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Common American Football Injuries

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Summary

As many as 1.5 million young men participate in American football in the United States. An estimated 1.2 million football-related injuries are sustained annually. Since the 1970s epidemiological studies have shown that the risk of injury is higher in older athletes and lower in teams with more experienced coaches and more assistant coaches. 51% of injuries occurred at training; contact sessions were 4.7 times more likely to produce injuries than controlled sessions. Injury rates were reduced by wearing shorter cleats and preseason conditioning.

Overall, lower extremity injuries accounted for 50% of all injuries (with knee injuries accounting for up to 36%). Upper extremity injuries accounted for 30%. In general, sprains and strains account for 40% of injuries, contusions 25%, fractures 10%, concussions 5% and dislocations 15%.

Cervical spine injuries have the potential to be catastrophic, but they declined dramatically in the decade 1975 to 1984, due to the impact of rule changes modifying tackling and blocking techniques and improved fitness, equipment and coaching. Appropriate diagnostic evaluation of cervical injuries is mandatory.

The evidence supporting prophylactic knee bracing is not compelling and does not mandate compulsory or routine use.

Return to play criteria include: full range of motion; normal strength; normal neurological evaluation; no joint swelling or instability; ability to run and sustain contact without pain; no intake of pain medication; player education about preventive measures and future risks. These criteria should be strictly observed.

In addition to ankle and knee rehabilitation, lumbar spine injuries present a challenge for the physician. Repetitive flexion, extension and torsional stresses predispose the lumbar spine to injury. Rehabilitation consists of pain control and training. The training phase aims to eliminate repetitive injuries by minimising stress at the intervertebral joint.

Football is a high risk sport. Coaches, players, trainers and physicians must all become aware of the proper means to prevent injuries.

As many as 1.5 million preadolescent and adolescent young men participate in American football programmes in the United States (Blyth & Mueller 1974a). Organised participation in football begins at age 9 with the Pee Wee leagues. Junior midget and midget levels of participation begin at ages 10 and 11, respectively. Estimates of the likelihood of an individual sustaining an injury have been reported to be as low as 11% and as high as 81% (Robey et al. 1971). These figures represent an estimated 1.2 million football-related injuries annually. 17% of the injuries sustained by children and adolescents that resulted in hospitalisation in Massachusetts in 1980-81 were reported to be sports injuries, the largest proportion of which (20%) were a result of football (Gallagher et al. 1984).

Rule changes have been implemented in an attempt to prevent injury. Protective equipment including shoulder pads, knee pads, tail bone protectors, mouth pieces, and properly designed and fitted helmets were made mandatory. Due to the high incidence of knee injuries, the National Collegiate Athletic Association (NCAA) has added rules to prevent certain types of blocking techniques.

Football is a contact sport that carries an obvious risk of injury. In 1869 when the first Princeton versus Rutgers game was played, no protective equipment was used. Following a Chicago Tribune report of 18 deaths and 159 serious injuries during the 1905 season, President Roosevelt met with representatives of the Ivy League schools to investigate a means of improving the safety of the sport.

1. *Aetiology of Football Injuries*

In the early 1970s, epidemiological studies began to be published analysing the risk factors associated with football injury. Interpreting the data from these studies, however, is difficult. The injury rates reported have been based on varying definitions of injury and have depended on differing forms of data collection. Therefore, the data are not easily compared statistically. No uniform criteria for measuring severity of injury exists in the football injury literature. Future research, when undertaken, must take these drawbacks into account. The severity of injury should be defined based on functional limitation, for example, the number of days of practice lost. A definition based on a quantifiable factor lends itself to less bias than reports of mild, moderate or severe injury. Furthermore, it appears that the direct interview offers the best source of incidence data when collecting information about injury (Thompson et al. 1987).

The North Carolina study conducted by Robey et al. (1971) represents an impressive range of data about the risk factors associated with football injuries. The study noted an increasing risk of injury as high school athletes approached 17 years of age (table I). A correlation between increasing risk of injury and age was also noted in a study investigating participation in the junior league (Goldberg et al. 1984). Unfortunately, neither of these studies analysed exposure time.

The North Carolina study also found an increased risk of injury correlated with less experienced head coaches and with teams that had fewer assistant coaches (Blyth & Mueller 1974b). Teams with coaches under the age of 30 had the highest

Table I. Relationship between age and rate of player injuries in high school football players, North Carolina, 1969

Age (years)	No. injured	Total no.	Injury rate (%)	RR	AR (%)
13-14	37	118	31.4	1.00	0
15	224	633	35.4	1.13	11
16	354	731	48.4	1.54	35
≥17	536	761	70.4	2.24	55
Totals	**1151**	**2243**	**51.3**	**NA**	**39**

injury rates whereas teams with coaches over the age of 45 had the lowest injury rates. Coaches with playing experience at the high school level only had the highest injury rates. Coaches with playing experience in college only had the lowest injury rates. It was clearly demonstrated that schools that hire more assistant coaches had the lowest injury rates. Coaches who demand more live contact in practice had the highest injury rates (Cahill & Griffith 1974). It was also found that less than 50% of the coaches gave their players water as recommended by the state athletic association guidelines. 34% of coaches only allowed water once during practice, and some coaches allowed no water during practice (Blyth & Mueller 1974b).

51% of high school football injuries occurred during practice, although limiting the amount of contact time can reduce injury rates and may not affect win-lose records (Mueller & Blyth 1974). Contact practice activities were 4.7 times more likely to produce an injury than were controlled practice sessions. Preseason practice accounted for 86% of all practice-related injuries and was 5.4 times more likely to result in injury than in-season practice. Contact drills of 3 or more players accounted for 58% of these injuries. In addition, practice-related injuries were more likely to occur in the third and fourth intervals of practice sessions (Halpern et al. 1987).

The resurfacing of playing fields and the wearing of shorter cleats were shown to reduce the rates of injury of the lower extremities (Mueller & Blyth 1974). It was estimated that knee and ankle injuries could be reduced by as much as 42% by instituting these changes. Preseason conditioning was shown to decrease the incidence of knee injuries in a group of high school football players studied over an 8-year period (Cahill & Griffith 1978). The programme stressed aerobic conditioning, acclimatisation to heat, weight-training, flexibility drills and agility drills. It is interesting that lower extremity conditioning was not the sole emphasis of the programme. This programme of preseason conditioning reduced early season injuries, total number of knee injuries throughout the season, and the severity of knee injuries.

Table II. Site of injuries as a percentage of all injuries by study, high school football players, United States

Site of injury	Hale (1981)	Olson (1979)	Culpepper (1983)	Pritchett (1980)	Moretz (1978)
Head/neck	6	9.7	7.6	11.3	5.8
Shoulder	10	9.3	13.3		6.6
Upper arm		1.2	1.4		
Elbow	3	1.6	3.4		2.5
Lower arm	4	0.8	2.0		0.4
Hand/fingers/wrists	16	12.8	14.7		10.0
Upper extremity				35.5	19.5
Chest/ribs/abdomen		5.4	4.1		
Back	5	2.3	4.9	7.7	5.4
Pelvis/groin/hip	3		2.8	7.4	12.0
Upper leg	10	4.3	4.6		3.7
Knee	13	36.5	22.2	12.7	22.0
Lower leg	8	3.5	4.0		
Ankle/foot	12	11.6	15.1		22.0
Lower extremity				20.0	
Other	10	0.8	0.2	5.4	9.5
Total injuries	**885**	**257**	**1877**	**1849**	**241**
(N)	**(NS)**	**(4500)**	**(NS)**	**(3501)**	**(903)**

Table III. Types of injuries as a percentage of all injuries in high school football players in the United States

Types of injury	Hale (1981) [n = 885]	Olson (1979) [n = 257]	Culpepper (1983) [n = 1877]	Pritchett (1980) [n = 1849]	Moretz (1978) [n = 241]
Sprain/injury	46.6	8.2	44.6	37.6	61.8
Contusion	30.1	14.4	24.8	25.5	18.3
Fracture	9.4	24.1	11.0	15.8	
Dislocation	5.4	7.8	2.1	3.1	
(Fractures plus dislocations)	(14.8)	(31.9)	(13.1)	(18.9)	(12.9)
Concussion	4.7	9.0	1.0	2.9	
Other	3.2	36.5	16.7	15.1	7.5

2. *Classification of Injuries* (tables II and III)

Knee injuries account for 22 to 36.5% of all football injuries (Culpepper & Niemann 1983; Hale & Mitchell 1981; Moretz et al. 1978; Mueller & Blyth 1974; Pritchett 1980). Medial, collateral ligament injuries of the knee are the most common, followed by meniscal injuries and anterior cruciate ligament injuries. Knee and ankle injuries account for 33% of all medical costs. Overall, lower extremity injuries account for about 50% of all injuries, and upper extremity injuries 30%. The distribution of injuries is reportedly the same in junior league (Goldberg et al. 1984) and high school participants (Robey et al. 1971). In general, sprains and strains account for about 40% of the injuries; contusions 25%; fractures 10%; concussions 5%; dislocations 5%; and other 15%.

3. *Cervical Spine Injuries*

Cervical spine injuries have the potential to be catastrophic. Table IV shows a total of 111 cervical spine fatalities from 1945 through 1984, by level of play. As shown in table V, the decade of 1975 through 1984 had a precipitous drop in frequency of cervical spine fatalities.

Figure 1, from the National Football Head and Neck Injury Registry, shows the incidence of cervical spine fractures, subluxations and dislocations and quadriplegia secondary to cervical injury for high school and college football. Both demonstrate a significant decline in 1977. This drop in catastrophic injuries and fatalities was due to a combination of factors.

The precipitous drop in injuries as noted in tables IV and V and figures 1 and 2 demonstrates a dramatic decline in the incidence of injury. This data represents the impact of rule changes that were implemented to modify tackling and blocking techniques and thus, to reduce cervical spine injuries. In addition, improved equipment, coaching and physical conditioning also help to reduce injuries.

Upon analysis of the epidemiological and biomechanical data, the mechanism of these injuries has been more clearly demonstrated. The majority of these injuries were due to axial load applied to a flexed cervical spine. Shortly after this fact came to light rule changes were instituted in 1976, prohibiting the use of the helmet as a weapon; the player could not make initial contact with their opponent's head while tackling or blocking.

Improved on-site medical care is probably an additional factor in catastrophic injury reduction. School districts are encouraging attendance of properly trained personnel during practice and at games. In 1958, a California appellate court re-

Table IV. Head and cervical spine fatalities (1945-1984) [McCabe et al. 1984]

Body part	No. of fatalities	Percentage of total
Head	433	67.3
Cervical spine	111	17.3
Other	99	15.4
Total	**643**	**100**

Table V. Head and cervical spine fatalities by decades

Years	Head		Cervical spine	
	no. of fatalities	percentage of total	no. of fatalities	percentage of total
1945-1954	87	20.1	32	28.8
1955-1964	115	26.6	23	20.7
1965-1974	162	37.4	42	37.9
1975-1984	69	15.9	14	12.6
Total	**433**	**100**	**111**	**100**

viewed the case of a high school football player who was unable to get up off the turf after being tackled. His coach instructed team members to carry him off the field, which resulted in the injured player's permanent quadriplegia. Medical experts testified that the improper transport of the injured player had caused the neurological damage.

In 1968, the National Operating Committee on Standards in Athletic Equipment (NOCSAE) was founded in an effort to establish safety standards. Helmet and shoulder pad characteristics were analysed. It was concluded that proper fit and maintenance were the critical factors in ensuring that equipment would prevent injury. The spectrum of cervical spine injury included ligament and soft tissue disruption, fracture and neurological compromise. Injury to supporting ligamentous structures, i.e. sprain, may result from minor trauma, or may be more extensive depending on the magnitude and direction of force.

Annular injury to the intervertebral disc probably occurs with greater frequency than is commonly appreciated. The common 'cervical sprain' diagnosis probably represents, at least, in part, repetitive trauma to the intervertebral disc. This type of injury may lead to progressive disc prolapse with disc herniation radiculopathy and/or myelopathy. Repetitive injury may lead to the development of degenerative spinal stenosis. A developmentally stenotic canal when further compromised by degenerative stenosis may lead to delayed neurological syndromes.

Cervical spine fractures occur due to excessive axial loading combined with flexion or extension. The fractures vary from stable type vertebral body and facet injuries to unstable type fracture dislocation injuries. Nerve root injuries are commonly called 'burners' or 'stingers'. The mechanism of injury appears to be a combination of traction and compression on the nerve. Cervical nerve avulsions resulting in permanent neurological and functional deficits have also occurred.

Appropriate diagnostic evaluation of cervical injuries is mandatory. Any injured player with local spinal tenderness should undergo radiographs of the entire cervical spine including C7. Persistent symptoms or neurological deficit warrant further work up. The persistent loss of cervical range of motion may indicate underlying pathology. Computed tomography will image fractures that cannot be seen on plain films. This is especially important with subtle fractures such as facet and nondisplaced posterior element fractures. Magnetic resonance imaging may be also necessary to evaluate disc displacement and cord pathology. Flexion and extension radiographs are necessary to evaluate stability when instability is clinically suspected. Electrodiagnostic studies including electromyography, nerve conduction velocities, and somatosensory evoked potentials are available to electrophysiologically evaluate spinal root, brachial plexus, peripheral nerve and cervical cord function. Persistent neurological deficit of more than 3 weeks warrants electrodiagnostic evaluation. Obviously, central nervous system signs and symptoms require immediate evaluation.

4. Prophylactic Knee Bracing: Fact or Fantasy?

Prophylactic knee bracing has become an important topic. It has received attention from the

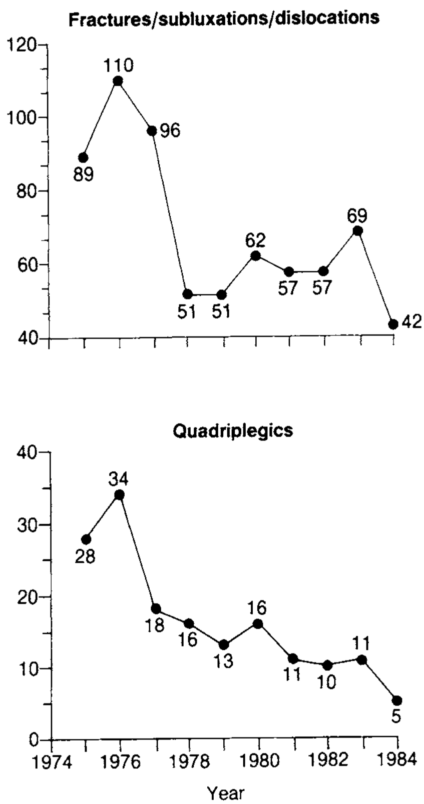

Fig. 1. The incidence of cervical spine fractures, subluxations and dislocations, and quadriplegia secondary to cervical injury in high school and college football.

media and from the medical community. An analysis of the data from prophylactic knee bracing studies is revealing. Anderson and colleagues (1979) described the use of a single-sided hinge brace in 9 football players who had previously sustained medial collateral ligament injuries of the knee. The fact that these players used the brace without sustaining reinjury prompted the authors to exalt the efficacy of the brace as a knee injury protector. From 1985 to 1987, four studies were published which attempted to analyse the efficacy of single upright knee bracing upon injury prevention (Hansen et al. 1985; Hewson et al. 1986; Rovere et al. 1987; Teitz et al. 1987). All of these studies suffer from design flaws. The definition of injury and the identification of the population at risk vary from study to study. In addition, the use of prophylactic knee bracing is motivated by the assumption that medial collateral ligament injuries can be prevented. The use of a single-sided hinge brace, however, does not address other forms of knee injuries, nor does it attempt to tackle the issue of bracing a previously injured unstable knee.

A study of the University of Southern California (USC) football team from 1980 to 1984 did not set the criteria for brace usage nor define the exposure time for the braced and unbraced population. Furthermore, the definition of knee injury was not given (Hansen et al. 1985). A similar study at the University of Arizona compared the knee injury rate from 1977 to 1981 when no players wore braces to a 4-year period when all of the linemen, linebackers and tight ends wore braces (Hewson et al. 1986). A study at Wake Forest University analysed all players wearing braces for 1 season (Rovere et al. 1987). An NCAA Division-1 study compared 7010 unbraced players and 4584 braced players (Teitz et al. 1987). Overall these studies did not present compelling evidence that bracing reduced knee injuries. The division-1 study actually reported an increased incidence of knee (meniscal) injuries in the braced group.

These studies raise a few questions. Should bracing be routinely used, and if so should all players wear them, or should players be selected by position or previous injury to wear them. The interpretation of the data certainly does not mandate the use of routine bracing, and by attempting to

Table VI. Return to play criteria

Full range of motion
Normal strength, with less than 20% side to side differential
Normal neurological examination
No persistent joint swelling
No unchecked joint instability
Ability to run and sustain contact without pain
No intake of pain medication
Has received instruction about:
proper warmup
flexibility and strength programmes
proper use of ice and heat
proper use of taping and bracing to protect the injured area
reporting increases in pain and postexercise swelling
Has been informed about the risks of future injury and disability given the previously sustained injury

Table VII. Athletic head injury protocol

	Type I	Type II	Type III-A
Loss of consciousness	None	Momentary (seconds, if at all)	None or momentary
Neurological signs	None	None	None
Retrograde amnesia	None	None (the player can remember the play as well as the hit)	Present. The player is unable to remember the play or the hit. This amnesia will eventually clear.
Post-traumatic amnesia	None	None	If this develops, the injury should be classified as a type III-B
Symptoms	Low-grade headache, dizziness without true vertigo, and mild unsteadiness of gait that clears quickly	Headache, unsteadiness of gait	Headache, dizziness without vertigo, unsteadiness of gait
Follow-up examination	No change in orientation or neurological signs 15 minutes after coming off the field	At 15-minute intervals the player has been examined and there is no change in the development of post-traumatic amnesia and neurological signs. The unsteadiness of gait is totally resolved and a mild headache persists	
Return to play criteria	Once the player totally clears with absolutely no signs of significant headache, has no evidence of neurological signs as discussed above, and has been observed for a minimum of one offensive series, the player can return to play	With total resolution of symptoms on repetitive examination, the player is able to return after an observation period of approximately 30 minutes (by the doctor's watch, not the game clock). The player should once again be re-examined after coming off the field following the first offensive-defensive personnel shift	Out for the game
Medical treatment	A head injury instruction sheet should be given to all parents of high school students and they should be instructed regarding re-examination if post-traumatic amnesia or any other localising neurological signs should develop. On the collegiate level, the player should be checked the next morning in training quarters by the trainer for any signs of post-traumatic amnesia	Same as type I	This player should be watched very closely on the sidelines. Careful instruction should be given to the parents regarding the neurological signs to check throughout the night. At the collegiate level, an overnight stay in the health centre, if available, would be appropriate. (Due to the dormitory and apartment living status of college students, the health centre would be appropriate, whereas at the high school level, returning home with parent would be appropriate.)

Type III-B	Type IV	Type V
Minutes	5-10 minutes	Player is not arousable
None	Sluggish pupillary reflexes and vestibular signs	Pupillary dilatation. Immediate transfer to hospital on a spinal board with a call ahead to the emergency room to have a neurosurgical team waiting for possible decompression
Unable to remember play or hit (will eventually clear)	Does not remember the entire game day	
Will sometimes develop and subsequently clear	Often present	
Headache, dizziness, some nausea without vomiting. Unsteadiness of gait. All these symptoms clear over 15 to 30 minutes	Headache, vertigo, disorientation, nausea with vomiting, lethargy, unsteadiness of gait	
Careful observation on the sidelines using the buddy system and/or student trainer as described in previous section	This player should be transported on a spinal board by ambulance to the emergency room for immediate neurosurgical evaluation. The player should not be discharged from the hospital until evaluated by a neurosurgeon and should not return to football play until cleared by him. This injury is of the type to end a player's season or career	
Unable to play that day. Able to play when all symptoms clear on a subsequent day, after medical follow-up and evaluation		
Close observation on the sidelines as described. Overnight stay in a health centre or careful instruction to a parent about evaluation. Patient should be evaluated again the next morning. If dizzy, and if headache is severe, or retrograde amnesia is not cleared, and/or post-traumatic amnesia has developed, in-hospital evaluation by a neurosurgeon is appropriate. Transport: either by ambulance or private car.*		

* If retrograde amnesia does not clear by the end of the game, given a minimum waiting time of 30 minutes, then the patient should be taken to the emergency room. If he clears in the emergency room, he may be discharged from the emergency room or stay in the hospital at the discretion of the hospital staff physician. If the player's amnesia does not clear while in the emergency room, he should be admitted and further neurosurgical evaluation is appropriate. If the problem resolves in the emergency room, with total clearing of retrograde amnesia, and the player is discharged from the hospital, an overnight stay in the health centre, if available, is appropriate, or close observation by parents. If there is a living situation, such as living alone in an apartment, that is not conducive to appropriate neurological recheck, the patient should stay in the hospital overnight for observation. All players should be rechecked 24 hours later, either after discharge from hospital or in the event they are not kept in the hospital.

select a population at risk, the physician and trainer expose themselves to liability. Therefore, routine knee bracing is not recommended. The decision to wear a brace should be left to the individual. No claim should be made to the player, coach or parent that the brace is effective in prevention of injury.

5. *Recommendations for Injury Prevention*

Despite the violent nature of football, it is fortunate that there are ways to prevent injury. The issue of knee bracing raises important questions about prevention of football injuries. Is equipment the crucial factor in the prevention of injury or do other factors prevail? The North Carolina study clearly pointed out the need for experienced coaches and for enlarging the coaching staff. The team physician can help a high school appreciate these facts. The epidemiological data support the ideas that contact drills should be limited and that intrasquad full contact scrimmages should be minimised to reduce the rate of injury. Preseason practice sessions should be shortened and should emphasise conditioning rather than contact drills. Furthermore, the playing surface should be carefully maintained. If an inordinate number of lower extremity injuries are noted, the playing field should be inspected. Appropriate short cleat footwear in combination with improved playing field characteristics will prevent a large number of the lower extremity injuries observed.

The coaching staff should be helped to develop an off-season conditioning programme in which previously injured athletes are encouraged to participate. Furthermore, injured athletes should not be allowed to return to competition too soon.

6. *Return to Play Criteria*

An injured athlete should return to play only when he meets the criteria outlined in table VI. A great number of catastrophic cervical spine injuries can be prevented. Appropriate training in the techniques of blocking and tackling is most important. Furthermore, guidelines presented for return to play following an injury must be observed. As discussed in the cervical spine section of this article, it is crucial that there be adequate early evaluation of cervical injuries. Allowing players to return to competition without full range of motion and with neurological deficits courts disaster.

One of the most difficult decisions for the team physician is to decide when an athlete can return to competition after an injury. General criteria are presented in table VI to guide team physicians in making these decisions. However, these are only guidelines. They are not rigid rules and by their very nature must be applied in a flexible manner. Precise knowledge of the injured structures, the athlete's level of rehabilitation, and level of competition must also factor in the decision algorithm.

Even the most persuasive athlete, coach, agent or parent should not alter return to play guidelines. Nor should the guidelines afford special consideration to the team's star halfback versus the special team's platoon player. Individual players should decide how much pain they can endure. Obviously the timing within a given season and the importance of a particular contest may allow an athlete to push himself though the pain more easily. Nevertheless, structural injury which has led to neurological loss, joint instability or significant loss of motion should restrict the player from returning to action prematurely.

Concussions represent a small but significant number of football injuries. Guidelines for assessing concussive head injury presented below will allow the sideline physican and trainer to make appropriate decisions regarding who should and should not return to play and who requires medical attention.

7. *Athletic Head Injury Protocol* (tables VII and VIII)

The terminology of concussion is notably absent from this protocol. The variety of definitions (Ommaya & Gennarelli 1974; Symonds 1962) attests to the difficulty of defining this nonspecific term and has led to its abandonment in our protocol. For most of this century, concussion was viewed as a transient and completely reversible neurological event caused by cerebral ischaemia, secondary to vasoparalysis or circulatory compromise due to the instantaneous rise of intracranial pressure at the moment of injury (Symonds 1962). As the cerebral ischaemia theory has been disproven, so has the concept that even the mildest of head injuries or 'concussion' is entirely reversible.

The length of post-traumatic amnesia has been correlated with the severity of a head injury (Jennett & Teasdale 1976; Levy et al. 1981) and therefore it is a useful guideline for an on-the-field evaluation. The player is potentially at a great risk if he is permitted to return to play while suffering from post-traumatic amnesia. Retrograde amnesia is a frequent finding in all injuries that disturb consciousness and, therefore, it is also a very important guideline in determining the severity of injury (Russel & Nathan 1946). Apparently the longer the post-traumatic amnesia, the longer one will notice retrograde amnesia (Russel & Nathan 1946). Mental status serial examinations are necessary to eliminate the possibility of missing the development of retrograde amnesia minutes after the initial blow (Yarnell & Lynch 1970). Yarnell and Lynch (1973) discuss how often immediate memory (i.e. digit recall) remains intact, yet recently transpired events (i.e. the play, the score) are forgotten. Thus, these aspects of amnesia should be tested. It should be re-emphasised that any focal neurological finding, vestibular finding, or facial bleeding (scalp, ear, nose or throat) [McCabe & Angelos 1984] mandates that the patient be taken immediately to the emergency room. Clinically, it is often hard to distinguish traumatic intracranial haematoma from a mild head injury, as both can initially present with normal mental status, normal neurological examination, and identical symptoms e.g. headache, lethargy, vertigo [Hockberger 1986].

The physician must also be aware of concurrent spinal or internal organ injuries in a head-injured athlete. It is well established that occult spinal cord injuries occur in the head-injured population and vice versa [Wilmot et al. 1985]. If a concurrent spinal injury is detected, a complete spine x-ray series is imperative, as there is a high incidence of noncontiguous spinal fractures (Wilmot et al. 1985).

Table VIII. Recurrent athletic head injury protocol

Recurrent type II
The player is unable to participate in practice or in games until he is cleared by a neurosurgical and/or neurological evaluation, which will probably include MRI and/or CT brain scanning.
Recurrent type III
The player is through for the season. Neurosurgical examination is mandatory. Complete workup is necessary before the player is able to return to play the following season.
The same criteria for all types discussed above pertain also to practice where a physician is usually not in attendance. The coach and/or trainers/student trainers should manage the medical triage in these situations.

8. *Rehabilitation*

8.1 Lower Extremity Injuries *(figs 2, 3 and 4)*

Ankle sprains represent a very frequent football injury. An algorithm for the rehabilitation plan to return the athlete to competition is presented in figure 2.

Evaluation of the acutely injured knee often presents difficulty for the primary care sideline physician. An algorithm of evaluation is presented in figure 3.

An algorithm for the rehabilitation plan to return the football player with a medial collateral ligament injury to competition is presented in figure 4.

8.2 Lumbar Pain

Rehabilitation of a football player with a lumbar spine injury presents a significant challenge for the physician practicing sports medicine. Some of the activities intrinsic to football, e.g. repetitive flexion, extension and torsional stresses to the lumbar motion segments, predispose the lumbar spine

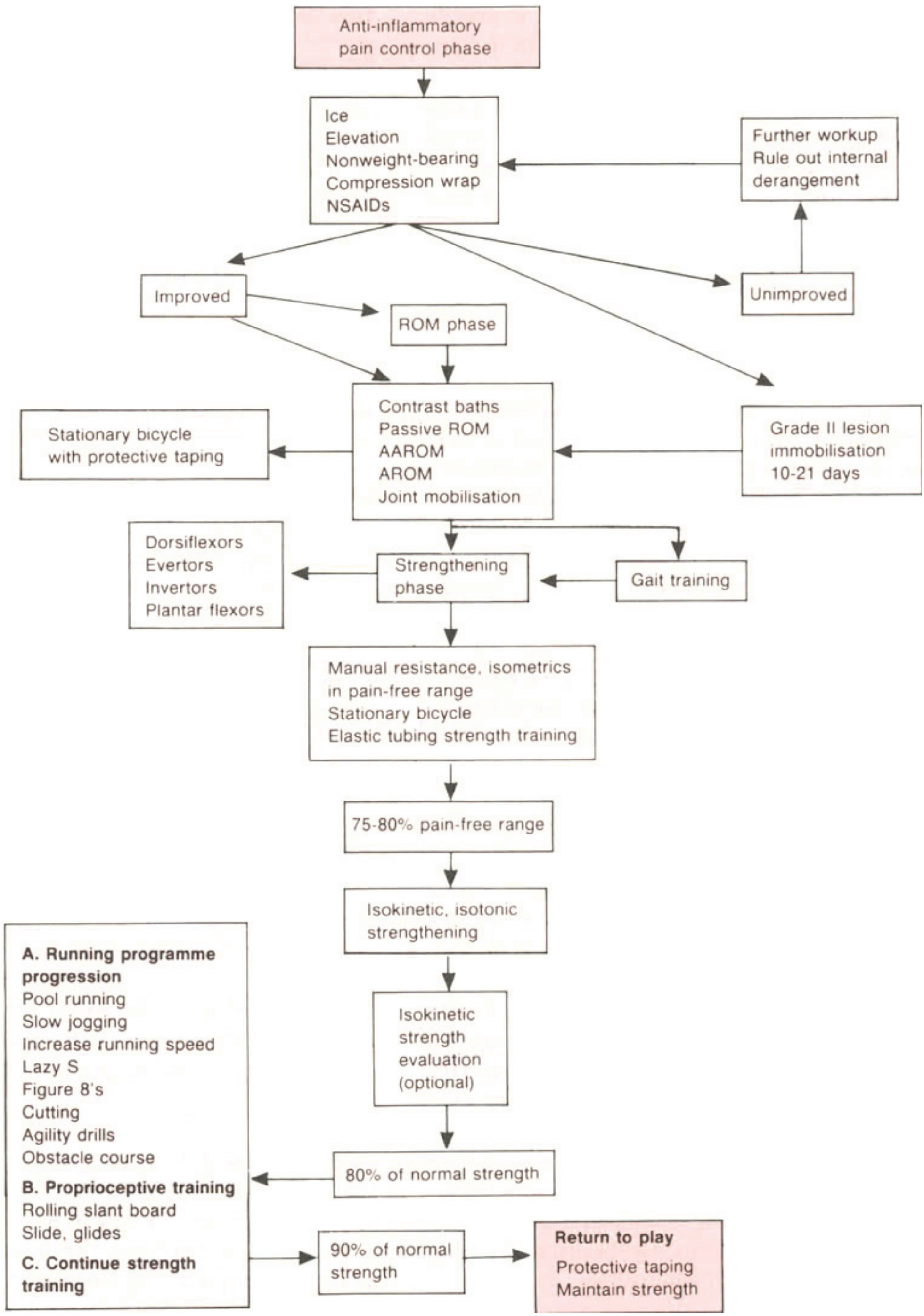

Fig. 2. Rehabilitation algorithm for ankle ligament injury. ROM = range of motion; AROM = active range of motion; AAROM = active assisted range of motion (with permission from Saal et al. 1988c).

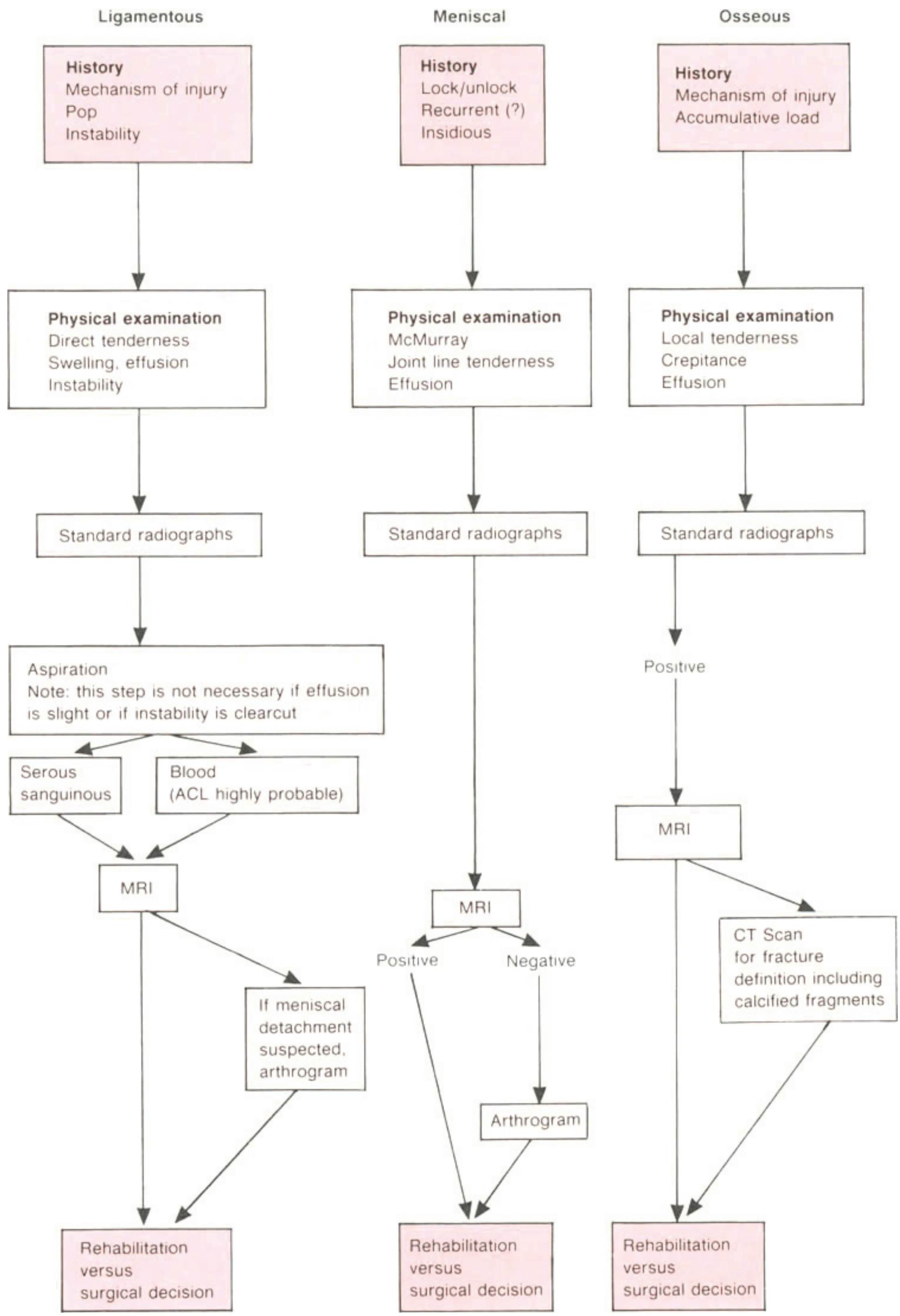

Fig. 3. Evaluation algorithm for acute knee injury (with permission from Saal et al. 1988c).

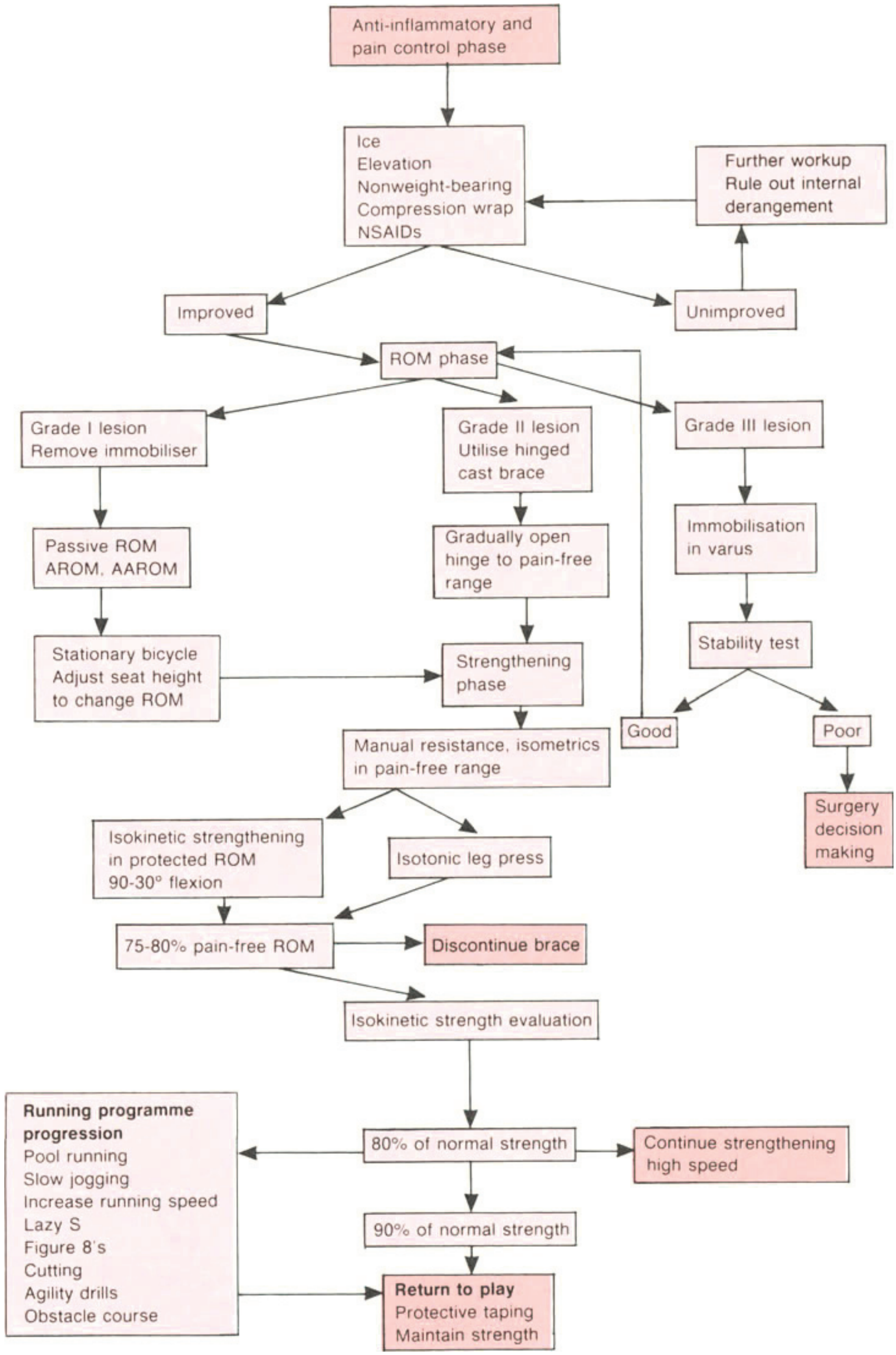

Fig. 4. Rehabilitation algorithm for collateral ligament injury of the knee. *Abbreviations:* See figure 2.

to injury. The likelihood of collision in football also places the spine in jeopardy. The sports and activities most commonly associated with lumbar spine injuries are gymnastics, weightlifting, football, dance, rowing and wrestling. It has been reported that 30% of college football players will lose playing time because of a lumbar spine problem (Ferguson et al. 1974; McCarrol et al. 1986). A survey of injuries (1980 through 1986) in National Football League players reported a 12% incidence of spine injuries resulting in lost playing time (Powell 1987).

Repetitive extension and loading of the posterior elements of the lumbar spine have been associated with fatigue fracture of the neural arch, i.e. spondylolysis (Cyron & Hutton 1978; Hutton et al. 1977; Jackson et al. 1976). The incidence of spondylolysis in gymnasts is reportedly as high as 22% (Jackson 1979). An incidence of 21% was reported in a survey of 677 male high school and university athletes (Hoshina 1980). A study of college football players (McCarrol 1986) noted a 15% incidence of lumbar spondylolysis, which did not significantly increase during their college years. A higher incidence of spondylolysis has been found in interior linemen (Ferguson et al. 1974). This finding probably is related to the repetitive loading of the posterior lumbar elements that occurs when the linemen rise from their low starting position to the blocking posture, while maintaining lumbar lordosis. Indeed, linemen may sustain many of their injuries in the weight room; weight-training is a common cause of low back injuries in football players. It has been observed that improper technique while attempting squats using free weights accounts for many of these injuries (Saal 1988a,b).

Rehabilitation programmes can be divided into 2 phases: pain control and training. The pain-control phase may include a variety of passive modalities, flexion or extension exercises, lumbar mobilisation, traction and selective injections. After successfully completing the pain-control phase, the individual advances to the training phase, which emphasises movement training and specific lumbar stabilisation exercises.

The main goal of the training phase is to attain adequate musculoligamentous control of lumbar spine forces to eliminate repetitive injury to the intervertebral discs, facet joints, and related structures. If athletes did not advance to the training phase after completing the pain-control phase, they would continue to be at risk of sustaining a re-injury that would further limit their activity.

Repetitive torsional stress to the lumbar intervertebral discs and facet joints leads to advanced degenerative changes (Farfan 1969; Farfan et al. 1970). Conceptualisation of gradual disc prolapse secondary to fatiguing of the annular fibres is also important in understanding the effects of repetitive microtrauma applied to the lumbar segments (Adams et al. 1985). Stabilisation involves eliminating this repetitive microtrauma to the lumbar motion segments, thereby limiting the injury that has occurred, and allowing healing to occur. Additionally, stabilisation can potentially alter the natural course of degenerative processes.

Muscle fusion involves using the muscles of the trunk and lower extremities to brace the spine and to protect the motion segments from repetitive microtrauma and excessively high, single-occurrence loads. The abdominal mechanism couples the use of the midline ligament with use of the lumbodorsal fascia to reduce lumbar lordosis. This coupling can eliminate shear stress to the lumbar intervertebral segments. Lowering the centre of gravity with knee flexion, which is easier for individuals with strong quadricep muscles, is an important part of the formula.

This biomechanical and pathophysiological construct hypothesises that the intervertebral joint, for its own protection, reacts to its internal stress to control the force exerted upon it by an applied load. The hypothesis suggests that a feedback mechanism monitoring the stress at the intervertebral joint can modify muscle activity in a way that minimises stress at the joint, and thus reduces the risk of injury. Muscle activity can also control the stress on ligaments because of its ability to modify spinal geometry.

We have previously demonstrated the efficacy of this type of programme in the nonoperative treatment of herniated lumbar intervertebral disc.

More than 90% of our patients were successfully rehabilitated nonoperatively (Saal & Saal 1989).

One of the most important and difficult decisions the sports medicine physician faces is deciding when to allow the athlete to return to activity and at what level. Athletes may return to play when they have:

- full range of motion
- normal strength
- normal neurological examination
- no persistent swelling
- no unchecked joint instability
- ability to run without pain
- been instructed in proper warm-up, flexibility, and strength programme
- been instructed in proper use of ice and heat
- been instructed regarding proper taping and bracing to protect the injured area
- been instructed to report increases in pain and postexercise swelling to the physician and/or trainer and coaching staff
- stopped taking any corticosteroid and analgesic medications
- been informed regarding risks of future injury and disability as they relate to the injury and the chosen sport.

The guidelines presented above are broad and general and may not precisely fit every clinical circumstance. For instance, the loss of the end ranges of motion in an injured metacarpal joint or a previously operated-upon knee may not militate against competition. The strength requirements for return to competition are also not absolute. After a neurological insult such as a brachial plexus injury, regaining full strength prior to returning to activity is necessary as is a normal neurological examination. But a patient who has undergone anterior cruciate reconstruction may be able to return to competition at 80%+ of strength, compared with the opposite side, if movement retraining shows no functional deficiencies. Small amounts of swelling can be tolerated; however, a continually effused ankle and knee indicates that the athlete should not return to activity. Joint instability that is braced, taped or well compensated for by muscular mechanisms is not a contraindication for return to athletics, whereas unchecked joint instability noted during movement retraining is.

When the athlete returns to activity, drugs that significantly alter the perception of pain should be eliminated. Corticosteroids and opiate analgesics fall into this category. There are arguments against the use of nonsteroidal anti-inflammatory drugs, but in my opinion they can be utilised in the athlete who returns to activity. Running without pain is a criterion for most sports, but obviously has no bearing on water sports, equestrian activities, or weight lifting.

9. Conclusions

The general principles of rehabilitation presented will allow one to design a thoughtful and rational care plan. These guidelines are intended to assist the decision-making process but need to be adapted to each individual. The level of competition and the social profile of the athlete are important factors that colour all decisions in this regard. The whole scheme is predicated upon accurate diagnosis and early intervention.

Football is a high risk sport. The coaches, players, trainers and physicians must all become more aware of the proper means to prevent injuries. An adequate appreciation of return to play criteria is also imperative. In these days of school athletic budget cuts and medicolegal entanglements the sports physician is quite vulnerable. Algorithmic care and protocol guidelines for participation present one important means to improve the quality of health care and limit liability.

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