

# PREVENTION OF LOW BACK INJURIES IN ATHLETES

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Low back injury is very prevalent among athletes. Stanitski (1982) holds that low back pain is one of the most common complaints of athletes. Mutoh(1978) reported 60% of 53 competitive swimmers experienced low back pain while Aggrawal(1979) found 48% of 25 track and field athletes and 40% of 25 weightlifters experienced backaches. Kotani(1971) found an even higher incidence of 92% in 26 career weight lifters who had lifted for 4 or more years. Similarly, the author found 86% of 43 professional modern dancers treated for more than one injury presented with low back pain on one or more occasions. These high incidences of reported low back pain suggest that better preventative efforts should be made.

## INTRA-ABDOMINAL PRESSURE

The spine can be subjected to tremendous forces during athletic endeavors. Morris(1961) calculated that 2,071 pounds (9.2kN) of force would be imposed on the lumbosacral disc when lifting a 170 lb (77kg) weight in a flexed position. Hall(1985) found selected aerobic dance hip extension exercises resulted in torque values at the lumbar spine greater than found in a previous study to occur during lifting a 100lb (45kg) load. Eie(1966) measured landing forces at the lumbosacral junction of 200-400kg (2.0kN-3.9kN) with ski jumping. Such large forces appear to be potentially dangerous in light of findings that damage occurred in isolated discs with only 350-1400lb (1.6kN-6.2kN) of force (Bartelink, 1957). Similarly, damage to isolated adult vertebrae was found to occur in the bone itself with only 484-1430lb (2.2kN-6.4kN) of force by Eie(1966) and .8kN-16kN by Hutton(1978).

The similarity in magnitude between stresses borne by the spine during lifting and other athletic movement and those stresses causing damage to the spine has led to the conjecture that in vivo, something must serve to protect the spine. Several investigators have suggested that this protection is provided by intra-abdominal pressure (IAP). IAP is the pressure which can be generated if the muscle walls around the abdominal cavity are contracted. The function of IAP can be pictured as a fluid ball which resists deformation as soon as the pressure within it is raised (Bartelink,1957) and thereby helps support the upper body (Grillner, 1978). This, in effect, provides an alternate loading route from the thorax to the pelvis (Hutton, 1979) such that a relieving effect is offered to the spine (Grillner, 1978).

The magnitude of this unloading force, although somewhat controversial, appears to be significant. Bartelink(1957) predicted that IAP could decrease the force in the intervertebral discs by several hundred pounds. Morris(1961) estimated a 50% reduction in intradiscal force in the lower thoracic spine and a 30% reduction in the lumbosacral disc. During various forms of moderate and heavy exercise, Eie(1966) measured IAPs ranging from 50-225mmHg. These recorded pressures were calculated to provide a relieving force of approximately 77-413lb (.3kN-1.8kN) to the lumbar spine which represented up to 40% of the contraction force of the erector spinae muscles. Eie concluded that these relieving forces were sufficient to drop the forces borne by the vertebrae below the damage loads of normal adult vertebrae and so protect the spine during rigorous athletic movement.

The amount of IAP which can be generated is quite different among individuals and appears to be trainable. Slight, non-athletic individuals were reported to generate IAPs of only 60mmHg while athletic individuals were able to generate 140mmHg(Bartelink, 1957) or more (Grieve, 1978). In elite weightlifters, maximum IAPs of as high as 225 and 300mmHg were reported by Eie(1962) and Grieve, respectively. Since the spine is unloaded in a degree proportional to the actual IAP produced (Grillner, 1978), it appears desirable to maximize IAP through strengthening of the abdominals and encouraging athletes to use them during movement.

## POSTURE

In addition to their role in producing IAP, the abdominal muscles also serve another important function for preventing back injuries. Posteriorly, there is a bony connection between the rib-cage and pelvis. However, anteriorly, this connection is purely muscular and is made by the abdominal musculature. This architecture makes the "length" of the abdominal musculature very critical in determining the distance between the rib-cage and pelvis which in turn effects the curvature of the spine.

Micheli(1979) and Smith(1977) noted that athletes with low back pain classically exhibit functional lumbar hyperlordosis due to tight lumbodorsal fascia in conjunction with weak abdominals. Stanitski(1982) holds that the trunk should function as a column with equally distributed circumferential forces and that inadequate anterior support from weak abdominals or tightened posterior support causes uneven loading of the spine and a predisposition to abnormal stress. Troup(1970) notes that standing with lumbar hyperlordosis creates a force tending to displace L5 anterior on the sacrum and considerable shear force is borne by the pars interarticularis of L5. Stanish(1979) suggests that maintaining a fixed lumbar lordosis interferes with the needed periodic cyclic loading of the facet joints and can lead to cartilage breakdown. Wolf(1979) noted the EMG of the erector spinae was proportional to the lumbosacral angle and one could conjecture that muscle fatigue could more readily occur in a lordotic posture.

Whatever the mechanism, excessive lumbar lordosis appears to be a predisposing factor to low back injury in athletes (Stanish, 1979; Stanitski, 1982). Although structural problems should be evaluated by a physician, this functional excessive arching of the low back can often be corrected by strengthening the abdominals and encouraging athletes to actively use the abdominals during

movement. In essence, the abdominals can be contracted to pull the pelvis "under" so that the pelvis is vertical rather than in an anteriorly tilted position. In addition, Eie(1962) describes that use of the abdominals to generate IAP will also tend to straighten and elongate the spine since all the natural openings are closed and the only mobile parts are the disc articulations.

## STRENGTHENING THE ABDOMINALS

The role of the abdominals in IAP generation and reduction of lumbar hyperlordosis makes abdominal strengthening an important measure for preventing low back injury. However, to achieve these desired preventative effects requires that specific exercises be done in a meticulous manner. Although abdominal strengthening is a part of many athletes' training programs, abdominal weakness is almost ubiquitous. The author has worked with many elite athletes who perform 100-300 sit-ups daily and yet are unable to perform 5 curl-ups correctly. Similarly, evaluation of numerous aerobics dance instructors who teach 12 or more classes weekly again revealed weak abdominals. Despite often very rigorous abdominal strengthening routines, the mean of 30 athletes seen clinically was only 25deg and was 43% below "normal" using Kendall's Leg Lowering Test (Kendall, 1971).

The blatant ineffectiveness of many abdominal strengthening routines suggests that better instruction, feedback, and goal evaluation be provided to athletes. Common errors include poor choice of exercises, lack of specificity of muscle use, use of momentum, muscle substitution, and sacrificing good form for high repetitions. One frequent mistake made by the more elite athlete is the use of the roman chair, inversion curls, or hooking the feet on the incline board. The foot stabilization offered in these exercises allows for hip flexor substitution. This is ineffective for abdominal strengthening, produces large lumbar forces, and the repeated strengthening of the psoas major in this restricted arc without sufficient stretching can worsen lumbar lordosis. Some Common abdominal exercises and considerations for effective strengthening follow:

### Specific Muscle Emphasis

Kumar(1978) holds that on morphological grounds the transversus abdominis is of primary importance in IAP generation. Grieve(1978) notes that the transversus abdominis is the only abdominal muscle capable of pulling in on the abdominal wall without causing other movement. This would appear to make this muscle particularly suitable for stabilization and IAP generation during functional movement.

EMG studies suggest that the external obliquus abdominis also plays a role in IAP generation and maintenance of correct posture (Kumar,1978;Grillner,1978). In contrast, Bartelink (1957) found no significant contraction of the rectus abdominis during lifting and Grillner found an inconsistent relationship between increase in IAP and rectus abdominis activity. The rectus abdominis may function mainly in movement rather than postural stabilization.

These findings suggest that particular emphasis should be placed on strengthening the transverse and oblique abdominals.

Theoretically, inclusion of trunk rotation should emphasize oblique strengthening and pulling the abdominal wall inwards should utilize the transversus. This emphasis is an important practical consideration in that many athletes appear to develop rectus abdominis strength quite readily while remaining very weak in the transversus and obliquus.

#### Pelvic Tilt

One of the most fundamental abdominal exercises is the pelvic tilt. The pelvic tilt involves a posterior tilting of the top of the pelvis and a pulling in of the abdominal wall towards the low spine such that the lumbar curve is reduced and the pelvis and rib-cage are drawn slightly closer together. Common errors include using the hip extensors to effect the posterior pelvic tilt, arching the upper back such that the ribs stick out, and pushing the abdominal wall outwards versus pulling it in. Each of these errors reduces the needed overload of the abdominals and fails to create the muscle shortening or motor pattern needed for correction of lumbar hyperlordosis.

#### Curl-up

A curl-up involves sequential trunk flexion until the shoulder blades are off the ground while maintaining a pelvic tilt. The low back should remain in contact with the ground and the knees are bent. This modified sit-up is recommended because it minimizes lumbar spine flexion while still providing effective overload to the abdominals (Halpern, 1979). Halpern demonstrated that the obliquus abdominis was active in hook lying curl-ups for approximately 90% of the up cycle in contrast to only 25% of the up cycle during the long lying full sit-up.

Kelley(1982) holds the hook lying position also is preferred over the straight leg position because the accompanying hip flexion tends to release the pelvis from the passive constraints of the iliofemoral ligament and hip flexors. Slackening of these restraints would theoretically allow greater ability to effect a posterior pelvic tilt. Initial establishment of a posterior pelvic tilt through abdominal "setting" is necessary to prevent the tendency for the hip flexors to pull the pelvis forward in the latter stages of the curl-up.

Common errors include co-contraction of the back extensors and abdominals as the hip flexors are used to lift the trunk as a unit in a flat-back position, hyperextending the spine just prior to the curl to provide more momentum and muscle prestretch, failure to maintain a pelvic tilt, and failure to keep the abdominal wall pulled inwards. Although these errors might seem insignificant, correction of these errors dramatically increases the difficulty of these exercises. It is not uncommon to have an athlete who was performing 50 sit-ups be unable to raise more than a few inches with correct technique. When such marked abdominal weakness is present, the use of isometrics and eccentrics can be helpful for developing the desired specific strength.

#### Adding Rotation

Adding rotation to abdominal exercises provides greater overload to the obliquus. However, it is important to remember

that trunk rotation can be produced by either the abdominal musculature or back musculature. A common error is to use the hip flexors to maintain the trunk angle as the abdominals are used to isometrically hold the spine in slight hyperextension and the back musculature is used for rotation. Correction involves keeping the trunk in a position of flexion as rotation is effected by the abdominals.

#### Additional Exercises

Many other exercises for abdominal strengthening are commonly used by athletes. Some of these additional exercises can provide variety and be effective when the previously discussed principles are applied: 1) maintain a pelvic tilt 2) emphasize pulling both proximal and distal abdominal attachments towards each other 3) attempt to pull the abdominals inwards such that bulging out of the abdominal wall is avoided. Other exercises, however, such as double leg lowering and V-sits are more effective for strengthening hip flexors and are potentially dangerous. In general, good form should not be jeopardized for high reps, high speed, or complicated movement patterns.

#### APPLICATION TO MOVEMENT

Unfortunately, doing abdominal strengthening exercises is usually insufficient for changing lumbar hyperlordosis. Perhaps this is because it is difficult to correct a trunk flexor/extensor imbalance by doing abdominal exercises for 15 minutes if during the rest of the day the extensor use is emphasized. Whatever the reason, effective correction of posture and technique generally requires a re-education process. A progression from simple standing and walking to complex sport skills can be utilized. Success in this process often demands the initial use of concrete cues such as a wall, mirror, or hand. In time, the athlete can develop internal kinesthetic feedback. In the author's opinion, going beyond just strengthening the abdominals to being able to utilize the abdominals in good spinal mechanics is necessary for successful low back injury prevention and rehabilitation. Three case studies will be used to exemplify this process.

##### Case 1

An 11 year old ballet dancer presented with low back pain. The diagnosis made by the attending physician was lumbosacral sprain. Marked abdominal weakness and lumbar hyperlordosis were noted. Technique correction resulted in an immediate amelioration of pain. Abdominal strengthening and technique correction were prescribed. A progressive decrease in intensity and frequency of symptoms occurred until the patient was pain free approximately three months later.

##### Case 2

A 24 year old female aerobics instructor presented with low back pain which was exacerbated by teaching. There was a history of back pain after any strenuous physical activity over the past

5 years. The patient had undergone extensive orthopaedic evaluation and had been prescribed several physical therapy programs without relief of symptoms. Very weak transverse and oblique abdominals were noted as well as marked lumbar lordosis with teaching. Abdominal strengthening and technique correction were again instigated. A gradual decrease in pain occurred over the next two months and the patient was able to relate discomfort to classes where she was unable to keep good spinal mechanics. Currently, the patient has had no pain for 14 months and is unrestricted in her physical activities.

### Case 3

A male runner 35 years of age presented with low back pain. This was the third extended bout of low back pain in the last 3 years and the discomfort was increased with running. Weak abdominals, tight hamstrings, and an excessive anterior pelvic tilt with treadmill running was noted. Abdominal strengthening, hamstring flexibility, and technique correction were carried out. A gradual decrease in pain occurred such that 40 minutes of running was pain free at 3 months. Currently, 9 months post injury, the patient is running 48 miles per week pain-free.

### SUMMARY

In summary, athletes suffering from mechanical low back pain often exhibit weak abdominals and excessive lumbar lordosis. Although abdominal routines are often performed, inappropriate exercises and incorrect technique often result in inadequate building of abdominal strength. Specific muscle emphasis and good form during such exercises as pelvic tilts, curl-ups, and rotary curls should be utilized with an appropriate progression to reach abdominal strength goals. However, just strengthening the abdominals is often not enough for successful prevention and rehabilitation of low back injury. Instead, this base of abdominal strength must be utilized to produce appropriate IAP and correct sport specific spinal mechanics.

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