• *ТЕОРЕТИКО-МЕТОДИЧНІ АСПЕКТИ ФІЗИЧНОЇ РЕАБІЛІТАЦІЇ*

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BASIC PRINCIPLES FOR MUSCULOSKELETAL HEALTH AND IMAGING IN SPORTS MEDICINE AND REHABILITATION

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ОСНОВНІ ЗАСАДИ ЗДОРОВОГО ОПОРНО-РУХОВОГО АПАРАТУ ТА ВІЗУАЛІЗАЦІЙНА ДІАГНОСТИКА У СПОРТИВНІЙ ТА РЕАБІЛІТАЦІЙНІЙ МЕДИЦИНІ. Вльфганґ ҐОВІН *(Група Ґантер Імаджінґ, Нью-Лембтон, Австралія; Кафедра анатомії та фізіології Львівський державний університет фізичної культури, Україна)*

Анотація. У статті наводяться сучасні погляди з проблеми патофізіології кістки та сухожилку, а також значення цих новітніх поглядів для спортивної медицини та фізичної реабілітації спортсменів. Переважна більшість травм, особливо під час занять спортом, стосується саме сухожилків і кісток.

Досліджується проблема спортивного травматизму при перенавантаженнях; вказується на необхідність належної діагностики перед вибором відповідних методів лікування. Рання діагностика спортивних травм набирає особливого значення як для спортсмена чи команди, так і для спортивних лікарів, фізіотерапевтів та реабілітологів. Рання діагностика зменшує зусилля та витрати суспільства на лікування задавнених травм. Спортсмен повинен знати природу патофізіологічних процесів, викликаних больовим синдромом, для того, щоби вказати на них у ранніх стадіях ушкодження тканин. Знання про патофізіологічні процеси у тканинах в результаті травм є важливим засобом профілактики травмувань.

Ключові слова: спортивна медицина, реабілітація спортсмена, напруження у сухожилку, напружуння у кістці.

Topicality. The growing pursuit of peak performance in sport demands a constantly increasing support from skilled medical personnel, trainers, psychologists, physiotherapists, and other allied physiomedical personnel. The common goal of these professionals is to provide care and nurturing to the athletes. Injuries are part of life on this planet; however there is an increased propensity and susceptibility to all kinds of injuries in athletes. Consequently, sports medicine and athlete rehabilitation are often demanding disciplines in which to work.

The current problem in sports medicine is the increasing occurrence of overuse injuries. The constant demand for better results in sports is limited by the physiological provision of the biological tissues such as the tendons and the bones.

Specialized diagnostic procedures are often necessary to make the correct diagnosis when tissue was damaged. Unavailability of imaging equipment can be a problem in certain areas; and not uncommonly it increases the demand for experienced medical personnel to perform the appropriate treatment.

Herein, it is presented that at least a partial solution to the multifaceted problem of modern sports injuries would be familiarity with the current knowledge of the pathophysiology of overload conditions in bones and tendons. It would be an important step towards prevention of injuries and, importantly, would ease the psychological impact on the athlete.

The athletes as well as the sports management team have high hopes and expectations. Some of the more important factors influencing the performance level of an athlete are the condition of the athlete, the environment, the psychophysiological stress level, food and fluids, and the circadian

rhythm of hormonal output. While in training or during a high peak performance injuries can occur. The injury spectrum can range from acute trauma occurring in body contact and high-velocity sports to a more subtle and chronic musculoskeletal condition with insidious onset. Rehabilitation after the acute treatment is becoming an increasing issue in active athletes who want to go back to their previous peak performances. New concepts arising from better knowledge about bone, tendon and cartilage physiology will eventually dominate the future for physiotherapy and individually tailored rehabilitation programs. Magnetic and vibrational therapy ideas have been around for a few years. Studies are now underway involving larger population samples. Observational study results are promising, even in osteoporotic patient participants.

The increase in knowledge and experience has developed into subspecialized branches in sports medicine. Military medicine, performing arts medicine, medicine for athletes with disabilities and paediatric sports medicine are just a few examples of current developments in the wide range of physical culture physiology and medicine. Occupational medicine is constantly challenged with new and more severe injuries from patients working in such diverse places such as ballets, caves, or in mines. Repetitive physical activity is rising in the workplace concordant with increasing productivity. There are many aspects in community medicine which are being influenced by sports medicine and vice versa.

CURRENT PRINCIPLES IN DIAGNOSING SPORTS INJURIES

Diagnosing Sports Injuries. The old cornerstone of an accurate diagnosis is a thorough physical examination and clinical assessment, coupled with knowledge of the anatomy and physiology of the involved organs. Certainly, understanding of the pathology and physiological repair mechanisms of different tissues is essential for the management of the injured athlete. The provisional clinical diagnosis is mandatory for any decision to be made on how to proceed. This rational decision about additional laboratory work and/or imaging modalities is important for interpreting test results when they become available. Change of management, or more specifically directed therapeutic processes are usually the result of these tests. Consequently, the treating physician, physiotherapist or rehabilitation specialist must be flexible enough to change the provisional diagnosis. The athlete, not usually educated in medicine, should be fully informed about the provisional as well as the final diagnosis. This is essential for compliance. The uninformed or only partially informed athlete will not fully cooperate with the treatment and, therefore, reduces his chances to fully recuperate. The uninformed or misinformed injured athlete will later become a burden to trainers and eventually might develop a chronic illness.

Understanding of the normal variations and asymptomatic age-related changes is paramount for the interpretation of additional imaging procedures. Subclinical pathology is present in a large proportion of athletes [1]. The temptation to overplay the significance of an abnormal report must be resisted. However, it is known that intervertebral disc herniations, rotator cuff tears, or degenerative joint disease can sometimes be completely asymptomatic.

Imaging procedures become necessary mostly in the following circumstances:

- uncertain clinical diagnosis
- uncertain treatment management decision
- extent of injury
- presence of injury complications
- failure of treatment for unknown reasons
- exclusion of additional systemic pathology
- pre-operative assessment
- medico-legal reasons.

Other factors which may influence the final decision to order an additional imaging procedure include:

- local availability of imaging equipment and expertise
- radiation dosage
- pharmaceutical contrast medium sensitivity

- cost and convenience to the athlete
- compliance for treatment
- cost to the insurance company, tax payer or sporting club.

Plain radiographs are usually the first procedure to be ordered. These commonly allow the exclusion of underlying fractures. Then, depending on the tissue type that may have been injured, ultrasound, CT, or MRI imaging might be required to assess the injury further or in greater detail.

Bone injuries are best imaged with plain X-rays, CT or nuclear medicine scans. Joint injuries are more complex involving a variety of different tissues. For overall assessment and exclusion of small avulsion fractures, plain X-rays are again the first imaging modality in evaluating the assumed damage to the joint. Secondarily, CT and MRI, occasionally nuclear medicine scans, are being used for thorough evaluations.

Tendon, ligament and muscle injuries are assessed with ultrasound and MRI. CT or plain X-rays are much less useful for the damage assessment of soft tissues.

Complex injuries involving nerves and vessels demand active and immediate attention of medical personnel. Fast decision making is essential for the survival of depended tissues and organs. An array of imaging modalities involving ultrasound and both MR and CT angiography is commonly ordered for an accurate diagnosis.

When the athlete is in the rehabilitation, monitoring their progress is required in most circumstances. A single imaging modality for monitoring is selected according to the type of injured tissue. Switching between different methods is usually confusing, in particular when measurements are required to assess progress or failure. Bone injuries are commonly monitored with plain radiographs. Joint injuries are monitored with MRI, whereas tendon or ligament and muscle injuries can be safely monitored with ultrasound.

However, complications or failure to improve during rehabilitation may require a complete new approach and a new set of imaging procedures.

Interventional radiological procedures, such as image-guided injections, might be helpful in the treatment of the injured athlete at any stage.

Overuse Sporting Injuries. Biomechanical overload is the cause of most athletes' injuries. This relates to the acute high-energy overload situation as well as to the repetitive low-energy overload injury. Chronic repetitive trauma overwhelms the normal process of tissue repair. Passing time is of essence for the overuse injury to appear. The commencement of overuse is when, for instance, a small amount of fibrils are torn in one of the many fascicles in a tendon. This commonly does not cause any symptoms, as the body repair mechanism will start to work immediately. In the event that the athlete continues to exercise the particular tendon with the same motion and force, and the time between the first minimal fibre injury and the continuation of exercise is too short for the repair mechanism to complete its task, further injury to other fibres or re-injury of the partially repaired fibre might occur. If this happens too often and in a repetitive pattern, the biological material tendon will give way, and complete or partial ruptures will occur, causing symptoms. The occurrence of pain is usually the reason for discontinuation of the repetitive activity. Unfortunately, the delay of pain arising from the injury is a feature of the overuse injury; therefore, prevention is of great importance. The management of the training activities of athletes is paramount to the health of the individual athlete. It is important for both the athlete and the training team to understand that changes in the type and degree of activity are essential to minimise the risk of overuse injury. The pressure to be fit and to meet commitments might lead to the tendency to ignore the common understanding and knowledge of modern training.

Another type of overuse injury can occur when there is a change in previous monotonous training. A change of training equipment, training load, alteration in technique, or even new shoes, might cause overuse injury. In this instance, it is not the repetitively overused and half repaired tendon that is subjected to further injury. To keep the example of a tendon, another muscle seldom trained, is being newly used and immediately overloaded due to the change in technique or equipment. As a result, the repetitively loaded tendon will be intact but the previously underloaded tendon will tear or partially rupture.

This type of overuse injury can occur in well trained soccer players when they are subjected to long runs or walks when this type of exercise has not been part of their normal training program. The well trained lower leg and foot skeleton is suddenly exposed to a different load pattern that may result in stress fractures of the metatarsal bones or even the tibia, when the athlete is young.

CURRENT BIOMECHANICAL CONSIDERATIONS ABOUT TISSUE STRESS

Tendon Stress. Fibroblasts produce type 1 collagen within tendons. Collagen is arranged in a hierarchical manner. Collagen molecules form fibrils. The fibrils form fibres, fibres organise themselves into bundles. Bundles form fascicles. Tenocytes produce an organic matrix consisting of hydrophilic gel-like proteoglycans. These complex macromolecules provide the "glue" between the fibrils, fibres and bundles. They also regulate the assembly of procollagen molecules. The collagen manufacture and consequent tendon repair is relatively slow, lasting several months to over a year, depending on the demand and/or amount of repair required.

All tendons are exposed to a variety of stresses in normal life. There is a constant process of tendon micro-repair in all parts of the musculoskeletal system in order to maintain tendon integrity. The typical creeping tendon failure can occur when the normal rate of tendon repair is overwhelmed with repetitive tensile loading.

On a cellular level in a tendon, there is mechanoreception in connective tissue cells sensing alterations in loading. Chronic repetitive trauma causes a change in the shape of these cells. The normally spindle-shaped cell turns into a plump spheroidal shape due to the accumulation of mucoid vacuoles. The cell surrounds itself with mucoid ground substance and there is a fibrinoid degeneration of freshly produced collagen. This pattern of change is called mucoid degeneration, metaplasia in terms of pathological degeneration. The continuation of this process leads to diminution of collagen and consequently to progressive accumulation of proteoglycans. The capillary proliferation around the connective tissue cells produces microvascular ingrowth in the tendon, further weakening the tendon. Fibrinous exudate follows the neovascularisation. This may then lead to internal compression of tendon fibrils and fibroblasts, reducing the blood supply to these important cells [2]. The final result is a macro-tear of the tendon.

Attempted repair in continuous repetitively low-loaded tendons results in fibroblastic and myofibroblastic proliferation [3]. A further result of this is hypertrophic scarring which can occasionally lead to dystrophic calcification.

All these pathological changes are summarized in the term tendonosis or, more generally in radiology and sports medicine, as tendinopathy. Tendonosis is the cause of 97 % of all spontaneous tendon ruptures [4].

The cause of pain within the tendon remains unsolved. There are no nociceptors in the tendon. It remains unclear at this point in time why some tendinopathies cause pain while others with a similar degree of damage in the same individual, are asymptomatic [5].

Bone Stress. A common problem in sports medicine is chronic bone stress [6]. Bone tissue is similar to tendon tissue constantly remodelled in order to adapt to the changes of the musculoskeletal behaviour of the individual. Opposed to the tendon which reacts to tensile stress, bone reacts to compressive stress. The healthy normal gravitational pressure on bone can be interrupted with repetitive low-energy stress. The bone's response to compressive force is the production of new bone matrix which in time is mineralized and incorporated into the pre-existing bone structure. Repetitive stress overwhelms the production of new bone, in particular the non-linear ordered mineralization. The result is accelerated and partially chaotic bone remodelling. The athlete may become symptomatic at this stage. This early warning system within the bone is a self-protective mechanism, signalling imminent susceptibility to fracture. MRI or nuclear bone imaging can detect this stage of bone stress which is not detectable on plain X-rays.

As with a tendon, continuing stress will result in ruptured trabeculae, a micro-crack and finally a macro-fracture. This stress fracture may be detectable on a plain radiograph. It requires treatment. Early diagnosis is important, since rapid recovery can follow when the stress fracture

is properly attended to. Failure to investigate will lead to further injury with devastating consequences to the athlete.

Fatigue fractures are stress fractures in an otherwise normal healthy bone. They are commonly found in athletes. They are a result of abnormal low-energy repetitive biomechanical loading conditions.

Insufficiency fractures are fractures that occur under normal conditions in a metabolic abnormal bone. They are commonly found in patients with osteopenia, osteoporosis, osteopetrosis, renal osteodystrophy, Paget's disease and other metabolic bone diseases producing diminished elastic resistance. Insufficiency fractures are an increasing problem for the society, since osteoporosis is exponentially increasing causing a large amount of additional costs to health care systems.

Conclusion. The prevention of injuries is a prime consideration in the management of training activities. Knowledge and application of modern training methods is essential for the health of an athlete.

Early diagnosis of sports injuries is essential for the athlete, the sports team, the sports physician, the physiotherapist and the rehabilitation specialist. It also reduces the costs to the society of consequential late treatment and then greater tissue damage.

It is therefore important to educate the athlete about the numerous causes of pain. The athlete must be aware of the pathophysiological principles behind pain, so that he can report it in early stages of tissue stress. The sports medicine team must be ready to investigate complaints of bone and tendon stress before greater damage occurs.

The rehabilitation specialist's capabilities are sought after when acute treatment has been finalised. Knowledge of the repair mechanism and the normal time frames of musculoskeletal tissues healing are important for successful facilitation of natural processes in rehabilitation. Concordantly, a well tailored rehabilitation program supports the psychological mind set of the athlete and most commonly stimulates new motivational forces.

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ОСНОВНЫЕ ПРИНЦИПЫ ЗДОРОВОГО ОПОРНО-ДВИГАТЕЛЬНОГО АППАРАТА И ВИЗУАЛИЗАЦИОННАЯ ДИАГНОСТИКА В СПОРТИВНОЙ И РЕАБИЛИТАЦИОННОЙ МЕДИЦИНЕ

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Аннотация. В статье представлены современные тенденции в патофизиологии кости и сухожилья, а также значение этих тенденций для спортивой медицины и физической реабилитации спортсменов. Наибольшее количество травм, особенно при занатиях спортом, касается прежде всего сухожилий и костей.

Исследуется проблема спортивного травматизма при перегрузках; подчеркивается необходимость правильной диагностики перед выбором соответствующих методов лечения. Ранняя диагностика спортивных травм приобретает особое значание как для спортсмена или команды, так и для спортивных врачей, физиотерапевтов и реабилитологов. Ранняя диагностика требует меньших общественных усилий и затрат для лечения запущенных травм. Спортсмен должен знать природу патофизиологических процессов, лежащих в основе болевого синдрома, с тем, чтобы выявить их на ранних стадиях повреждения тканей. Знание о патофизиологических процессах, происходящих в тканях в результате травм, является важным способом профилактики травматизма.

Ключевые слова: спортивная медицина, реабилитация спортсмена, напряжение в сухожилии, напряжение в кости.

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Annotation. This work assesses current thoughts about bone and tendon pathophysiology and its impact on sports medicine and athlete rehabilitation. The majority of all injuries, in particular, during sports activities are related to tendon and bone injuries.

Further attention is brought to overuse sporting injuries as well as the diagnostic procedures before treatment options can be explored. Early diagnosis of sports injuries is essential for the athlete, the sports team, the sports physician, the physiotherapist and the rehabilitation specialist. It reduces the costs to the society of consequential late treatment. The athlete must be aware of the pathophysiological principles behind pain, so that he can report it in early stages of tissue stress.

In conclusion, knowledge about the underlying tissue pathophysiology is an important tool for injury prevention.

Key words: Sports medicine, athlete rehabilitation, tendon stress, bone stress.