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Rehabilitation of Football Players With Lumbar Spine Injury (Part 2 of 2)

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In brief: Football is a collision sport that places tremendous demands on the lumbar spine. With a thorough, rational rehabilitation program, players who sustain injuries to the lumbar spine can return to competition. Part 1 of this article discussed the pain-control phase of the rehabilitation plan for football players with low back pain. In this concluding article, the author discusses the second phase of rehabilitation—the training phase—which emphasizes movement training and exercises for strengthening the abdominal muscles, in order to stabilize the lumbar spine.

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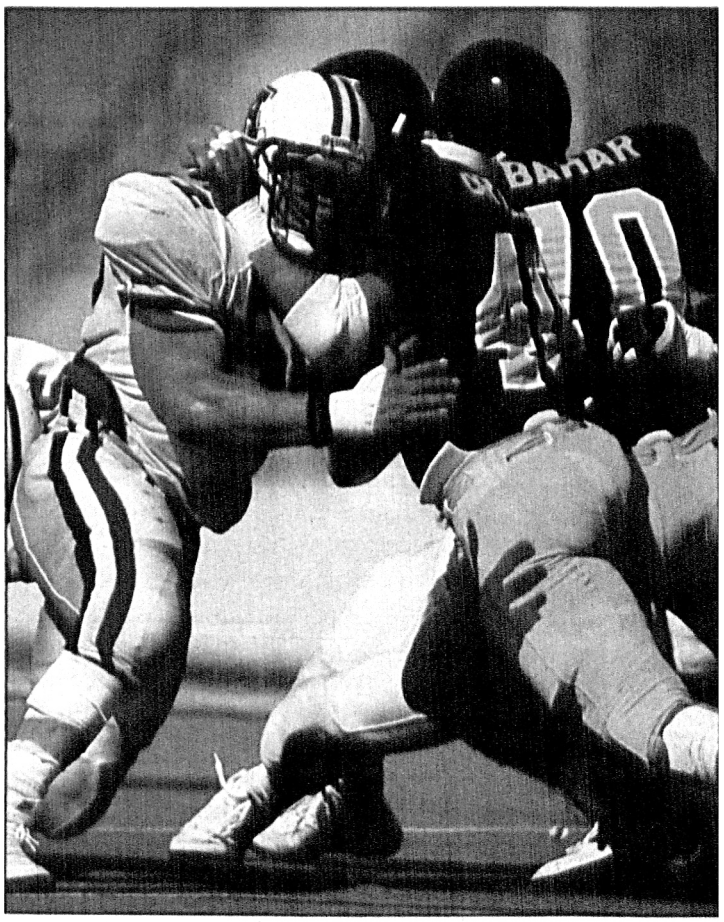

After successfully completing the pain-control phase of the rehabilitation program (discussed in part 1 of this article, September, page 61), the athlete advances to the training phase. This phase, which is the key component of the rehabilitation program, emphasizes movement training and specific lumbar stabilization exercises (see memory jogger).

Training Phase

The main goal of the training phase is to attain adequate musculoligamentous control of lumbar spine forces to eliminate repetitive injury to the intervertebral disks, 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 reinjury that would further limit their activity.

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It is of prime importance to try to identify the cause of an athlete's injury and the risk factors for reinjury. Athletes should be made aware of these causes and risks so they can learn, understand, and apply appropriate preventive measures. A lumbar motion segment that has been injured is at risk for repetitive injury. Patients with low back pain often have recurring or continual pain.[1] Moffett et al[2] demonstrated the benefits of prevention programs in the industrial workplace. Applying these principles of the "back school" to athletes requires the participation not only of the athlete, but of the physi-

continued

memory jogger

Rehabilitation Exercises for Football Players With Lumbar Spine Injury

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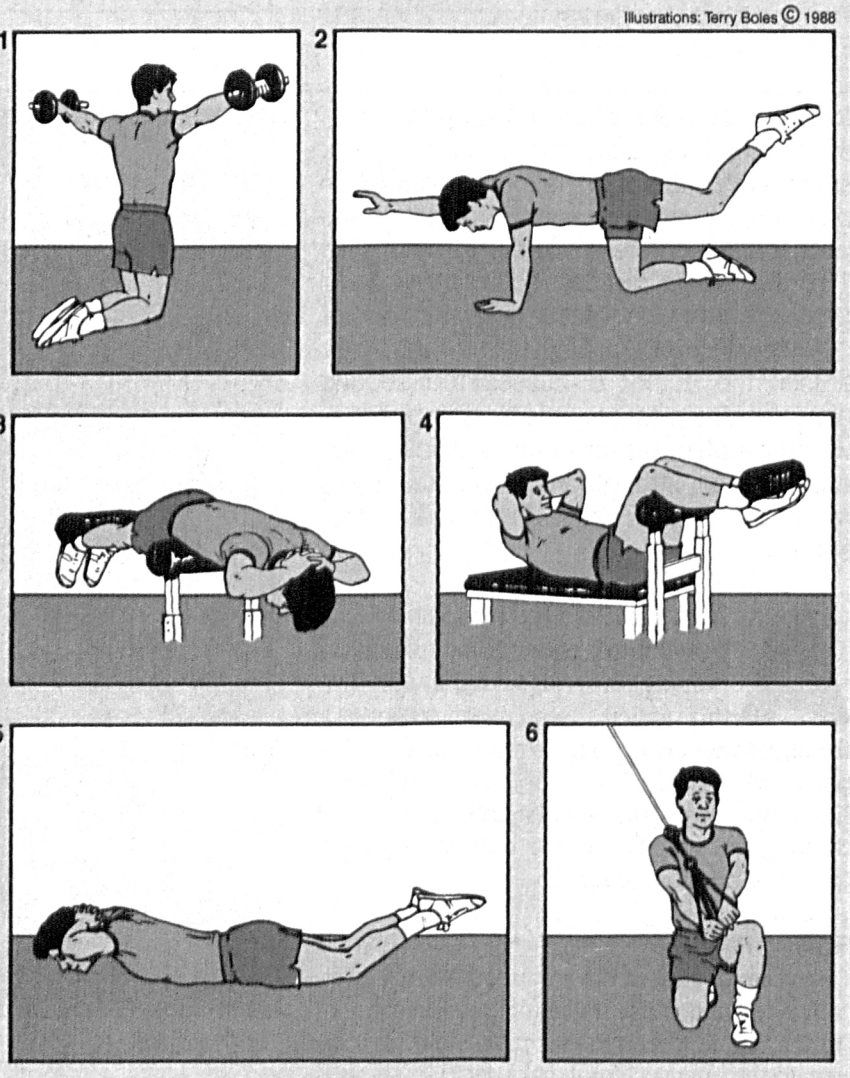

A few of the exercises used to enhance strength and coordination in football players with lower back pain caused by lumbar spine injury are illustrated here. Exercises 1 and 2 are basic low-intensity exercises that train for strength and balance. Exercises 3 and 4 strengthen the spinal extensor and abdominal muscles; they are higher in intensity and require more strength. Exercises 5 and 6 are designed to improve dynamic control of balance and coordination and are performed at a high level of intensity.

Exercise 1. Lifting weights to shoulder height while in a kneeling position trains for balance and coordination. The trunk remains stable. Co-contraction of the gluteal and lower abdominal muscles is necessary. The spinal extensor muscles enhance the stability of the lumbar spine segments.

Exercise 2. The quadruped is a basic exercise involving simple arm and leg movements, alternating left and right sides, to train for lumbar spine stabilization. The level of difficulty can be increased by using ankle and wrist weights. A long, lightweight broomstick balanced across the lower back will reinforce balance. Three sets of 12 repetitions should be performed.

Exercise 3. Exercises performed on a hyperextension bench strengthen the spinal extensor muscles. The axis of movement should be from the hip, not the lumbar spine, to avoid excessive lumbar flexion and extension. Three sets of 15 repetitions should be performed.

Exercise 4. Curl-ups (performed with the knees bent and feet anchored) strengthen the abdominal muscles and facilitate contraction of the lower abdominal muscles. Three sets of 30 to 40 repetitions should be performed.

Exercise 5. This floor exercise (trunk hyperextension) is useful for strengthening the spinal extensor muscles and learning muscle coordination. Contraction of the gluteal, hamstring, and paraspinal muscles, are coupled with contraction of the lower abdominal muscles. Three sets of 15 repetitions should be performed.

Exercise 6. The bent-knee diagonal pull-down is a high-intensity stabilization exercise that requires balance and symmetric muscle control. A pulley system or surgical tubing can be used for this exercise. The pull should extend from above the head down to knee level. It is important to maintain lumbar spine stability while changing positions or amount of resistance. Three sets of 15 repetitions should be performed.

Clip and copy for a useful guide.

cian, the physical therapist, and the coaching staff as well.

Adams and Hutton[3] studied the effect of fatigue on the lumbar intervertebral disk and the progressive development of gradual disk prolapse, demonstrating the biomechanical construct of repetitive injuries to the intervertebral disk leading to progressive pathology. This construct explains how a "simple" annular tear can, with subsequent annular injury, develop into a full-blown disk protrusion or herniation. Therefore, it would be best if individuals with an annular tear were identified early and placed in a back-school program, where they could learn to prevent injury.

The role of physicians in treating injured athletes is not simply to supply so-called Band-Aid treatment. Our mandate is not merely to make athletes pain free so they can return to competition (and possibly sustain a similar, potentially more severe, injury as a result). Therefore, programs to help prevent further injury are an imperative part of a rehabilitation program.

Stabilization. Repetitive torsional stress to the lumbar intervertebral disks and facet joints leads to advanced degenerative changes.[4,5] Conceptualization of gradual disk prolapse secondary to fatiguing of the annular fibers is also important in understanding the effects of repetitive microtrauma applied to the lumbar segments.[3] Stabilization involves eliminating this repetitive microtrauma to the lumbar motion segments, thereby limiting the injury that has occurred, and allowing healing to occur. Additionally, stabilization can potentially alter the natural course of degenerative processes.

Muscle fusion (table 1) involves using the muscles 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 can eliminate shear stress to the lumbar intervertebral segments. Lowering the center of gravity with knee flexion, which is easier for individuals with strong quadricep muscles, is an important part of the formula.

This biomechanical and pathophysiologic construct hypothesizes 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 contends that a feedback mechanism monitoring the stress at the intervertebral joint can modify muscle activity in a way that minimizes 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.

Table 1. Muscle Fusion (Mechanisms for Bracing the Spine)

Abdominal mechanism uses midline ligament structures.
Quadriceps strength maintains controlled center of gravity.
Gluteus maximus balances anterior translation.
Spinal extensor muscles balance anterior shear stress.
Latissimus dorsi use upper portion of lumbodorsal fascia.

The stress induced by this muscle activity can also be monitored and controlled by a feedback mechanism. This mechanism lowers the level of equalized stress to a minimum, thereby reducing the potential risk of injury to the lumbar spine. Gracovetsky and Farfan[6] identified a well-developed, extensively distributed network of nerve fibers that connects receptor systems located in places such as the periosteum. This system is important not only in pain transmission but possibly in kinesthetic feedback for joint positioning as well.

Because of the changes in axial rotation that are possible at the intervertebral segments at different degrees of lordosis, control of lordosis during flexion and extension is extremely important. Once these control mechanisms are understood, one may then understand how balanced muscle function and flexibility lead to control of stresses applied to the lumbar intervertebral segments. It should be pointed out that the anulus of the intervertebral disk seems to be entirely responsible for the transmission of a load from one segment to another. Removal of the nucleus reportedly does not greatly affect the joint response.[4] Therefore, repetitive loads applied to the lumbar intervertebral joint necessarily fall upon the outer fibers of the anulus, leading to progressive tearing, fatigue, and potential disk prolapse.

It is simpler to understand the concept of load transmission to the facet joints if one first understands the mechanics of repetitive extension

continued

Table 2. Basic Exercises for Stabilizing the Lumbar Spine

Hamstring stretching
Quadriceps stretching
Hip flexor and rotator stretching
Gastrocsoleus complex stretching
Abdominal curl-ups
Pelvic bracing
Prone neutral spine positioning
Prone and side-lying leg raises
Bridging (supine with knees bent; feet, head, and shoulders on floor; raising lower trunk with spine in neutral position, ie, between rounding and arching the back)
Advanced bridging (while bridging, lifting and straightening one leg)
Bridging with stepping (while bridging, taking small steps with one foot at a time, straightening the knees, holding the back in neutral position)
Ball-balanced bridging (balancing the upper part of the body on a large ball, eg, a medicine ball)
Quadruped (arm and leg exercises)
Kneeling stabilization (lifting weights with arms while kneeling)
Squat strengthening (wall slides, counter squats)
Position transition (sitting-to standing, kneeling to standing, prone to kneeling) with/without weight

maneuvers. Dunlop et al[7] demonstrated that the narrowing of the intervertebral disk results in increased load transmission to the facet joints. A degenerative segment, combined with repetitive extension and rotation loads to the lumbar intervertebral joints, can lead to joint failure. Thus, the principle of neutral spine positioning can be applied to this portion of the motion segment as well.

Therefore, the concept of muscle fusion involves the co-contraction of the abdominal muscles to maintain a corseting effect on the lumbar spine, using the midline ligament and thoracolumbar fascia, coupled with proper pelvic positioning, to accomplish the task. It is important that the patient use the spinal extensor muscles to reduce anteroposterior translational stress to the intervertebral segments during activity as well, and these muscles must be trained to balance off shear stress to the intervertebral segments. The central slits of the lumbodorsal fascia will cause extension of the lumbar spine, thereby balancing the tendency of the abdominal mechanism to cause excessive flexion. The multifidus muscle appears to be the most active muscle in this regard. It is also the most difficult muscle to strengthen because of the short distance between its origin and its insertion. Indeed, the gluteus maximus may be the most important extensor muscle controlling the lifting power of the lumbar spine.[8] The internal oblique abdominal muscles are the only muscles that can protect against torsional stress. The vector of force of spine-extension muscle pull lies too close to the midline to contribute to anything other than pure anteroposterior balancing.

To apply the muscle-fusion concept, the patient must attain adequate flexibility and spinal range of motion. Adams et al[9] found that diurnal variations and stresses on the lumbar spine denote changes in lumbar disk and ligament extensibility as the day progresses. This is based on progressive lengthening of the soft-tissue structures caused by increased tissue extensibility, which leads to increased range of motion. They pointed out that when an individual performs bending and lifting activities (involving nonextensible ligament and anulus fibers) early in the morning, the disk accumulates fatigue damage more easily than it does later in the day.

This concept can be further applied to the need for flexibility of the structures to eliminate this repetitive fatigue stress to the intervertebral joint. Also, we should think of the muscles that attach to the pelvis as guy wires that can effectively change the position and symmetry of the pelvis. Considering that the pelvis is the platform on which the lumbar spine rests, pelvic positioning is the key to postural control of the lumbar spine. Thus the hamstring, quadriceps, iliopsoas, gastrocsoleus complex, and hip rotator muscles should be flexible. The neural elements and iliotibial band also should be flexible.

Stabilization Training Exercises. These can be divided into two levels: basic (table 2) and advanced (table 3).

The basic exercise program can be classified as a neurodevelopmental progression of posture control, starting with the most primitive positions—ie, supine and prone lying—and advancing to kneeling, to standing, and to position transition movements. Because it is imperative that the basic exercises be performed with meticulous technique, a skilled and experienced physical therapist must work with the patient in a painstaking manner.

Initially, the athlete performs the exercises

with one-on-one instruction and then, after satisfactorily completing the basic program, advances to a class situation. Each exercise is designed to develop isolated and co-contraction muscle patterns to stabilize the lumbar spine in a neutral position. A neutral spine position does not necessarily mean an absence of lordosis, but rather the most comfortable position for the individual, based on the biomechanical principles discussed earlier.

The physical therapist uses a hands-on technique to show the patient the optimal spine position. The patient tries to maintain this position while performing the exercises at each level of the program. Care must be taken to ensure proper form and slow speed of exercise repetition. The neurophysiologic principle of central pathway irradiation (the spread of electrical signals across the cerebral motor cortex) secondary to increased amplitude of effort must be continually kept in mind.[10] Engram programming is the goal; therefore, careful repetition with precision of movement is imperative.

When the individual has finished the basic exercise program and can demonstrate proper form and technique, the principles of this program can be applied to the advanced portion of the training phase, which involves weight training. In this phase the athlete is taught how to get on and off of weight-training equipment while continuing to apply stabilization principles, to be careful when changing the weight-stack resistance pin on the machines (as well as when lifting and racking free weights), and how to use resistance equipment including free weights, pulleys, and single-station weight machines.

The athlete must use co-contraction of the lower abdominal muscles to maintain optimal, anteverted pelvic positioning while flattening the lower back against a back support; a stabilized neutral spine must be maintained. The strengthening program is tailored to the injured athlete's deficits and to the particular sport involved. Therefore, the weight-training program is designed not merely to strengthen the muscles of the trunk, but rather to achieve total fitness. Incorporated in this total fitness program are aerobic and anaerobic training.

Teaching the athletes to stabilize the spine while riding a stationary bicycle, running on the treadmill, and swimming is an integral part of the training phase of the rehabilitation program. One-on-one instruction to demonstrate proper spinal positioning while performing each of these activities is mandatory. Athletes advance from treadmill walking to treadmill running to supervised running on a track. Advancement continues to the point in the training phase at which the individual is ready to begin recoordination training for his or her particular sport. Recoordination requires specific instruction in athletic technique, coupled with stabilization principles. It should be remembered that the most energy-efficient form in any sport incorporates control of one's center of gravity.[11]

Table 3. Advanced Exercises for Stabilizing the Lumbar Spine

Advanced abdominal exercises
Weight training
Stationary cycling
Treadmill running
Cross-country ski machine
Swimming
Sport-specific, neutral spine training

Sport-Specific Training. The rehabilitation program can be tailored to an athlete's particular sport or position. For instance, the tasks of football linemen are broken down into individual components—eg, positioning themselves in a stance, back pedaling while pass blocking, and pulling and diving while blocking for a running play. Emphasis is placed on achieving adequate knee flexion and strong abdominal muscles, which co-contract with the gluteus maximus muscle to attain the forward pelvic tilt. This eliminates excessive lordosis of the lumbar spine during axial loading. The lineman is taught how to take a blow and how to fall and roll, contracting the abdominal muscles to stabilize the spine. The motivated athlete finds this type of positioning comfortable, efficient, and powerful. (Not all program participants are equally motivated.) One-on-one drills are designed to reinforce stabilization principles while the lineman is pushed and pulled.

During the other sport-specific training programs (eg, tennis, baseball, running), the athlete progresses through the basic exercises, then through the advanced training, then to sport-specific training. The sport-specific training begins with hands-on, one-on-one mat work, progressing from isolated to compound movements. Videotapes of exercise demonstrations

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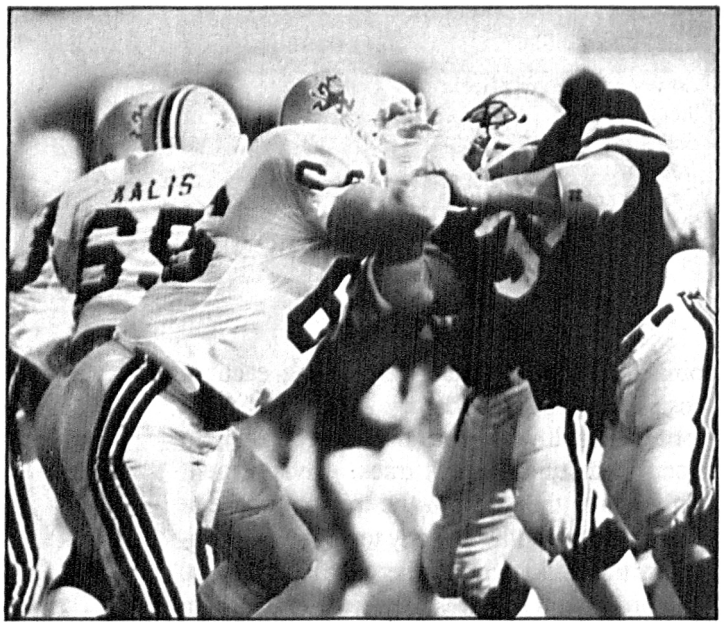

Photo: Robert Beck/ALLSPORT © 1988

Football players are particularly susceptible to lumbar spine injury because the sport places tremendous demands on the lumbar spine. With appropriate rehabilitation, injured players can return to competition.

and of the athlete performing specific techniques are valuable training aids.

The principles regarding training the lumbar spine, discussed earlier, can be extrapolated to virtually all sports. Working with the coaches of injured athletes—ie, a team approach—is imperative before designing a training program.

Many sports involve torque to the lumbar spine. Therefore, it is impossible to totally eliminate rotational stress. The goal is to try to minimize this stress and control it whenever possible. Once again, it must be kept in mind that most sports-related lumbar spine injuries occur in the weight room (before the athlete ever sets foot on the playing field or gymnasium floor) and are secondary to repetitive microtrauma.

Exercising the Abdominal Muscles. The abdominal muscles play a key role in lumbar spine stabilization, as discussed earlier. Many exercises to strengthen these muscles have been advocated and taught.

The iliac muscle is the major muscle used to bring the body from a 45° angle to a vertical sitting position when performing sit-ups.[12] The exercise that requires the least effort from the abdominal muscles is the full sit-up and abdominal curl-up after the initial 30% of motion.[13] Floyd and Silver[14] found a greater percentage of activity in the abdominal muscles during the total concentric phase than during the total eccentric phase of sit-ups. The oblique muscles and the rectus abdominis muscle are most active during the initial phase of the sit-up, when the head and shoulders are lifted. The force of abdominal muscle contraction can be increased by adding resistance by means of slant board inversion, manual resistance, or cross-chest weight holding.[14]

The magnitude of muscle recruitment for the lower section of the rectus abdominis muscle is greatly increased when the feet are held in place.[14] Nonsupported feet during this exercise favor greater contraction of the upper section of the rectus abdominis muscle. Raising both legs while supporting the trunk, as in an elevated-chair position (in which body weight is supported by the forearms with legs suspended in air, as in hanging from a bar or rings), causes a greater degree of muscle recruitment than any other exercise.[14] The curl-up—raising only the head and scapula off the surface, with the knees flexed 45°, with or without the feet supported—accompanied by a body twist, causes greater muscle recruitment in all portions of the oblique muscles and the rectus abdominis muscle than symmetric exercises. This curl-up position has also been demonstrated to cause the least amount of movement of the lumbar spine.[14]

Leg circling is one of the few exercises that is performed mainly by the external oblique muscles.[15] Leg circling is performed in a supine position, with the knees flexed to the chest, then dropped to the left; the legs (straightened out) make a low circle around to the right; the knees are flexed and brought back to the starting position on the chest; the legs are then dropped to the opposite side, and the circular movement is performed in reverse.

The internal oblique muscles are used in any activity involving tilt to the pelvis.[16] Trunk rotation, for example, is performed largely by the internal oblique muscles. The rectus abdominis does not function as a trunk flexor; rather, it only shows a firing pattern when the spine has attained almost full flexion.[15,16] Therefore, it seems that the curl-up described above is the appropriate beginning exercise for the abdominal muscles. There is no need to do a full sit-up. The abdominal muscles do not work in the second 45° of that exercise; rather, the iliacus and

continued

rectus femoris muscles do all the work. Also, the full sit-up places greater stress on the lumbar spine. Therefore, full sit-ups are not advisable for anyone, including individuals with no lumbar spine problem. Many lumbar spine injuries are caused by improper abdominal strengthening technique.

A combination of fast repetitions and isometric repetitions will involve the most muscle fibers and will train the abdominal muscles for endurance as well as for absolute isometric strength. It would seem prudent to perform sit-ups in the foot-supported position, with the knees bent 45° to allow for maximum contraction of the lower oblique muscles and rectus abdominis muscle, because of their importance in pelvic tilting. However, performing some repetitions unsupported will enable more isolated strength to develop in the upper rectus abdominis muscle.

Advanced exercises for abdominal strength involve bilateral straight leg raising and lowering while supporting oneself in an elevated chair position. During this exercise, meticulous control of pelvic tilt is required to eliminate repetitive swaying of the lumbar spine. Slowly raising and lowering the legs ensures isolation of the lower abdominal muscles and eliminates cheating movements associated with leg swinging (eg, swinging the legs like a pendulum, which effectively reduces the need for the lower abdominal muscles to raise and lower the legs). An advanced exercise program also includes curl-ups on an incline board, both in symmetric and in diagonal patterns. Manual resistance provided by a work-out partner, or holding a weight plate securely across the chest can increase the gain in abdominal strength.

Full sit-ups are not advisable for anyone, including individuals with no lumbar spine problem.

Side-lying trunk raises may place excessive axial rotation stress on the lumbar spine. These exercises can probably be performed by individuals who have no lumbar disk pathology, and by individuals who have been totally rehabilitated from previous lumbar spine problems. The exercises must be performed carefully and correctly. It is unclear whether side-lying trunk raises have any significant benefit in a strength-training program, although they are advocated by some coaches. We do not recommend them.

Football is a collision sport that places tremendous demands on the lumbar spine. Thorough and rational rehabilitation programs can enable injured players to return to competition. The value of such programs is based on accurate diagnosis and early intervention. **PSM**

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