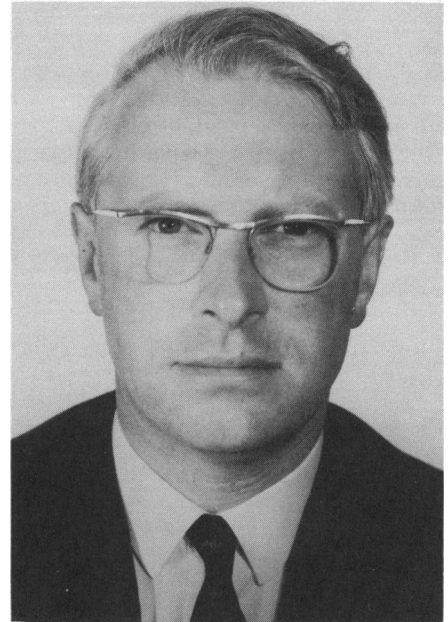


BIOMECHANICAL FACTORS IN SPINAL INJURIES

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A proper understanding of the biomechanics of injury to the spine serves as an illustration of concepts relating to injury generally, and should have special relevance to work in general practice. Sport is stressful, and stress produces injury. The significantly increasing proportion of the population taking part in physical recreation leads obviously to an increase in the number of injuries. It is hoped that certain misconceptions about the aetiology of injuries, sporting and general, will be dispelled.

Injuries to the spine are common, accounting for about 15% of injuries sustained in sport. Accurate statistics are difficult to obtain; figures quoted by Adams (1980) are taken from cases seen in an Accident and Emergency Department, Walkden (1979) deals with injuries occurring on the Rugby field and therefore excludes overuse injuries, and the series reported by Sperryn and Williams (1977) includes few acute injuries, but many chronic overuse lesions.

Sports injuries are common; their number exceeds that of road traffic accidents, though relatively few are serious. There are some two million injuries a year in the United Kingdom attributable to sport – a major epidemic – and some 10% of them involve time off work. Sperryn and Williams classified 1750 consecutive cases attending their sports clinics into three "Specialist-management" categories.

- a. Patients with problems that could, and should, be dealt with by competent general practitioners or casualty officers.
- b. Those that require attention in a specialised field;

orthopaedic surgery, orthopaedic medicine, rheumatology, ophthalmology, gynaecology or other specialist departments of a hospital or clinic.

- c. Patients requiring advice, investigation and treatment by specialists with a particular knowledge, experience and interest in sport and sports medicine. (It was noted that none in this category in the series mentioned above had any injuries to the neck, trunk and back that could be classed as specific to sport).

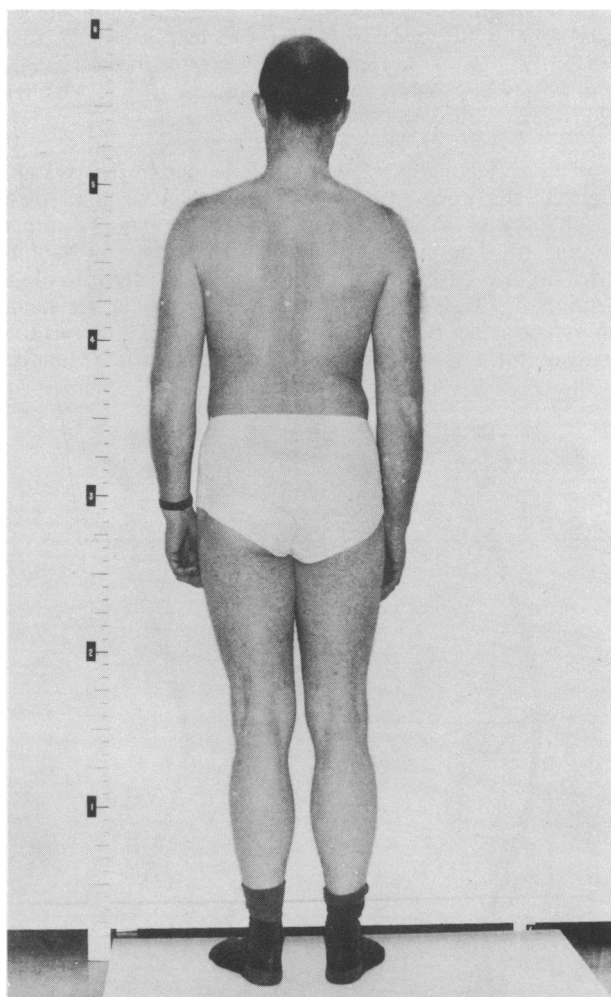
All these injuries (the majority of which did not require some special attention) were of the type that could and should be managed within the available facilities of the National Health Service, without the need for additional "specialoid" expertise. From an epidemiological view, the whole problem of injury in sport should be taken seriously as this is a disease of the young. 50% of the patients in the group were aged between 20 – 30, and 25% were under the age of 20. The social and economic significance is obvious, when 10% of the injured lose work, and some suffer long-term if not permanent disability that may need prolonged and continuous care and support for many decades.

Apart from actual injury, many spinal conditions cause problems to sportsmen.

Developmental abnormalities: Spina bifida occulta, hemivertebra, partial or complete sacralisation or lumbarisation of adjoining vertebrae, though unsuspected and symptomless in many sedentary workers, will cause trouble in a sportsman undergoing

heavy training as well as in those in heavy manual employment.

Non-traumatic mechanical derangements may occur, such as the "locked facet" syndrome and Scheuermann's disease (osteochondritis juvenilis), which leads to adolescent kyphosis, and shows on X-Ray as Schmorl's nodes, and gives to the outline of the vertebrae the familiar "moth-eaten" appearance. These conditions are often exacerbated, if not actually induced by physical exertion, typically in pre-adolescent female gymnasts whose "suppling" exercises are designed to give spinal hyper-extension. Concern must also be felt regarding the introduction of weight training at progressively diminishing ages.

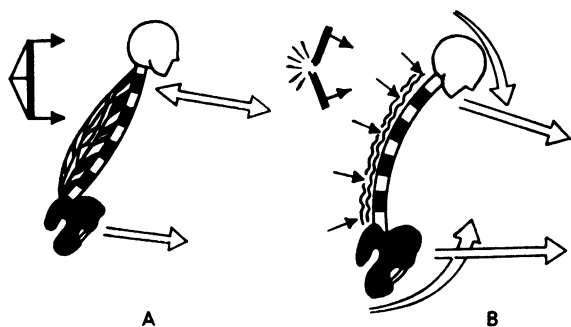


It is possible to identify a number of sports associated with injuries at different spinal levels. In the cervical area, the sports mainly involved are Rugby football, high jumping, (particularly with the "Fosbury flop" and

anywhere if there are inadequate landing facilities), and trampolining. Diving, especially into shallow water, is the commonest cause, the usual mechanism being forced flexion of the neck often associated with some rotation. Injuries of the dorsal spine are associated with motor racing, and riding, particularly steeplechasing, hunting and show jumping. They are due to severe flexion/rotation stresses, usually with the shoulders pinned and unable to move. In the lumbar spine, gliding, parachuting and mountaineering are implicated, when landing on the feet with velocity. In the lumbo-sacral joint, weight-lifting with exaggerated hyper-extension is a hazard. These, however, are not sport specific injuries.

Injury occurs as a result of a MECHANISM, not as a result of the SPORT itself. The mechanism is the application of a vector force or stress to which the body cannot adapt. Any particular mechanism may be found in one particular sport; but it will be found in many other sports and indeed in a variety of activities that have no connection with sport. This is why, in the series of sports injuries referred to above, there were no neck and back injuries specifically requiring the attention of a sports medicine specialist. The mechanisms of injury to the spine in sport are incriminated in a wide variety of other human activities. Sport does not produce injuries per se, but many involve mechanisms which overload the body in part or as a whole, and it is this overloading that causes the injury. This concept is important and essential to an understanding of injury. In approaching a patient with an injury, it is essential to identify the mechanism. The patient should be encouraged to demonstrate what happened, and once the mechanism has been identified it should become simple to recognise the type of damage that has been done, and so deal with it accordingly. Unless this is appreciated, dealing with injury in sport becomes totally empirical.

A similar approach is required in less immediate injury, chronic strain or overuse. When the spine is under load, it should function as a braced cantilever. Thus for example when pulling on an oar, when lifting a weight or pushing in the scrum, the spine is safe if the back is held firm, but if it is allowed to buckle and give way, the tie-brace effect is lost, overstress follows – a simple and familiar example of a biomechanical process leading to injury. Once a mechanism becomes apparent, it becomes possible logically to devise means of protecting people from injury, so that, if one can identify the mechanism, then it can begin to be eradicated from a particular sport. As an example, there has been an increase in the incidence of cervical spine injuries in Rugby football associated with scrum collapse, and also with letting the ball fall to the ground and going over it, producing severe flexion of the neck. This is an identifiable mechanism, and if it is possible to modify the way the game is played so that this



mechanism is eradicated, the consequent injury is removed as well.

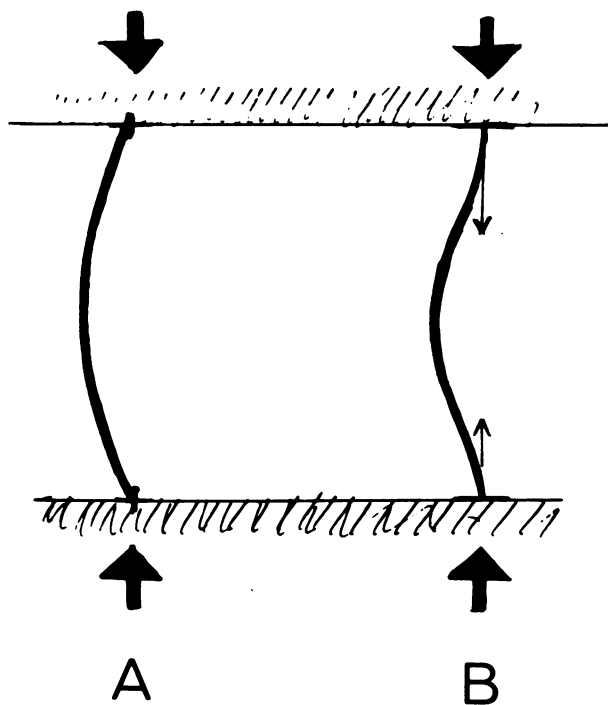
It is important when dealing with sports injuries generally to remember that vehicular and other high velocity accidents tend to produce more severe injuries that people can inflict upon themselves. Intrinsic soft tissue injuries such as pulled muscles never involve as much damage because the velocities and forces involved are very much lower; — a simple fundamental mechanical principle. Even so, severe stresses may be applied, for example, to the lumbar spine, as in a weight lifter's press, which produces tremendous shearing stresses at the lumbo-sacral joint; such heavy loading may be sufficient to cause a stress fracture of the spine.

In the pre-stress fracture situation, where patients are beginning to develop changes in the pars interarticularis, but a crack can still not be seen on the X-Ray plate, a "hot node" can often be demonstrated on a bone scan. The further extension of the stress fracture (spondylolysis) is overt spondylolisthesis, with forward slip of one vertebra upon another. This usually presents as back pain, though in some instances sciatica is the main symptom and sometimes may be assumed to be a chronic hamstring strain associated with running. Chronic hamstring strain never comes on gradually, and if a patient gives a history of a pain in the back of the thigh going down the leg, and coming on gradually, it is almost always true sciatica. It is not recognised generally that one of the major problems of middle and long distance track runners is back pain or other spinal trouble, for the simple mechanical reason that they tend to wear unsuitable and inadequately padded shoes and run on hard surfaces such as tarmac road, concrete or frozen plough land. They often have a bad running action involving a positive velocity heel strike, the heel moving forward as it hits the ground, and transmitting shock waves from the calcaneum up the leg and hip joint into the lumbo-sacral joint.

The fundamental basic anatomical unit of the spine has a nerve root emerging between the intervertebral disc in front and the posterior facet joint behind. Each segment of the spine may be regarded as a tripod, and the spinal column as a series of tripods superimposed

upon each other. If one element of the tripod is shifted or damaged at least one other must move as well, because the tripod represents a closed kinematic chain. The posterior spinal joint is more often affected than is the disc, and too commonly "prolapsed disc" is diagnosed as a cause of backache without any justification. It is much more likely that the posterior facet synovial joint is involved. A common feature of the "locked facet" syndrome is intense muscle spasm, which can be described to patients as "a form of natural splinting to prevent movement at the inflamed small joints". This produces a typical picture of marked scoliosis, with a loss of normal contour. It is not diagnostic of a prolapsed intervertebral disc unless there are positive neurological signs in the affected limb, and radiological confirmation by myelogram or radiculogram. The majority of patients with lower backache who have no neurological signs almost certainly have a lesion in the posterior facet joint, which lies just behind the nerve root, which it irritates if inflamed or injured.

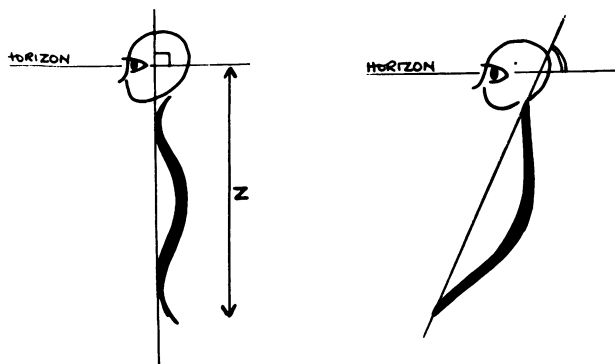
The concept that the body is a locomotive system that breaks down mechanically unless it is used in a mechanically efficient and effective way is most important. The spine may be regarded as a link to join two hollow cavities (the skull and the pelvis) with a section of "basketwork" fixed in the middle. As such, the spine is acting as a strut, particularly as it carries the load of the upper hollow cavity. When a strut is loaded



the end may be position-fixed only, and allowed to adopt any attitude; or it may be direction-fixed, so that not only is the position of the end determined, but also the direction in which the end is pointing. The effect of direction-fixation of the end of the strut under load is that it adopts a different shape, because the strut has to start off in the direction already determined, and so has a different and more complex curve. The significance in spinal terms is that the shape of the spine is determined by the position of the cranium and the pelvis. When the subject is standing erect, with his long axis vertical and is looking horizontally, he has a dorsal kyphosis which is more or less fixed, and a normal compensatory lordosis of the cervical and lumbar spines, resembling an archer's bow. When the angle between the long axis and line of sight is reduced, as when reclining backwards but looking horizontally these two lordotic curves are flattened out. For example an ill-designed car seat can position-fix and direction-fix the spine, not only at its ends, but along practically all the length of the column, causing great discomfort. If, however, the spine is allowed to take up the comfortable neutral position with an easy curve, (helped perhaps by padding and building up the back of the seat) a much better and unstrained

position is achieved. Just by using knowledge of the way in which the spine works in relation to the curves it adopts it is possible to reduce strain and so reduce pain and discomfort. By direction-fixing the lower end of the spine, for example by the use of a lumbar support, or by preventing movement in the seat a biphasic curve is induced which is intensely uncomfortable. By allowing the lower end to rotate freely, the upper end being fixed by the need to see the road, the subject can adopt the most comfortable position and produce a spinal curve more like the catenary curve (which is not the shape of the average car seat, though it should be). Experiments show that as the sitting subject moves back into a reclining position, keeping the line of sight horizontal, the pre-existing lordosis in the lumbar spine is flattened out and replaced by a kyphosis. The line of sight determines the shape of the spine, and explains the necessity when lifting of keeping the head erect to avoid buckling of the lumbar spine, so bringing in to play the tie-bar muscles which protect against injury.

The final point to be made is that, for an understanding of the causes of injury, whether mechanical or otherwise, it is necessary to study their mechanism specifically, as without such study adequate prevention and treatment becomes almost impossible. Given an understanding of the way in which injuries occur, whether to the spine or to other structures, it should be possible to prevent, and treat effectively those that cannot be prevented. This will help to reduce morbidity in the population as a whole, and also, hopefully, reduce the stored up dam of osteo-arthritis and degenerative joint disease due to affect that section of the population in 20, 30 or 40 years hence. By learning something of injuries and their mechanics it is possible to extend the frontiers of medicine, and there is no better reason for practising sports medicine than that, other than, of course, the great pleasure and delight it gives to restore a patient back fit to his or her normal occupation and recreation.



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