RELATIONS BETWEEN ORTHOPEDICS AND BIOMECHANICS IN SPORTS TRAUMA AND OVERUSE INJURY

Bernhard Segesser, Muttenz-Basel, Switzerland

INTRODUCTION: In all European countries sports are promoted as a means to prevent damage to the circulatory system and the locomotor apparatus caused by inactivity. According to recent studies, the discrepancy between mechanized transportation and physically undemanding working conditions, on the one hand, and a greater amount of leisure time, on the other, is encouraging many people to actively engage in sports. In Switzerland, out of a population of seven million, 52% regularly participate in sports. Every year each inhabitant spends an average of 250 Swiss Franks on sports equipment. In Germany more than 70% of the population of 80 million participate in some form of sport activity. In 1994 they spent 64 billion German marks on products offered on the sports and leisure market. A further annual growth of 15 billion German marks is expected. Throughout Europe the sports industry has become a huge market which is made up of traditional kinds of sports, as well as new sport trends such as inline skating and snowboarding [Marketing Journal 1996].
In many countries sports are promoted by institutions of public health care, as well as by private health insurance companies, as a means to achieve well-being and a way to reduce the risks which shorten people's lives. Sporting activity is considered healthy and necessary for living. Sports are strongly promoted as a prophylactic. The risks sports pose for health and safety are still not being taken seriously enough, however. Sport is in itself risky. In the future we will probably have to face the question of whether we would rather contract arthrosis from inactivity and overweight or from sport activities.

SPORTS AS A RISK: Those who participate in sports take the risk of inflicting acute and chronic damage on their bodies. Depending on the type of sport, injuries occur with a frequency which can be calculated statistically.
Epidemiological data confirm an overall growth of injuries and damage caused by sport activity. Depending on national traditions, football, volleyball, basketball and skiing are at the top of the list. [Steinbrück, 1980; Tenvergert, 1992; UVG Stat., 1996]. An increase in the frequency of sports injuries is obvious in comparison to the frequency of accidents of other types (e.g., traffic, household and garden).
The patterns of injuries changes in the course of time owing to improvements in equipment (e.g., skiing) [Heim, 1993; Matter, 1993], changes in the rules (e.g., ice hockey) or preventive measures like stretching exercises. To estimate the potential risks of a certain kind of sport one can calculate an injury factor. This factor represents the number of injured persons in a given sport in relation to the number of persons who are organized in groups and associations to participate in this sport. In Germany rugby has the highest factor [Hawkins, 1988], followed by basketball (9.2), volleyball (3.1), squash (2.9), ice hockey (1.9), the martial arts, judo and karate (1.7), football (1.5), skiing (1.2) and athletics (1.1) [Steinbrueck 1980].

The severity of an injury is also reflected in the costs which each accident causes. Sports involving a higher average risk, such as paragliding, can result in costs which per accident are three times greater than those resulting from a traffic accident. Traffic accidents are again two times more expensive than skiing accidents and four times more expensive than injuries sustained by football players [UVG Stat. 1996].

We spend enormous amounts of money for the therapeutic and social consequences of sports accidents. Leisure time activities and sports as a way to channel aggression cost us dearly and will continue to do so. It is probably going to cost us even more as the gap between the thirst for adventure and the physical constitution of the individual widens. The load capacity of the locomotor apparatus depends on the tolerance of the tissue in reacting to the forces typical for the particular kinds of sport. Due to lack of movement, from an early age on many peoples' tissue receives only insufficient stimulation by strains. Therefore the quality of the tissue is very likely to become worse later on in their lives if specific stimuli are not provided by purposeful training. The effect of forces of high frequency, especially with kinds of sport characterized by a high passive acceleration, insufficient regeneration and the aging of the tissue caused by metabolism lead to strains close to the borderline of tolerance. This involves the risk of irreversible damage [Nigg, 1993; Segesser, 1993]. Patterns of damage emerge for specific tissues which are typical for movements and forces characterizing certain kinds of sports. Jogging puts a strain on muscles, tendons and the gliding tissue, ball sports strain the capsula and ligament apparatus of knee and ankle joints, whereas racket sports put a strain on all tissues *(Table 1)* [Nigg, 1992; Segesser, 1991, 1993]. Here gliding and friction between foot and ground seem to have an essential influence [Nigg, 1988; Segesser, 1995]. In general, one has to look for the etiological factors of excessive strain *(Table 2)* and to integrate them into preventive and therapeutic conceptions [Segesser, 1983]. Therefore knowledge about the specific movements involved in different kinds of sport is necessary to reduce the number of injuries by developing adequate equipment and protective gear. This was successfully done in the case of snowboarding, inline skating and roller skating [Biasca 1995; Campell, 1993; Jacques, 1994; Malanga, 1995; Micheli, 1986; Schieber, 1994, 1995; Zollinger, 1994].

Tolerance of the Tissue

Sports activities imply pressure-, tension- and shear forces to the locomotive apparatus. The body tries to neutralize them passively through the elasticity of the tissue and actively by muscular slow down and ligamentary conducted movements, stressing bones mainly by pressure and tension, cartilage mainly by pressure and ligamentary as well as muscular capsular structures and muscles by tension. Asymmetric stress implies shear forces to the different tissue structures.

The tolerance of these tissues concerning the above-mentioned forces depends, on one hand, on the total amount and time of the forces acting and, on the other hand, on the tissue quality. It is well known that tissue adapts age- and metabolism rate dependently qualitatively and quantitatively to mechanical stress, i.e., by means of collagen fiber condensation. Apart from the musculature this process usually takes from months to years. Stress through pressure and tension is of essential importance for the locomotive apparatus' bradytroph tissue nutrition. Collagen and extracellular matrix form the mechanically viscoelastic components with specific force-deformation graphs. Within the elastic range of deformation the tissue normalizes its morphological structure concerning length, width and tissue quality after stress has ceased. The forces are tolerated. Within the plastic range damage must be expected and the tissue, reversibly or not, will not regain its original quality. Distortions and disruptions of muscles, ligaments and tendons are typical examples of acute trauma caused by sudden plastic tissue deformation. Insertion tendinosis, tendinitis, microdistortions and microruptures of the musculature, as well as damage to the cartilage, overuse fractures or overuse of the growth plate are examples of damage caused by chronic plastic deformation.

Epiphyseal/apophyseal overuse injuries

Sports activities in youth, besides positive physiological, psychological and social aspects, expose participants to the risk of injuries and overuse of the locomotive system. Previous studies have shown that increased stress to the growth plates by sports activities, in relation to the intensity of strain during growth spurts, can affect normal growth.

In female gymnasts, hormonal changes can decrease the growth rate and the long-term growth. On the other hand, during more intensive phases of growth the column cartilage of the growth plate is the weakest part of the locomotor system because of the influence of somatotropin and low levels of testosterone. This can cause subchondral stress fractures in the growing cartilage which later on, if overlooked or not sufficiently treated, can cause osteochondrosis dissecans.

The apophysis of tendons of big muscle groups can display loosening of the apophysis caused by increased muscle strength and acute or chronic micro-trauma. Male adolescents show an incidence of lesions in the relation of 9:1 compared to female adolescents. The therapy of apophyseal lesions is generally non-operative.

Due to the persistent growth possibility, pseudo-tumors can occur, which can cause problems of differential diagnosis among skeletal tumors. Too high pressure-, push- and tearing forces can affect growth.

Later examinations of previously high-level athletes and patients with coxarthrosis, with and without a sports history, suggest that blockage of the rotation of the foot during growth, for example caused by soccer-shoes, can produce high push forces on the femoral epiphysis which can lead to an epiphyseolysis cap. fem. lenta and thereby to pre-arthrotic deformities. This can be understood as an over-correction of the "physiological" epiphyseolysis described by Morscher.

Knowledge of the reduced strength of the growth plate provides a basis for better adaptation of training and supervision of the adolescent high-level athlete. Regular check-ups for growing athletes and a reduction in the intensity of sport activity during the growth spurts, a prohibition of negative training aspects and sometimes even a total prohibition of sports, if there is a lesion of the growth plate or a hormonal disorder, are sometimes necessary to minimize later defects. In addition to this, a reduction of strain in some sports and, for example, a prohibition of the wearing of rotation-blocking soccer shoes by adolescent soccer players is necessary.

To obtain a feeling of freedom human beings seem to need some sort of risk. A lack of self-realization at work is compensated for with sports activities [Gabl 1991] Sport then becomes a compulsion. Sport adventures are being marketed as a source of freedom, and they promise escape from everyday routine. One cannot claim that such a concept of sports is healthy, and perhaps its promoters do not even want to, because the search for an individual, often hazardous, quality of life, on the one hand, and healthy behavior in the sense of preventive medicine, on the other, are not compatible and never will be. At the same time, sports can never be reduced to a mere means to preserve our bodily functions. They will always function as an outlet for joy, for ambitions and at the same time as a way to channel aggressions. Therefore sport will remain a risk factor which will ultimately cost the health care system a great deal of money.

THE EDUCATION OF A SPECIALIST IN SPORTS MEDICINE: The great number of sports injuries requires competent treatment. As in all fields of medicine, the *Morscher* motto is applicable here: *"A diagnosis one doesn't know one can't make."* University education is alarmingly inadequate in view of the enormous direct and indirect costs caused by sport injuries. The objection that knowledge of general traumatology can also be applied to sports traumatology may bear some justification, but for the traumatologist the groin pain of the football player or the achillodynia of the runner - soft tissue traumatology in general - are a minor problem. So every physician must gain his own experience with the athlete, his patient. A purposeful postgraduate education is desired, but only a few countries in Europe have introduced a sub-specialization which gives the specialist a name. In Germany this specialization can be obtained in a 240 hour course. Postgraduate education is inadequate in view of the high socioeconomic costs caused by sports. A physician who treats athletes has no more right to call himself a "sports physician" than does any colleague who simply participates in sports himself. Both share an interest in sports traumatology, but the requirements imposed on sports traumatologists are more extensive. They comprise functional thinking combined with specific knowledge of the movements performed in the particular kinds of sports, the injury patterns of a particular kind of sports and their biomechanics. The requirements also extend to knowledge of conservative and operative possibilities of treatment, of rehabilitation, nutrition and of training physiology. A sports physician has a great deal of responsibility, even if he is not required to decide on matters of life and death. He must take decisions, however, which affect the subjective well-being and the quality of life of his patients. Moreover, he is also taking the risk of providing medical treatment which in the long term can be damaging to the locomotor apparatus of the patient.
To face this challenge, specially trained sports physicians are needed who have a good overall knowledge of sports traumatology. Unfortunately, specialization focuses on the knee joint only. Yet of all patients in sports traumatology, only 33% of the injuries have to do with the knee joint and only 38% with the capsula ligament apparatus *(Table 3).* Therefore it is necessary to teach different localizations and the remaining soft tissue traumatology equally intensively [Segesser 1991].

THE INCLUSION OF BIOMECHANICS IN FUNCTIONAL EXAMINATION TECHNIQUES AND FUNCTIONAL DIAGNOSTICS: In spite of reservations concerning the training of sports physicians, sports traumatology has become an established field as a sub-specialization of traumatology and orthopedics. It is owing to sports traumatology in connection with biomechanics that functional techniques of examination, early functional strategies of therapy and rehabilitation

congruent with the findings of training science have also become a standard applied to injuries of other kinds. At the same time, sports traumatology has been profiting from progress in particular fields of medicine and technology.
Biomechanics and its diverse techniques of measurement have thoroughly improved the functional understanding of movements. The measurement of tension and the tensile strength of different tissues, the measurement of outward forces as well as models for the calculation of strains on joints, ligaments and tendons have enlarged our knowledge in the mechanics of joints and tissues. It also improved our knowledge of the specific strains of particular kinds of sport and helped us to understand the etiology of acute and chronic traumata of the tissue caused by sports. The results of the investigations were: Shears and asymmetric strains by tractive forces reduce the tissue's tolerance towards strain; ground and boots provoke physiologically inappropriate forms of movement by friction and leverage, and reaction forces and vibrations must be dampened without affecting proprioception. In this field biomechanics must provide us with further knowledge. It must, e.g., answer the question as to what extent it makes sense to reduce external forces by absorption. Biomechanics must distinguish between influence on performance or protection of the locomotor apparatus. The results of the investigations have at the same time influenced the development of sports shoes and the condition of ground surfaces, as well as therapy and rehabilitation of sports injuries [Nigg, 1988, 1992, 1993; Segesser, 1993; Renstroem, 1993]

Clinical examination

For all optical and imaging diagnostics hand and eye are still essential means of examination. From anamnesis and clinical examination a diagnosis emerges which must be confirmed. The clinical examination consists of a test of the ligament structures and the active muscle and tendinous stabilizers, both under load and without load, as well as of movement excursions. The test of the quality and function of the muscles is as much an indispensable part of the systematic process of examination as is a test of statics and the manner of walking.

Imaging diagnostics

Functional radiographs: Conventional radiographs are still of some use in sports traumatology if they - as functional radiographs - show the joint in extreme positions, e.g., exostoses on tibia and talus which mechanically are in the way or an impingement of the Os trigonum.

Sonography: Sonography has enabled us to view tissue in function. Especially with regard to soft tissue injuries of muscles, tendons and partly ligaments, sonography has revolutionized therapeutics. It has also enabled us to make distinctions as to the extent of the damage to the tissue by localizing hematomas, scars, etc. Therapeutic measures such as punctures are possible under sonographic control. Whether sonography will become a generally accepted means to the diagnosis of knee damage remains to be seen. If used for shoulder diagnosis and the diagnosis of injuries of the muscles and the Achilles tendon, it is the reference examination and is also much cheaper than comparable examination methods [Belhobek, 1989; Jerosch, 1989; Hannesschlager, 1988; Holzach, 1990; Laine, 1991].

MRI: Magnetic resonance imaging quickly became established in sports traumatology, because it depicts anatomical structure and tissue quality better than any other method of imaging examination, even if functional interpretation is not possible [Belhobek, 1989; Crues, 3rd, 1994; Galloway, 1992; Tehranzadeh, 1994]. Therefore MRI gives limited indications of the arthroscopy of the particular joints. Interpretation of the findings is not always easy, but nevertheless the diagnostics of soft tissue traumatology of muscles and tendons has been improved considerably by MRI. It allows us, e.g., to diagnose the extent of tissue lesions like cysts *(Figure 1),* partial ruptures, damage of the tendons caused by compression by the posterior processus of the calcaneus and the bursa subachillae which is located between bone and tendon. This facilitates a differential diagnosis of the achillodynia and leads to adequate operative measures like the decompression of the subachillar space or to the strengthening of greater partial ruptures of the tendon (if the diameter of the lesion is more than 30 %) [Segesser 1995].

Technical Examinations

Analysis of Walking, Stabilization, Function of Muscles: Biomechanical analysis of mobility, especially analysis of walking, can be helpful for the evaluation of false pressure on the locomotor apparatus, provided that the necessary measurement devices are available. Important in the field of sports are highly resolving procedures of analysis that are also able to process all the outputted data. Mechanical instabilities, e.g., of the ankle joints, are often only distinguishable from functional deficiencies of muscular stability by specific measurement processes of stabilization that can deliver the results of the muscle functions.

Arthroscopy: Arthroscopy lost its with the advent of MRI status. However, a functional judgement of a joint in passive mobility (under local anesthesia active as well) is still best done by the means of arthroscopy. Today arthroscopy of the knee, shoulder and ankle joints is a standard diagnostic and also therapeutic technique [Ewing 1995; Gächter, 1993; Hawkins, 1988; Hurley 1993; Jaivin 1994; Sandmeier 1995; Villar, 1994], whereas the indications for diagnostic arthroscopy of the elbow can replace other methods only in exceptional cases [Morrey, 1986; Woods, 1987].

Measurement of Compartment Pressure: In many cases disturbances of the physiological muscular pressure gradient during physical activity are becoming more frequent as effects of injuries after trivialized injuries of the soft tissue caused by contusions, etc. Muscle avulsions and injuries of fascia with scar formations can effect local compartment syndromes. Muscular overuse syndromes appear mainly with athletes in a relatively bad training condition or whose muscular capillarity exists at a low level. Moreover, only those muscle groups are affected that are used strongly in a specific kind of sport, but little affected in daily activities. Our medical records show that mainly runners are affected by the deep medial tibialis compartment accompanied by tibialis posterior and flexor of the toes. Such appearances are known as medial tibial syndrome or shin splints, whose nomenclature avoids the distinction between tendinous insertion and compartment syndrome. With persistent trouble despite functional relief of the muscles, in the case of shin splints by arch support in the shoes with medial support, the suspicion of a chronic relapsing compartment syndrome is present. With other kinds of sport

one finds compartment[2] syndromes of the deep plantar flexors and the peroneal compartment as well.
The diagnosis of a compartment syndrome is given mainly clinically and confirmed by a dynamic functional measurement of compartment pressure. We prefer a mobile digital system of pressure measurement with pressure reception on a piezoresistive basis[1]. The advantages in comparison to manometric methods of measurement lie in the independence of influences of temperature, a permanent measurement, and the possibility of the functional measurement of pressure without the risk of system blockage. The measurement of pressure under tension is clearly superior to the exclusive measurement of pressure in a state of rest, because not only the pressure in a state of rest, but also the pressure under tension and moreover the pressure in a state of rest after tension, shows significant results *(Table 4)*. Depending on the kind of sport and the pain evoking strain, the pressure may be measured on a treadmill, cybex, bicycle ergometer or rowing ergometer [Segesser, 1984, 1996].

REHABILITATION

Early Functional Treatment

Until a few years ago conservative therapy and postoperative treatment alike meant temporary rest in a plaster cast. After damages due to immobility, such as deficiency in the nutrition of cartilage, muscle atrophy, disturbances of coordination and proprioception, etc., had become better known, early functional treatment with initial limited motion and strain were applied. Once knowledge of the positions of stress of ligaments and tendons had been gained, the search began for a posttraumatic or postoperative application of limited motion excursion on continuous passive motion splints and later in an active way. The more differentiated the knowledge of the joints mechanics, the proprioception, the tolerance of the tissue and the structures of collagen became, the more active became rehabilitation. Instead of immobilization a controlled movement with the help of orthosis or stabilized shoes was aimed at. These methods helped to shorten the postoperative treatment of fibular hand surgeries and Achilles tendon ruptures and reconstructions considerably [Segesser, 1993; Zwipp, 1990]. The release of the last 10 degrees of extension during the postoperative treatment of reconstructions of the front cruciate ligament reduced complications and rehabilitation time by means of a faster recruitment of the activity of the muscles in the closed chain of motion with identical good later results [Shelbourne 1995].
The rehabilitation of an athlete shows some remarkable peculiarities: In addition to guaranteeing the restoration of the stability of the ligaments and muscular stabilization, it is necessary to achieve the restitution of the coordinative muscle functions for sport-specific movements and the preservation and improvement of the general condition factors. Therefore, knowledge of training methods and requirements for the specific kind of sport are essential. Inadequate rehabilitation for physical activity bears the risk of retraumatization. However, the restoration of physical activity cannot be assured. The therapeutic aim of insurance companies is the restoration of the ability to work. Statistics show that higher costs of treatment

---

[1] *MCDM-I, Mammendorfer Institut für Physik und Medizin, Hattenhofen.*

can be compensated for by lower costs patients must pay for loss of earnings [Segesser, 1996; Shelbourne, 1995; Zwipp, 1990].

CONCLUSION: Sports are healthy, but also a source of traumatization. The socioeconomic consequences are considerable. The treatment of sports injuries and damage requires specific knowledge of etiology, as well as of diagnostic and therapeutic possibilities. Therefore better education in sports medicine is needed. Modern tendencies in sport traumatology were pointed to. The inclusion of biomechanics improved the understanding of the development of sport injuries. Modern procedures of examination are responsible for a more thorough diagnosis, including the quality of tissue and functional techniques of examination. Therapeutic measures comprise early functional treatments of fresh injuries, in the case of surgical treatments minimal invasive techniques. For adequate rehabilitation knowledge of training methods is indispensable to optimize the result of the treatment and to avoid retraumatization.

REFERENCES:

Belhobek, G. H., Richmond, B. J., Piraino, D. W., Freed, H. (1989). Special Diagnostic Procedures in Sports Medicine. *Clin. Sports Med.* **8**, 517-540.

Biasca, N., Battaglia, H., Simmen, H. P., Disler, P., Trentz, O. (1995). Übersicht der Snowboardverletzungen. *Unfallchirurg* **98**, 33-39.

Campell, L., Soklic, P., Ziegler, W., Matter, P., Fenner, A., Noesberger, B., Rigo, M. (1993). Snowboardunfälle. Multizentrische schweizerische Snowboardstudie 1992/93 unter Mitwirkung der bfu. *Z. Unfallchir. Versicherungsmed.* **Suppl. 1**, 43-53.

Crues, J. V. 3rd. (1994). The Impact of MRI on our Understanding of the Pathology of Sports Injuries. *Sportverletz. Sportschaden* **8**, 156-159.

Ewing, J. W., Tasto, J. A., Tippett, J. W. (1995). Arthroscopic Surgery of the Ankle. *Instr. Course Lect.* **44**, 325-340.

Freizeitsport 2000. (1996). *Marketing Journal* **3**, 162-164.

Gabl, M., Lang, T., Pechlaner, S., Sailer, R. (1991). Snowboardverletzungen. *Sportverletz. Sportschaden* **5**, 172-174.

Gaechter, A. (1993). Stellenwert der Arthroskopie in der Diagnose und Therapie von Schultergelenksverletzungen. *Chirurg* 64, 157-162.

Galloway, H. R., Suh, J. S., Everson, L. I., Griffiths, H. J. (1992). Radiologic Case Study. MRI and Sports Injuries. *Orthopedics* **15**, 249, 252-6.

Hannesschlager, G., Reschauer, R., Riedelberger, W., Stadler, R. (1988). Hochauflösende Real-Time-Sonographie bei sportspezifischen Muskel-verletzungen. Sonomorphologisch-anatomische Korrelation und diagnostische Kriterien. *Sportverletz. Sportschaden* **2**, 45-54.

Hawkins, R. B. (1988). Arthroscopic Treatment of Sports-Related Anterior Osteophytes in the Ankle. *Foot Ankle* **9**, 87-90.

Heim, D., Weymann, A., Loeliger, U., Matter, P. (1993). Epidemiologie der Wintersportunfälle. *Z. Unfallchir. Versicherungsmed.* **Suppl. 1**, 16-31.

Holzach, P., Mattli, J., Benz, K., Streicher, U., Matter, P. (1990). Die Ultrasonographie von Meniskuslasionen. *Sportverletz. Sportschaden* **4**, 135-138.

Hurley, J., Bronstein, R. (1993). Shoulder Arthroscopy in the Athlete. Practical Applications. *Sports Med.* **15**, 133-138.

Jacques, L. B., Grzesiak, E. (1994). Personal Protective Equipment Use by In-Line Roller Skaters. *J. Fam. Pract.* **38**, 486-488.
Jaivin, J. S., Ferkel, R. D. (1994). Arthroscopy of the Foot and Ankle. *Clin. Sports Med.* **13**, 761-783.
Jerosch, V. J., Castro, W. H., Sons, H. U. (1989). Einsatzmöglichkeiten der Sonographie bei Sportverletzungen des Schultergelenkes. *Sportverletz. Sportschaden* **3**, 74-80.
Kommision für Statistik der Unfallversicherung UVG (KSUV). (1996). Taschenstatistik UVG.
Laine, H. R., Peltokallio, P. (1991). Ultrasonographic Possibilities and Findings in most Common Sports Injuries. *Ann. Chir. Gynaecol.* **80**, 127-133.
Malanga, G. A., Stuart, M. J. (1995). In-Line Skating Injuries. *Mayo Clin. Proc.* **70**, 752-754.
Mann, G. et al. (1994). Recurrent Ankle Sprain. *Israel J. Sports Medicine* **1**, 104-113.
Matter, P., Holzach, P., Heim, D. (1993). *20 Jahre Wintersport und Sicherheit-Davos*. Bern.
Micheli, L. J. (1986). Pediatric and Adolescent Sports Injuries: Recent Trends. *Exerc. Sport Sci. Rev.* **14**, 359-374.
Morrey, B. F. (1986). Arthroscopy of the Elbow. *Instr. Course Lect.* **35**, 102-107.
Nigg, B. M., Segesser, B. (1992). Biomechanical and Orthopedic Concepts in Sport Shoe Construction. *Med. Sci. Sports Exerc.* **24**, 595-602.
Nigg, B. M., Segesser, B. (1988). The Influence of Playing Surfaces on the Load on the Locomotor System and on Football and Tennis Injuries. *Sports Med.* **5**, 375-385.
Nigg, B. M. (1993). Excessive Loads and Sports-Injury Mechanisms. In P. A. Renström (ed.), *Sports Injuries* (pp. 107-119). London, Blackwell Scientific Publications.
Renström, P. A., Theis, M. (1993). Die Biomechanik der Verletzungen der Sprunggelenksbänder. *Sportverletz. Sportschaden* **7**, 29-35.
Sandmeier, R. H., Renström, P. A. (1995). Ankle Arthroscopy. *Scand. J. Med. Sci. Sports* **5**, 64-70.
Schieber, R. A., Branche-Dorsey, C. M., Ryan, G. W. (1994). Comparison of In-Line Skating Injuries with Rollerskating and Skateboarding Injuries. *JAMA* **271**, 1856-1858.
Schieber, R. A., Branche-Dorsey, C. M. (1995). In-Line Skating Injuries. Epidemiology and Recommendations for Prevention. *Sports Med.* **19**, 427-432.
Segesser, B., Goesele, A., Renggli, P. (1995). Die Achillessehne im Sport. *Orthopäde* **24**, 252-267.
Segesser, B., Goesele, A. (1996). Chronische Logensyndrome. *Sportverletz. Sportschaden* (In Press).
Segesser, B., Goesele, A. (1996). Die Therapie der fibulären Bandinstabilität. *Sportverletz. Sportschaden* (In Press).
Segesser, B., Jenoure, P. (1991). Statistik Sportverletzungen Rennbahn 1981-1991. Jahresbericht Rennbahnklinik Muttenz.
Segesser, B., Morscher, E., Goesele, A. (1995). Störungen der Wachstumsfugen durch sportliche Überbelastung. *Orthopäde* **24**, 446-456.
Segesser, B., Nigg, B. M. (1993). Orthopädische und biomechanische Konzepte im Sportschuhbau. *Sportverletz. Sportschaden* **7**, 150-162.

Segesser, B. (1983). Aetiologie von reversiblen und irreversiblen Sportschäden. *Schweiz. Z. Sportmed.* **31**, 81-86.
Segesser, B. (1984). Chronische Logensyndrome. *Helv. Chir. Acta* **50**, 725-737.
Segesser, B. (1993). Der Sportschuh als therapeutisches Hilfsmittel. *Sportverletz. Sportschaden* **7**, 206-209.
Shelbourne, K. D., Patel, D. V., Kloottwyk, T. E. (1995). Anterior Cruciate Ligament Reconstructive Surgery with Patellar Tendon and Accelerated Rehabilitation. *Sports Exercise and Injury* **2**, 1-14.
Steinbrück, K., Rompe, G. (1980). Epidemiologie von Sportverletzungen. *Dt. Ärzteblatt* **8**, 443-448.
Tehranzadeh, J., Kerr, R., Amster, J. (1994). MRI of Trauma and Sports-Related Injuries of Tendons and Ligaments. Part I: Spine and Upper Extremities. *Crit. Rev. Diagn. Imaging* **35**, 85-129.
Tehranzadeh, J., Kerr, R., Amster, J. (1994). MRI of Trauma and Sports-Related Injuries of Tendons and Ligaments. Part II: Pelvis and Lower Extremities. *Crit. Rev. Diagn. Imaging* **35**, 131-200.
Tenvergert, E. M., Ten Duis, H. J., Klasen, H. J. (1992). Trends in Sports Injuries, 1982-1988: An In-Depth Study on Four Types of Sport. *J. Sports Med. Phys. Fitness* **32**, 214-220.
Villar, R. N. (1994). Arthroscopy. *BMJ* 308, 51-53.
Woods, G. W. (1987). Elbow Arthroscopy. *Clin. Sports Med.* **6**, 557-564.
Zollinger, H., Gorschewsky, O., Cathrein, P. (1994). Verletzungen beim Snowboardsport - eine prospektive Studie. *Sportverletz. Sportschaden* **8**, 31-37.
Zwipp, H., Thermann, H., Südkamp, N., Tscherne, H., Milbradt, H., Reimer, P., Heintz, P. (1990). Ein innovatives Konzept zur primärfunktionellen Behandlung der Achillessehnenruptur. *Sportverletz. Sportschaden* **4**, 29-35.

FIGURES AND TABLES:

Figure 1: MRI of an Achilles tendon cyst

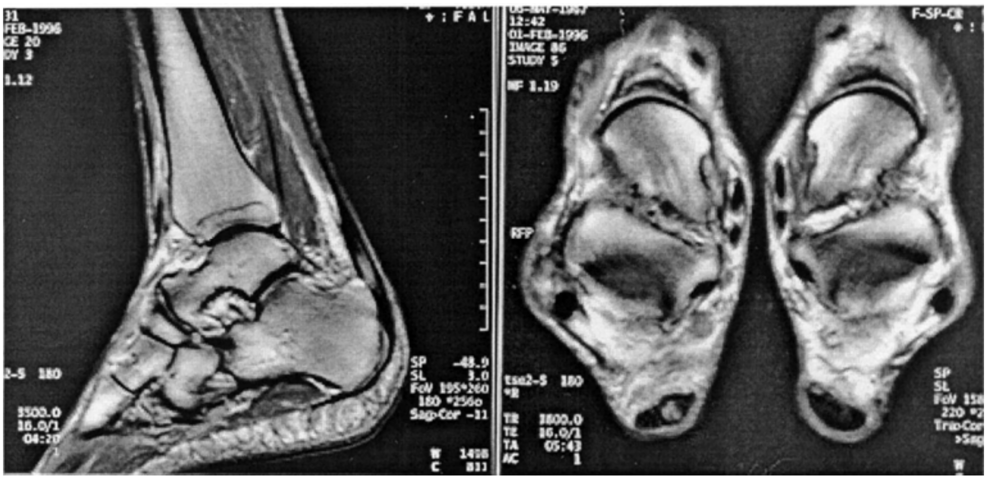


Table 1: Distribution of damaged tissues in various sports

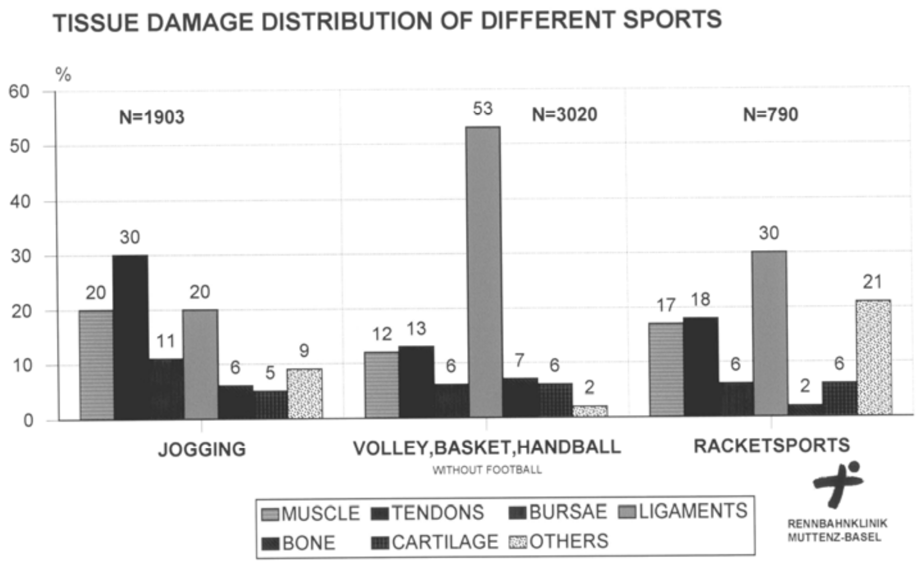


Table 2: Factors leading to sports injuries

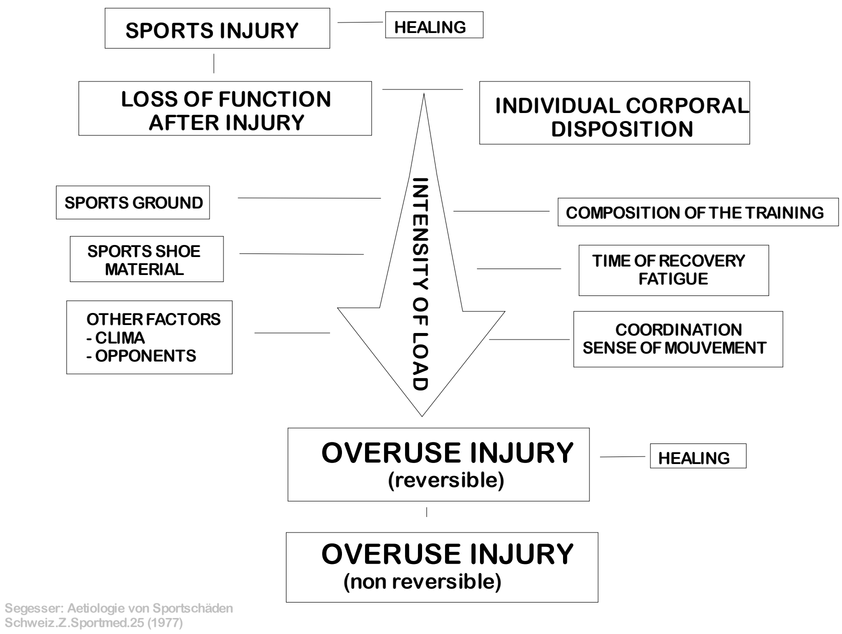
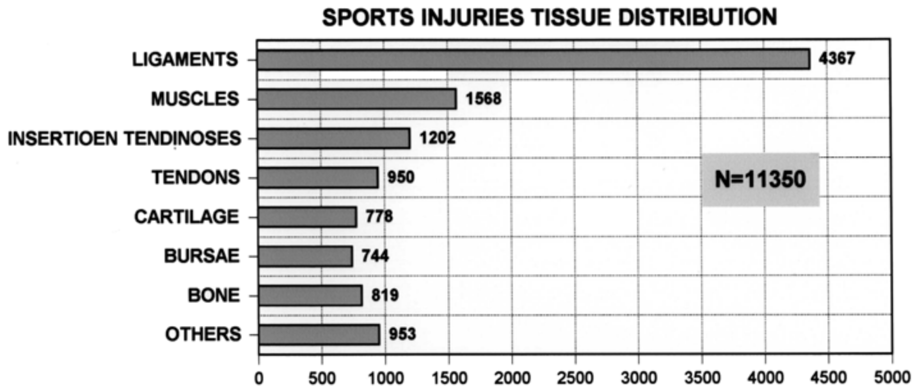


Table 3: Distribution of injured structures and tissues in our sport trauma population (Rennbahnklinik Muttenz 1981 – 1992)



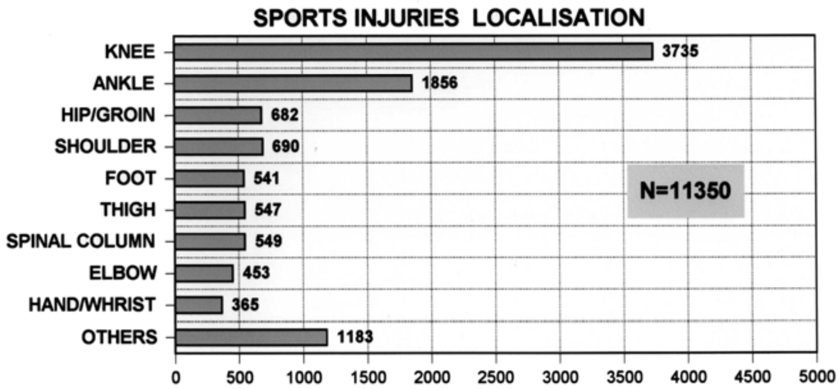


Table 4: Diagram of the compartment pressure: significant pressure increase in the compartment at rest before and after exercise