but it also carries a risk of injury, including concussion. An estimated 300,000 concussions occur in sports every year.[48] A study conducted to summarize 16 years of NCAA injury surveillance data showed an increase in concussion injury rate per 1000 athletic-exposures from 0.17 in 1988-1999 to 0.34 in 2003-2004.[49] One athletic exposure is defined as one athlete participating in one practice or game. This increase in concussion injury rate is partially because of an increase in sports activity and partially because of increased awareness and understanding of concussion. The most recent consensus statement on concussion was released at the third international conference on concussion in sports held in Zurich in 2008. The definition proposed at this conference is provided in Table 2.[50]

Concussion is caused by rotational and angular forces to the brain.[51,52] These shear forces disrupt neural membranes allowing potassium efflux into extracellular space. The increase in calcium and excitatory amino acids are followed by further potassium efflux into extracellular space. This leads to suppression of neuronal activity.[51-55] The disruption of autonomic regulation can persist for many weeks, and the brain may be vulnerable to additional injury. After a concussion, the brain may be susceptible to extremes of blood pressure. A catecholamine surge from the second impact to the head or body may cause vascular congestion, cerebral edema, increased intracranial pressure, and ultimately coma and death.[54] There have been a few documented cases of the "second impact syndrome," and all of these deaths have occurred in persons younger than 20 years of age.[51,54]

The suspected diagnosis of concussion can include one or more of the following clinical domains:[50]

(a) Symptoms — somatic (e.g., headache, pressure in the head, neck pain, nausea or vomiting, dizziness, tinnitus, blurred vision, sensitivity to light, sensitivity to sound, fatigue or low energy); cognitive (e.g., feeling like in a fog, feeling slowed down, "don't feel right," difficulty concentrating, difficulty remembering, confusion, slowed reaction time, inability to focus); and/or emotional (e.g., lability, personality changes, anxiety, depression)

(b) Physical signs (e.g., loss of consciousness, seizure or convulsions, amnesia, balance problems)

(c) Behavioral changes (e.g., irritability, sadness)

(d) Cognitive impairment (e.g., slowed reaction times)

(e) Sleep disturbance (e.g., drowsiness, increased or decreased sleep, difficulty initiating sleep).

If any one or more of these components is present, a concussion should be suspected and the appropriate management strategy instituted.

Baseline self-reported symptom (SRS) scales can be used at the time of pre-participation exam. This baseline score can assist in determining when the injury has resolved in a case where an athlete sustains a concussion. However, athletes may present with concussion-related symptoms at baseline. A recent study showed that a history of previous concussion, acute fatigue, physical

Table 3: Various Assessment Tools Used in Concussion Diagnosis and Management[58]

Type	Examples
Symptoms checklists	Graded symptom scale Head injury scale Post concussive symptoms scale McGill abbreviated concussion evaluation HeadMinder Concussion symptom inventory
Neuropsychological testing	Written tests Trail making test Digit Symbol Substitution test Controlled oral word association test Hopkins verbal association test Stroop color and word test Computer based tests HeadMinder CogSport ImPACT Automated neuropsychological assessment Metrics
Postural stability testing	BESS and modified version SOT
Sideline asssessment tools	SAC (Standardized Assessment of Concussion) SCAT (Sport Concussion Assessment Tool) SCAT 2

illness, or orthopedic injury can alter normal baseline responses. If the athlete is currently experiencing fatigue, physical illness, or orthopedic injury, baseline testing should be postponed until the athlete improves.[56] An athlete with a history of concussion or an elevated self-reported symptom score should be evaluated thoroughly.

In a recent study evaluating the sex differences in the concussion symptoms of high school athletes, there was no difference in the number of symptoms reported but there was a difference in the type of symptoms reported. Males reported amnesia, confusion, and disorientation more frequently than females, whereas females reported more drowsiness and phonophobia than did males. No differences were observed for the symptom resolution time in this study.[57]

An athlete with concussion may be evaluated in a hospital emergency department or doctor's office as a point of first contact following injury or may have been referred from another care provider. In addition to the points outlined above, the key features of this exam should include a determination of the need for emergent neuroimaging to exclude a more severe brain injury involving a structural abnormality. A comprehensive history and detailed neurological examination can be helpful in determining the need for imaging study. A comprehensive history may entail seeking additional information from parents, coaches, teammates, and eyewitnesses to the injury. It is worth mentioning that conventional structural neuroimaging is generally normal in concussive injury. Brain CT or MRI brain scan contributes little to concussion evaluation but should be employed whenever suspicion of an intracerebral structural lesion exists. Examples of such situations may include prolonged disturbance of conscious state, focal neurological deficit, evidence of skull fracture, or worsening symptoms. Once a serious structural injury is ruled out, a detailed evaluation involving symptom checklist, sideline assessment tools, neuropsychological test, and postural stability test are used to diagnose concussion.[50] Although none are exclusively effective, combining these tools can increase sensitivity and specificity. Various assessment tools used in concussion diagnosis and management are listed in Table 3.[58]

Standard orientation questions are not sensitive enough for subtle changes caused by concussion. Modified Maddocks questions, which are part of SCAT 2, are sensitive for sideline assessment. Modified Maddocks questions are listed in Table 4.[59]

It appears that postural stability testing provides a useful tool for objectively assessing the motor domain of neurological functioning, and should be considered a reliable and valid addition to the assessment of athletes suffering from concussion, particularly where symptoms or signs indicate a balance component. A modified Balance Error Scoring System (BESS) 6 can be easily used in an office and is listed in Table 5.[60]

The cornerstone of concussion management is physical and cognitive rest until symptoms resolve and then a gradual program of exertion prior to medical clearance and return to play. A well-known phenomenon called "second impact syndrome" carries the risk of sudden death in an athlete and should be kept in mind while making a return-to-play decision. It may take minutes, hours, days, or weeks to recover from the symptoms. It is inappropriate for a child or adolescent athlete with a concussion to return to play on the same day as injury regardless of the level of athletic performance. During the period of recovery while symptomatic following an injury, it is important to lay emphasis on the necessity to have both physical and cognitive rest. Activities that require concentration and attention (e.g., scholastic work, video games, text messaging, etc.) may aggravate symptoms and possibly delay recovery. The recovery and outcome of this injury may be modified by a number of factors that may require more sophisticated management strategies. Once complete symptomatic and cognitive recovery are achieved, an athlete can be started on a graded return-to-play protocol.[50,61,62]

The application of neuropsychological testing in concussion has been shown to be of clinical importance and is designed to identify subtle cognitive deficits.[55] Although in most cases cognitive recovery largely overlaps with the time course of symptom recovery, it has been recognized that cognitive recovery more commonly follows clinical symptom resolution, suggesting that the assessment of cognitive function should be an important component in any return to play modus operandi. Neuropsychological assessment should not be the solitary basis of management decisions; rather it should be seen as an aid to the clinical decision-making process in combination with a range of

Table 4: Modified Maddocks Score Sideline Assessment Tool[59]

Physician should say to the patient: "I am going to ask you a few questions, please listen carefully and give your best effort"

Modified Maddocks questions (1 point for each correct answer)

At what venue are we today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week/game?	0	1
Did your team win the last game?	0	1
Maddocks score		Out of 5

Table 5: Balance Error Scoring System-Modified (BESS) 6[60]

This balance testing is based on a modified version of the Balance Error Scoring System (BESS) 6. A stopwatch or watch with a second hand is required for this testing.

Balance testing

"I am now going to test your balance. Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of three 20-second tests with different stances."

(a) Double-leg Stance:

"The first stance is standing with your feet together with your hands on your hips and with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. I will start timing when you are set and have closed your eyes."

(b) Single-leg Stance:

"If you were to kick a ball, which foot would you use? [This will be the dominant foot] Now stand on your non-dominant foot. The dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

(c) Tandem stance:

"Now stand heel-to-toe with your non-dominant foot in back. Your weight should be evenly distributed across both feet. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

Balance testing — types of errors

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

Each of the 20-second trials is scored by counting the errors, or deviations from the proper stance, accumulated by the athlete. The examiner will begin counting errors only after the individual has assumed the proper start position. The modified BESS is calculated by adding one error point for each error during the three 20-second tests. The maximum total number of errors for any single condition is 10. If a athlete commits multiple errors simultaneously, only one error is recorded but the athlete should quickly return to the testing position, and counting should resume once subject is set. Subjects who are unable to maintain the testing procedure for a minimum of 5 seconds at the start are assigned the highest possible score, 10, for that testing condition.

Which foot was tested: left or right (i.e., which is the non-dominant foot)?
Condition Total errors
Double-leg stance (feet together) of 10
Single-leg stance (non-dominant foot) of 10
Tandem stance (non-dominant foot at back) of 10
Balance examination score (30 minus total errors) of 30

clinical domains and investigational results.[50,55] Various commercial computer-based screening tools (e.g., ImPACT) are often utilized in sports clinics to assist in return to play decision making. In a majority of cases, neuropsychological testing is not done until the patient is symptom-free. In certain situations

(e.g., child and adolescent athletes), testing may be done early while the patient is still symptomatic to assist in determining management. In patients with a complicated history, prolonged recovery time, or requiring medication to control symptoms, a formal neuropsychological evaluation through a neurophysiologist may be required to assist in return to play decision making. Athletes with concerning historical factors or concussive symptoms lasting more than 7-10 days may benefit from referral to an expert in concussion management. Some of these factors may include previous history of concussions, severity, comorbidities like ADHD, and sleep disorders.[50]

Helmets have been ineffective in the prevention of concussion injury, although a study conducted by Collins et al suggests that a newer design of football helmets (e.g., the Riddell Revolution, Elyria, OH) may have some protective role from concussion.[63] Recently, a new system was developed to evaluate the protective performance of football helmets to integrate player head impact exposure and the risk of concussion. The Summation Test for the Analysis of Risk (STAR) relates on-field impact exposure to a series of drop tests performed at four impact location and six impact energy levels. The data from all drop tests are combined into one number using a complex formula. This new evaluation system is supposed to provide consumers with a meaningful metric to assess relative performance of football helmets.[64]

Concussion has different objectives in on-field assessment when the immediate safety of the athlete needs to be ensured and sideline assessment is needed to accurately determine what actions should be taken after the concussion occurs. The off-field/office assessment is required to determine the extent of the concussion and also to make the return to play decision. If physicians do not complete comprehensive assessments, they potentially could place athletes in dangerous situations. To ensure athletes' safety, established guidelines must be followed.[65]

Baseline measurements of subjective symptoms, balance testing, and neuropsychological testing should be obtained in high-risk contact/collision sports activity in the pre-participation physical exam. Managing a concussion can be challenging and requires a delicate balance between returning the player to sports as soon as possible and ensuring the athletes' safety. Clinicians should not be pressured by athletes, coaches, or teammates to return athletes to play too early.

Platelet-rich Plasma Therapy

Platelet-rich plasma therapy (PRP) recently has been promoted as an option to treat both acute and chronic musculoskeletal problems and to promote healing. A significant proportion of injuries in athletes results in long-standing symptoms and decreased performance. Most sports medicine physicians have to deal with situations when rapid recovery and early return to play is strongly desired by the athletes. Athletes may feel it affects their sports future, and in professional sports, it may translate directly into fame and money. PRP has been used as a treatment option with the objective of decreasing recovery time and facilitating earlier return to play without compromising the athlete's safety, performance, or the risk of recurrent injury.

Various growth factors long have been known for having tissue-healing properties. Early studies focused on purified isolated growth factors that were known to have a role in tissue healing. It is now well known that to target various signaling pathways, there is a need to administer a balanced combination of mediators. Isolated growth factors likely would not be able to satisfy the multiple requirements of the injured tissue.

The clinical rationale behind PRP therapy is that the treatment contains many biologically active growth factors, including proteins responsible for homeostasis. These growth factors support regeneration of new connective tissue and also assist in revascularization. The higher concentration of cytokines and growth factors in PRP may act locally as regulators of most basic repair functions in acute and chronic injuries.[66] Typical hematomas formed after acute muscle tear contain about 94% red blood cells (RBC) and 6% platelets. RBCs in general do not contribute to the healing process. The idea behind the PRP therapy is to reverse the RBC:platelet ratio from about 94% RBC and 6% platelets to 94% platelets and 6% RBC to stimulate recovery.[67,68]

The main growth factors in the PRP concentrate are the transforming growth factor-beta (TGF-beta), platelet-derived growth factor (PDGF), vascular endothelial factor, epithelial growth factor, hepatocyte growth factor, and insulin-like growth factor 1.[66,68-70] Most of these growth factors play a role in muscle, ligament, cartilage, and bone healing by stimulating angiogenesis, epithelialisation, cell differentiation, and formation of extracellular matrix.[68-71] In particular, TGF-beta is one of the most important factors involved in cartilage regeneration.[72,73] TGF-beta is involved in the chondrocytes phenotype expression and differentiation of the mesenchymal stem cells. TGF-beta also has a role in matrix deposition and it counteracts with most of the suppressive effects of inflammatory mediators, including interleukin-1, on cartilage-specific macromolecules synthesis.[67,74]

Various in vitro and in vivo studies have been conducted to show the usefulness of PRP therapy after acute injury.[67,72-81] In one study, after ultrasound-guided injections of platelet-released growth factors in 22 muscle injuries of 20 high-level professional athletes, full functional recovery was restored in as early as half of the expected time.[82] Furthermore, fibrosis did not appear in any of the treated cases and no re-injuries occurred in any athletes after resuming their sports activities. There is a report of significant acceleration in functional recovery after surgical repair of ruptured Achilles tendons compared with a matched group

who had conventional surgery.[83] PRP therapy has been used to enhance the healing of meniscal defects,[74] and to stimulate chondrocytes[71-73] to synthesize cartilaginous tissues in animal models.[84,85] These results are stimulating, since both the avascular cartilage and meniscus have limited chances of proper functional repair.

PRP treatment is considered an option in athletes with chronic tendon injury. Positive effects of PRP on tendon healing have been documented in animal studies.[70,86] Most of the human studies published on the use of PRP for the treatment of tendon injuries are case studies. In a cohort study conducted by Mishra et al, there was a reported reduction in pain in patients treated with PRP therapy in cases of chronic severe lateral epicondylitis.[87] Another small study using autologus blood injections followed by dry needling of tendon under ultrasound guidance suggested successful outcome in cases of refractory medial epicondylitis (golfer's elbow).[88] Three studies have shown the benefit of PRP therapy in patellar tendinopathy.[89,90]

Cartilage injury is a significant part of morbidity of athletes and the general population. Studies also are being conducted to see the results of PRP treatment in patients with cartilage injury and osteoarthritis. In vitro studies have shown the evidence of enhanced secretion of hyaluronic acid by synovial fibroblast from arthritic patients when exposed to preprations rich in platelet-released growth factors.[91] In a pilot study of more than 100 patients with osteoarthritis treated with an intra-articular PRP injection, statistically significant improvement in pain and function were observed. In this study, mild pain reaction and minimal effusion after the injection were the most common side effects reported. The patients were followed up at 2, 6, and 12 months post-treatment. The positive beneficial effects of improved function and pain reduction were observed at 12 months follow-up with a mean duration of beneficial effects lasting 9 months. However, the overall symptom reduction and quality of life at the 12-month follow-up continued to remain much higher than the baseline symptoms evaluation conducted before the initiation of the therapy.[92] The intra-articular injection of PRP has been compared with the intra-articular hyaluronon injection. This observational retrospective cohort study in patients with knee osteoarthritis showed better pain control and improvement in function in patients treated with PRP compared with hyaluronan injections.[93]

Overall, there is sufficient evidence from in vitro and animal studies to strongly suggest the usefulness of PRP therapy and its role in tissue regeneration and also in chronic tendinopathies. However, there is a lack of adequately powered studies and RCTs to substantiate the use of PRP therapy in humans. More human studies are being conducted and the results are likely to become available in the near future. In general, the use of PRP appears to be safe with mixed results on the potential beneficial effects of PRP over traditional management. Further studies are needed to validate the role of PRP and to define clear indications for its use in various musculoskeletal problems.

Prolotherapy

Prolotherapy is aimed at the rehabilitation of an incompetent structure by the generation of new collagen tissue accomplished by injecting a proliferant solution into the osseo-ligamenteous junction of the dysfunctional spinal segments. Prolotherapy involves injection of proliferant material, which stimulates the production of new cells. The goal of most rehabilitative programs is to improve the performance of supporting musculature, but the ligament insufficiency and instability of the joint structures is ignored. Prolotherapy focuses on the rehabilitation of passive structures, including ligaments and tendons, with a goal to neutralize instability, correct the dysfunction of these structures, and thus alleviate pain.

The healing cascade is comprised of three stages:[94-96]

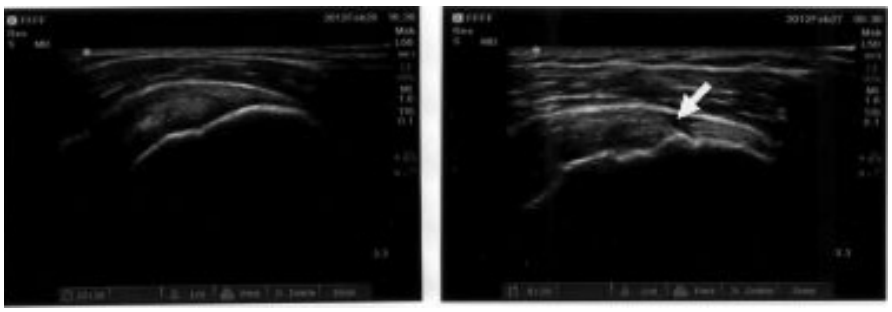
1. Early inflammation when the tissue damage results in spillage of cell contents into the wound sites. The granulocytes debride the wound in this early stage.
2. Late inflammation when macrophages and monophages secrete humoral factors to attract fibroblasts.
3. Fibroblasts lay down new collagen fibers adding strength to the wound.

After injury, connective tissue can return to its normal length but it only regains 50-70% of its original strength.[97] Weakened ligaments may result in instability and recurrent injuries in the affected area. Nocioceptors in the ligaments have limited stretch capabilities and any abnormal stretch of the ligament results in stretching of the pain receptors culminating in pain response and muscle inhibition. This may result in exercise intolerance, which in turn may result in progressive weakening of the ligaments and instability. This perpetuates the vicious cycle and results in poor rehabilitative outcome. Any interruption in the healing process may lead to even poorer outcome.[96,97]

Prolotherapy works by initiating the healing cascade and fibroblasts. Most solutions used for prolotherapy trigger inflammation and eventually fibroblastic proliferation. In one study, histological samples of tissue from the posterior sacroiliac joint ligament were taken 2 weeks before prolotherapy. Repeat samples were taken from the same ligament 3 months after the prolotherapy treatment. Comparison of these tissue samples by light microscopy revealed increased number of total collagen fibers in 3 months post prolotherapy treatment compared with samples taken 2 weeks before the therapy.[98]

In 1939, Hackett et all gave prolotherapy injections to the spine. Different agents have been used in the past including a mixture of glucose, glycerine, and phenol. Currently, dextrose solution and sodium morrhuate are commonly used. Irritants like phenol and tannic acid work by causing local cell death,

Figure 1: Long axis views of supraspinatus tendon on MSKUS showing normal tendon on the left and a significant tear as marked on the right in a different patient



thus stimulating the healing process. Osmotics like glucose solution and glycerine or zinc sulfate dehydrate the tissue thus causing local damage and inflammation.[96] Since the first step in healing is inflammation, NSAIDs should be avoided in patients receiving prolotherapy.

The potential toxicity from injection of phenol has been studied. Phenol is produced in humans during the digestion of proteins and is rapidly metabolized by the liver to less-toxic substances. The concentration of naturally occuring phenol present in the urines of untreated patients is greater than the amount that might be injected during a prolotherapy session. Furthermore, phenol has a half life of 1-4.5 hours and is completely eliminated from the body in 24 hours; therefore, there is little chance of chronic cumulative toxicity.[99]

Cases of death have been reported with inadvertent injection of zinc sulfate and phenol solution in the subarachnoid spaces resulting in severe arachnoiditis and subsequent death.[100] There have been two reported cases of sterile meningitis after inadvertent injection of a P2G (phenol, glucose, glycerine, lidocaine, and water) solution by accidently puncturing the dura while attempting to inject the interspinous ligament.[101] Both of these cases resolved without complications. Several authors maintain that with proper technique and strict adherence to the appropriate injection procedure, the risk can be minimized. Animal studies and earlier human studies have shown evidence of beneficial effects in various structural and ligamentous abnormalities including mechanical low back pain,[102-105] discogenic pain,[97,104,106] osteitis pubis,[105,107] foot problems,[108] fibromyalgia,[109] and overuse tendinopathies.[110]

Musculoskeletal Ultrasound

During the past 10 years, musculoskeletal ultrasound (MSKUS) has become a useful imaging, as well as an interventional modality in sports medicine. With the rapid development and sophistication of this modality, essential information for the increased understanding of the pathophysiology of many disorders has been established. With increased utilization of MSKUS in sports medicine, it will be useful for primary care physicians to become familiar with the advantages and disadvantages of the MSKUS. Musculoskeletal ultrasound is invaluable for its ready availability, low cost, speed, and diagnostic accuracy. Musculoskeletal ultrasound also offers some specific advantages over MRI, such as higher resolution capabilities and the ability to examine the tissue in both static and dynamic states with the patient in different positions. MSKUS allows rapid real-time evaluation and also rapid comparison with the same structures on the contra-lateral side.[111,112]

Ultrasound is safe and free from ionizing radiation. In patients who have contraindications to use of MRI or MRI claustrophobia, ultrasound can be an attractive alternative assuming the lesion is suitable for evaluation by ultrasound. In ultrasound machines with power Doppler capabilities, it allows for evaluation for "neovascularization" in tendinopathies.

One disadvantage of MSKUS is that it is operator-dependent and requires a long learning curve for competence in scan skills. MSKUS cannot penetrate the bones to any useful levels but is very useful in the detection of bony erosions, calluses, and stress fractures. Artifacts are common pitfalls in the evaluation with MSKUS with the most common being anisotropy.[113] (*See Figure 1.*)

The shoulder is one of the most common applications of the MSKUS due to the high incidence of rotator cuff disorders related to increasing age and sporting activities. Many papers discussing the accuracy of musculoskeletal ultrasound already have been published in radiological and orthopedic literature. Although the use of ultrasound is operator dependent, in skilled hands and with appropriate equipment, this technique provides assessment of rotator cuff pathology with high sensitivity and specificity in the diagnosis of both partial and full thickness tears.[111,112]

Interventional ultrasound refers to a wide and heterogeneous range of invasive procedures performed percutaneously using ultrasound guidance. Most of these procedures include aspiration of fluid from a cyst or a joint or injection of medication either into a joint cavity, tendon sheath, or para-articular soft tissue.[113]

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Primary Care Reports CME Objectives

Upon completion of this activity, participants should be able to:

1. Summarize recent, significant studies related to the practice of primary care medicine;
2. Evaluate the credibility of published data and recommendations related to primary care medicine;
3. Discuss the advantages and disadvantages of new diagnostic and therapeutic procedures in the primary care setting.

CME Instructions

To earn credit for this activity, please follow these instructions.

1. Read and study the activity, using the provided references for further research.
2. Log on to www.cmecity.com to take a post-test; tests can be taken after each issue or collectively at the end of the semester. First-time users will have to register on the site using the 8-digit subscriber number printed on their mailing label, invoice or renewal notice.
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4. After successfully completing the last test of the semester, your browser will be automatically directed to the activity evaluation form, which you will submit online.
5. Once the completed evaluation is received, a credit letter will be e-mailed to you instantly.

CME Questions

1. According to the Physical Activity Guidelines for Americans 2008:
   a. adults should obtain at least 150 minutes of moderate intensity physical activity in a week.
   b. adults can accumulate 150 minutes of moderate intensity per week in various ways, which could mean 30 minutes for 5 days a week or 50 minutes for 3 days a week.
   c. children should do 60 minutes of physical activity daily.
   d. as a part of daily physical activity, children and adolescents should include muscle-strengthening activity for at least 3 days a week and bone strengthening physical activity for at least 3 days a week.
   e. All of the above

2. In rehabilitation of acute ankle injuries, which of the following is ***not*** true?
   a. Rehabilitation starts with normal range of motion, gentle stretching, and progressive weight-bearing activity.
   b. Strengthening can begin as soon as the patient has pain-free range of motion and full weight bearing.
   c. Use of ankle support has no role in acute ankle rehabilitation.
   d. Balance exercises have been shown to decrease symptoms of functional instability.

3. In prevention of ACL injury, which of the following is ***not*** true?
   a. Proper landing techniques can help prevent ACL injury in an athlete.
   b. While landing, an athlete should land softly on the fore foot and then roll back on the rear foot, avoiding excessive genu-varum on the knees on landing and squatting.
   c. Increased strength and flexibility of hamstring, gluteus medius, and hip abductors can be helpful in prevention of acute ACL injury.
   d. All of the above are true

4. The assessment and management of an athlete with concussion involves all of the following ***except***:
   a. the postural stability testing is a useful tool for objective assessment of the motor domain of the neurological functioning.
   b. modified Maddocks questions are a sensitive tool for sideline assessment of orientation.
   c. all patient with suspected concussion should get CT scan or MRI of the head to rule out any structural damage.
   d. neuropsychological testing has a useful role in concussion management and in return-to-play decision making.

5. The musculoskeletal ultrasound as a diagnostic tool has all the advantages ***except***:
   a. MSK ultrasound is safe, free of ionizing radiation, and is low cost.
   b. MSK ultrasound can allow both static and dynamic studies.
   c. MSK ultrasound can allow rapid comparison with the structures on the contra lateral side.
   d. MSK ultrasound has deep bone penetration and can allow easy assessment of pathology like SLAP lesion.

In Future Issues: Managing Non-Cancer Related Chronic Pain without Opioids

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