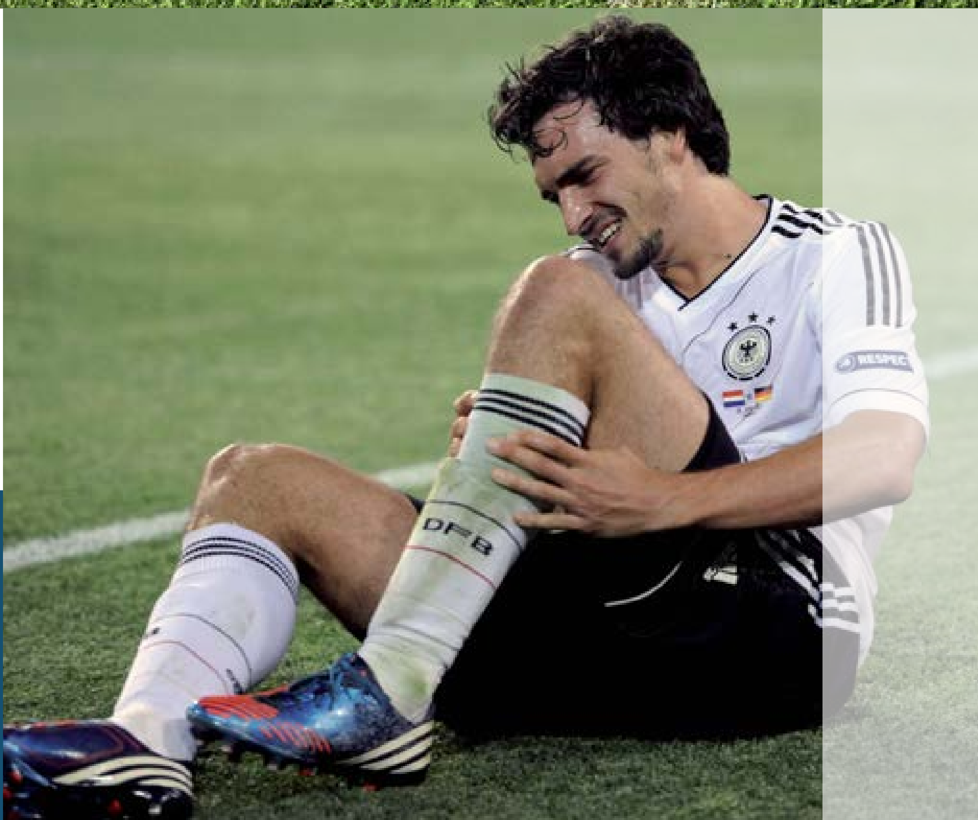
Tim Meyer | Oliver Faude | Karen aus der Fünten

SPORTS MEDICINE FOR FOOTBALL

Insight from Professional Football for All Levels of Play

WRITTEN BY THE GERMAN NATIONAL TEAM PHYSICIAN



MEYER & MEYER SPORT

Sports Medicine for Football

For our long-time teacher and constant companion Prof. Dr. med. Wilfried Kindermann, who has made a significant contribution to establishing serious sports medicine in football.

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FOREWORD

Sports medicine content and knowledge tend to be given either too little or too much importance, particularly in professional football; it is rare for sports medicine issues to be dealt with in a balanced way. For example, a coach who overestimates the physiological component of sports-specific performance will attach too much importance to sports-medicine-based training methods. Even physicians contribute toward the glorification of their profession by over-medicating their protégés or administering pseudomedical quack remedies (there is a difference between using pseudomedical remeides and polypharmacy). However, the opposite may also happen, and proven sports-medical facts may be completely discounted. Take as an example the need to protect players' health in the event of infections. Neglecting to adhere to the basic rules of sports medicine when planning training can have disastrous consequences, resulting in unnecessarily protracted illnesses caused by overtraining or at the very least a far from optimal training effect.

This book aims to dispel such errors and misunderstandings and aid a better understanding of the sports medicine aspects of football (not just at an elite level). It contains many years' experience in medical care of teams, of advising coaches on performance physiology and the testing of players as well as the exchange of ideas with different protagonists of this fantastic sport. We have also included a pinch of scientific skepticism gained from our university backgrounds, as this prevents the overly hasty adoption of purportedly miraculous methods and products. After all, in football, particularly in the pro game, new crazes are the order of the day.

Our book contains 10 chapters covering medical eligibility for football, illnesses, injuries, performance diagnostics, training, nutrition, women's football and the preventive value of the game of football, which may also all be read separately. While it is true that some details of sports medicine are not addressed (and which may be found in other books), we hope that this book will provide a good overview for coaches, players and for medical staff and other interested parties and will also serve as a guide for players themselves for certain behaviours. As this is our first book, constructive criticism is welcomed.

Throughout the text, unless otherwise stated, the term *player* refers to both genders.

Tim Meyer Oliver Faude Karen aus der Fünten

CHAPTER 1

MEDICAL
ELIGIBILITY FOR FOOTBALL

1.1 CARDIOVASCULAR SYSTEM

Sudden deaths of top football players are occasionally reported in the media. The cause can often be congenital heart defects (most frequently *cardiomyopathies*), but also myocarditis due to incomplete recovery from infection and systemic spread of infectious agents. Regular screening should prevent this kind of tragedy, but it is only possible to make these tests compulsory in professional clubs. However, an across-the-board, compulsory introduction of this kind of sports medical fitness testing is financially unrealistic for many players.

In line with the most recent revision carried out in 2012, dependent on the medical danger (which is significantly lower for female players and increases with age), there are three categories of eligibility examinations according to the German Football Association:

a) In the top men's professional leagues, a complete, non-invasive screening programme is carried out, as well as a thorough medical history and physical examination, a resting and exercise ECG plus blood pressure measurement, laboratory screening and a heart ultrasound (echocardiogram).

b) For the third league and regional leagues and for the top women's leagues, the echocardiogram and some lab tests are not conducted.

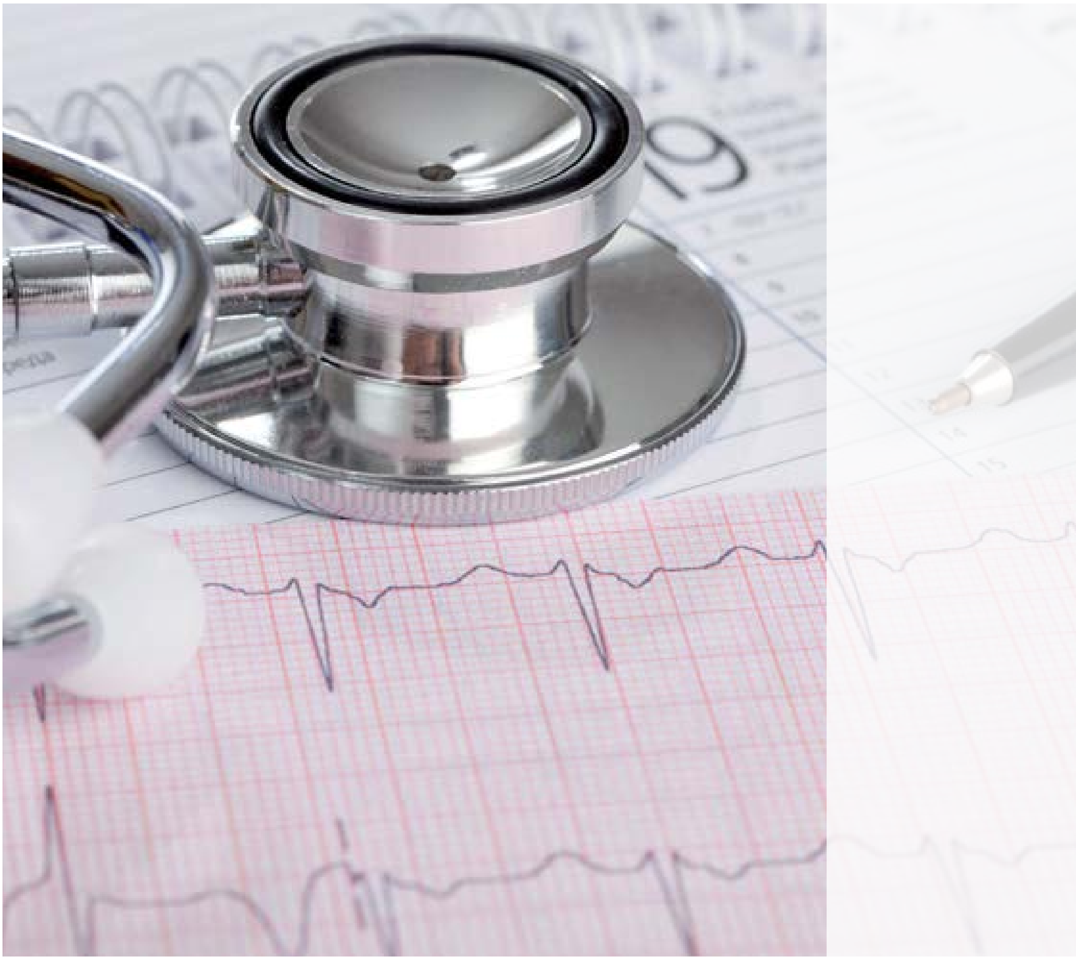
c) In the youth high-performance centres and junior professional football leagues, only medical history, physical examination, blood pressure measurement and a resting heart ECG are compulsory. This is a *basic programme*, which still complies with the most comprehensive current recommendations of the European Society of Cardiology (ESC) and exceeds the most current recommendations of the American Heart Association.

Further tests can be performed if medically indicated.

Preventive medical check-ups should be particularly sensitive to detect signs of dangerous illness early. Such signs are best found in the tests listed in c). These include suspicious complaints (e.g., unexplained fainting, heart palpitations, chest pain or breathlessness during exertion), information regarding the medical family history (particularly hereditary conditions and premature cardiac deaths in close relatives), findings during auscultation (e.g., cardiac murmurs) and unusual ECG readings or excessively high blood pressure. The next step is frequently an echocardiogram, if the anomalies can be attributed to heart alterations, because a heart ultrasound is safe, non-invasive and easily available. However, this demonstrates that an echocardiogram is actually an investigative test to be used only once suspicions have been aroused.

This can also apply to the exercise ECG, at least in relation to coronary heart disease (CHD; calcification and narrowing of the coronary arteries). In the case of suspected CHD, you would search for clear ECG changes during exercise *(ST Segment depression)* or typical pains *(angina pectoris)*. However, the exercise ECG is also an unspecific tool for the provocation of cardiac arrhythmia (heart palpitations), which could indicate various heart conditions, not just CHD.

Lab results serve mainly to identify cardiovascular risk factors (blood fats) and also search for deficiencies or signs of organ disease (e.g., kidney disease or diabetes). They rarely detect direct signs of *acute* threats; if they do, it's most likely in the identification of a generalised inflammation (see the following section).



Football players in lower leagues in which eligibility testing is not compulsory should therefore pose critical questions immediately if they experience such complaints. If one of the previously mentioned symptoms is present, a sports medical examination is definitely advisable. As these kinds of risks increase with age, Masters football is an area in which regular preventive medical check-ups are especially recommended.

1.2 MUSCULOSKELETAL SYSTEM

As well as diseases of the inner organs, medical eligibility for football tests must also identify both current and prior complaints and injuries of the musculoskeletal system. Life-threatening illnesses or injuries are fortunately rare in this area.

The primary goal of an orthopedic examination is to identify risk factors for future injuries as well as taking into account existing injuries that would limit football fitness in the short, medium and long term. Previous injuries are an independent risk factor for future injuries. Ideally, medical eligibility tests should reveal weak spots and prevent the first injury by providing specific preventive measures. For this reason, it is a good idea to start conducting orthopedic testing at a young age.

The orthopedic test consists of taking the (medical) history and performing a physical examination of the musculoskeletal system. Further tests such as X-rays, ultrasound or MRI scans are not included in the examination. If necessary, they should be carried out additionally, if medical eligibility cannot be determined by physical examination alone.

The orthopaedic examination should pay particular attention to previous knee or ankle ligament injuries as they can cause cartilage damage and a (permanent) joint instability. The wish to pursue a football career must be carefully weighed against the risk of deteriorating the injury as football is a so-called *stop-and-go sport* involving many sprints, stops and changes of directions, which can worsen symptoms of cartilage damage or joint instability.

Head injuries and concussions in particular should be speficially enquired after. Repeated concussions can lead to permanent damage of cognitive function. The greater the number and frequency of injuries, the higher the risk of damaged brain function.

Muscle injuries are common and tend to reoccur at the same location. Studies have shown that targeted strengthening exercises can reduce this kind of injury, which is why muscle injuries should also be specifically evaluated. The history should also include specific questions on groin, big toe (1st metatarsalphalangeal joint), achilles and patellar tendon injuries as these are among commonly encoutered football injuries. Shoulder and finger injuries deserve special attention in goalkeepers.

CHAPTER 2

THE SICK FOOTBALL PLAYER

Of course, football players can suffer from diverse illnesses, and it would take a whole textbook to cover the topic comprehensively. However, a few illnesses are particularly important due to their frequency or football-specific component. Based on our personal experience, we have selected the following, taking into consideration the fact that players, coaches and support staff often need to take personal responsibility for the management of these illnesses. Serious health problems such as pneumonia or rheumatic diseases are not dealt with here because they require short- or long-term medical treatment that is not primarily sports-medicine related.

2.1 UPPER RESPIRATORY TRACT INFECTIONS (URTI)

The most common illnesses among athletes are upper respiratory tract infections (i.e., head cold), characterised by a combination of sore throat, runny nose, headache, ear ache, general malaise, fever or aching limbs. The player may not always be able to play or train, and it is sometimes hard to make a decision about whether to do so. This decision should be based on the *non-medicated* player, as different medication can suppress the symptoms. The key question to be answered is if the infection is only local (only sore throat, otherwise fit), or the general condition is impaired in the sense of a **generalised infection** (feeling of illness, exhaustion, 'fluey')? If there is any doubt about the answer, a physician should be consulted, or a conservative decision should be made not to play or train.

Both when questioning sick players and in self-diagnosis, symptoms must be assembled and checked, which indicate a **generalisation**: raised temperature above 37° C/99° F (measured underneath the armpit), swollen lymph nodes (players can check this themselves), visible pus in the throat or typical feeling of malaise. It has been proven that a self-critical collaboration of the player-patient is important, as only he can provide reliable feedback on how he feels.

Occasionally, observation alone reveals that the player looks sick, but these are usually those cases that are clear anyway: rest until completely recovered. Should all these symptoms or problems not be present, the infection can be assumed to be local. If the player does not feel too weakened by the other complaints, it is possible to train and possibly even play a match. However, it should be added again that in case of doubt, you should always proceed conservatively. This, of course, applies in particular to non-elite football. Even though in the lower categories players are frequently very ambitious, those in charge should always bear in mind that it is not worth taking health risks just to play in one single match. Without consulting a physician, the safest thing to do is abstain from exercise for the entire duration of an infection.

The **health risks** arise from the presence of pathogens, which are always causes of the infection. In the West, these tend to be viruses more often than bacteria. Other pathogens like fungi, worms and parasites can really be ignored as long as the patient has not travelled to southern or non-Western countries in the weeks prior to the infection. Antibiotics are an effective treatment only for bacterial diseases, but they can only be prescribed by a physician. Conversely, this means that for the great majority of upper respiratory tract infections there is no causal treatment. The only possibility is to treat the symptoms (i.e., to relieve the pain and prevent symptoms from worsening). This can consist of the prescription or use of nasal drops, but also physical measures such as inhalation or just an increase in fluid intake. The feeling of malaise is best combated *with non-steroidal anti-inflammatory drugs* (NSAIDs). Ibuprofen and aspirin are most suitable for this purpose. Antioxidants like vitamin C do no harm, but neither do they help. None of the medicines mentioned (not even antibiotics) lead to a loss of training or match fitness. It is always the severity of the infection that determines whether or not the player can train or play a match.

You can sometimes read in the press that sick players have been isolated from their team-mates or even placed in quarantine in their hotel. This is rarely necessary for the kind of infections that occur in central Europe. URTIs are rarely infectious as long as other people are kept at a minimum distance of approximately one arm's length. The pathogens cannot fly, so you actually need to be coughed on to get infected over a distance greater than an arm's length. Obviously, the sensitivity to infection, meaning the current state of the immune system (unfortunately there is still no reliable way of measuring this), is a key factor that influences the manifestation of an infection. However, in team interactions, it is important to ensure adequate hand hygiene. Not only are gastrointestinal infections are spread via hand contact, but so are other pathogens. For this reason, the shared use of cutlery, hairdryers, etc. with sick team-mates or members of the medical staff should be strictly forbidden. It is also, therefore, a good idea to pack simple and inexpensive hand disinfectants in the team kit.

A clear separation between sick and healthy players is only necessary for very contagious infections or for those with potentially serious complications, such as measles and mumps, and also seasonal flu (for vaccination, see chapter 2.3.1) or variations of it (e.g., swine flu). On the other hand, from a medical perspective, there is very little point in allowing seriously ill players to take part in team get-togethers anyway.

2.2 GASTROINTESTINAL INFECTIONS

The typical symptoms of gastrointestinal infections (or more accurately nearly always intestinal or colon infections: enterocolitis or colitis) consist of diarrhea and possibly stomach aches, usually accompanied by a marked sense of malaise. This usually simplifies the decision as to whether to train or play a match, as the affected player rarely feels up to it. It only becomes more difficult on the return to training. There is not always a clear dividing line between diarrhea caused by pathogens or their enterotoxins (i.e., intestinal toxins formed by bacteria) and those caused by food poisoning. The latter are typically characterised by a very sudden onset and a relatively short duration, rarely longer than two days. This is caused by toxins that have already been produced in the food, which are, therefore, able to act rapidly. In these types of illness, players are very quickly fit again once symptoms have subsided, since there are no or almost no pathogens that could spread inside the body. This also makes infecting other people very unlikely.

However, in most cases, an intestinal disorder is caused by diarrhea pathogens; usually bacteria or viruses, with bacteria being more common here than in URTIs. They either attack the intestinal mucosa and are then also able to enter the blood stream, or they produce in the intestine additionally the previously mentioned enterotoxins. An infection via the *fecal-oral* route is then possible. In such cases, which can occur in a team environment, particular care should be taken with hand hygiene in order to stop it spreading. The assessment of fitness to play is based on the same criteria as for URTIs, which therefore involves determining whether the infection is generalised. Palpable lymph nodes rarely help in these cases, but fever, a feeling of malaise and weight loss are important symptoms that you should watch out for. In the case of symptoms of generalisation or a weight loss of more than 1 kg, caution should be exercised with regard to playing, especially because intestinal infections can cause the large joints, particularly the knee joint, to become inflamed, which is an extremely unpleasant complication for a football player.

The frequently-observed weight loss is also an indication of the most important treatment principle: fluid replacement. For in the days following the end of the infection, the fluid loss caused by diarrhea is usually the greatest obstacle on the road to recovery and normal fitness. As it is very easy to underestimate the extent of the deficiency, it is essential to use scales. (Important: start weighing as near as possible to the start of the illness.) The sick player must also be forced to drink as he can tolerate. Special non-prescription electrolyte solutions can be purchased from pharmacies for this purpose. However, simpler and cheaper mixtures of water and juice or even tea should similarly suffice. The aim should be to lose as little weight as possible. If the patient has the impression that 'it's all just passing through', someone should explain to him that he is mistaken. It will only be difficult in the case of vomiting, which is not uncommon in illnesses transmitted by toxins. People then usually resort to infusions in order to maintain a fluid balance.

At this point, we should emphasise that infusions performed outside the hospital, even for this purpose, are currently on the banned doping list. However, we would like to challenge very strongly the wisdom of such a rule for non-elite players. Under normal conditions (with no vomiting), the oral replacement of fluids via drinking is preferable to an infusion, because it is considerably more effective.

Other relevant drugs are usually more effective at treating symptoms than causes. Priority should be given to drugs that affect intestinal activity. The most well-known is loperamide, which is taken to control diarrhea. Anti-spasmodic drugs like butyl-scopolamin can also be used if this is accompanied by stomach aches or even colic. Note that many gastrointestinal drugs have a side-effect that make them rather incompatible with sports practise in that they can occasionally cause tiredness. However, this is usually not a problem, as training and matches are out of the question while these drugs are necessary.

It is, of course, important to be able to differentiate between other gastro-intestinal complaints (e.g., irritable bowel syndrome, gastritis), which are not contagious, but this is not always easy for a lay person. This is all the more true as the (completely normal and even quite desirable) excitement before important games can often lead to gastrointestinal complaints. In this case, even the otherwise effective differentiation regarding the presence of diarrhea can be misleading. Great excitement is sometimes automatically accompanied by diarrhea as a reaction of the autonomic nervous system, but this is usually not recurring and is not accompanied by a general feeling of malaise. A team physician or physiotherapist who has known the players of a team for many years will be able to assess the symptoms more easily than someone with less experience.

2.3 GENERAL REMARKS ON OTHER INFECTIONS

Of course, respiratory and gastrointestinal infections are not the end of the story; other organs frequently affected in football players are the skin, the eyes and the ears. Although it would exceed the scope of this book to explore all these infections in detail, it is possible to make a few general comments. So the skin, eyes and ears (as well as the nose and throat) are best treated topically due to their accessibility. Ointments, creams and eye and ear drops usually reach the site of infection directly or after a short diffusion course (passing through superficial layers of tissue). It is, therefore, very hard to reach such high drug levels in the desired place using other application methods. If you give tablets or even intravenous or intramuscular injections with the same drugs, the drugs will spread throughout the whole body so that the drug is present (also with potential side-effects) in organs where it is not needed at all.

Although conjunctivitis, ear canal or inner ear inflammations *(otitis externa and media)* and skin infections usually do not present dangerous diseases, they can disturb visibility or wellbeing or occur on stressed parts of the skin (in the shoes, on places where the jersey rubs). Then effective treatment is necessary to ensure complete match fitness. Medical risks that would justify a reduction in eligibility to play are rare, but, if they do occur, the same criteria would apply as for other infections.

If, from a medical point of view, there is doubt as to a player's state of fitness or health risk, a laboratory blood test may be required, particularly to check the blood count (number of blood cells and breakdown according to their function), C-reactive protein (CRP) and liver enzymes AST (GOT) and ALT (GPT). While the blood count can mainly help in making the decision whether an infection is viral or bacterial (bacterial infections often entail a high leucocyte count = *leucocytosis* and *left shift* of the younger cells) and whether the use of antibiotics should be considered, CRP is the most sensitive routine parameter for inflammatory activity in the body. The course of CRP, in particular, can help in the evaluation of training and match fitness.

But even a single increased level is a clear warning of an impending illness, as it indicates that the current infection is obviously not completely harmless. Liver enzymes are raised when an infection has attacked this organ. That is not a good sign and should usually mean no training or game, if there are no other reasons that could be responsible for such an increase (AST rises faster than ALT after intensive workouts and some players; however usually not without a simultaneous distinct increase in creatine kinase = CK). In elite football in particular, infections should usually be assessed by lab tests.

Unfortunately there is no simple lab test result or other simple result that is a reliable indication of a heart muscle inflammation (myocarditis), although this infection is the most serious, because it can cause acute heart rhythm disturbance and, in rare cases, may even be fatal. Some pathogens affect the heart more frequently than others, but this does not usually help evaluate the risk, because the exact pathogen of an infection is rarely known. As animal research findings have shown, under intense physical exercise and the spreading of pathogens throughout the whole body, the danger of myocarditis is heightened, so signs of the generalisation of an infection must always be grounds for questioning fitness to play. In such cases, medical advice should always be sought.

2.3.1 VACCINATIONS

Usually, vaccination practice is based on recommendations from national standing committees (like the STIKO in Germany). Such recommendations are based on economic as well as medical considerations, but not the specific aspects of elite sports or football. In elite football, the usefulness of vaccinations and also the risks involved are greater for players than for the general population. The benefit is increased because

- elite athletes' performance is significantly impaired by relatively mild illnesses that would not cause a member of the general public to be incapable of working;
- the risk of infection for some diseases, particularly respiratory infections (e.g., influenza, measles, chicken pox), is higher in football due to the close contact with opponents and team-mates, though the risk is only slighty increased for blood-borne infections such as hepatitis B or HIV;
- and pathogens that are rare in the general population (e.g., travel infections) can occur quite frequently among elite football players, because many players (and therefore people with whom they come into contact in training and games) spend long periods playing overseas.

It is also true that the possible vaccination side-effects (e.g., local skin reactions at the point of vaccination, pain in the arm or slight fever) are less relevant in the general population but can lead to a drop in performance or even a missed game in elite football players.

For high-level players, live vaccines are recommended against measles, rubella, mumps and chicken pox as well as toxoid vaccines against tetanus, diphtheria, whooping cough (pertussis), influenza, TBE (tick-borne encephalitis), hepatitis A and B. Depending on their situation (e.g., a player who travels frequently or a player originating from an endemic county who makes visits home), a vaccination against yellow fever, polio, typhus, pneumococcal or meningococcal diseases is advisable. A few vaccinations are usually unnecessary:

- Cholera vaccinations, as cholera is a rare disease that mainly occurs in risk areas and in poor sanitary conditions, which do not include match or training venues.
- The rabies vaccination has a relatively large number of side-effects; and in addition, a vaccination after a suspected infection can provide sufficient protection.
- The shingles vaccination is only administered to people over the age of 50, because shingles does not really affect those younger than this. Until now, this disease has not been covered in the scientific literature in connection with sports. This would seem to indicate that it does not play a significant role.

Because unnecessary vaccinations (i.e., via immunity from a previous infection) should be omitted in order to minimise side-effects, a previous **test of antibody titers** (a lab test that measures the level of antibodies in a sample) can be advisable. This is particularly true in the case of the vaccinations with live agents (measles, rubella, mumps, chicken pox) which have more side-effects and also of immigrant players who may have a high likelihood of natural immunity against hepatitis A or hepatitis B, for example.

The timing of the vaccination should be determined so that on the one hand, any side-effects cause as little disruption as possible but yet the immune reaction to the vaccination is not diminished. Side-effects caused by inactivated vaccines (usually local side-effects, very rarely slight fever and swollen lymph nodes) are to be expected in the first two days post-vaccination. Live virus vaccinations may also cause systemic side-effects that do not occur until 10 days post-vaccination, when the pathogen reproduction is at its highest in the body. An appropriate timing for vaccinations that are not acutely necessary would be immediately before a vacation or in the off-season.

Should it be necessary to give a vaccination during a training or match phase (e.g., influenza vaccine), there is no reason not to vaccinate just before a game in order to benefit from as a long a period of time as possible before the next game. It has already been demonstrated that after exercise among leisure athletes, the immediate influenza vaccine does not lead to lower vaccine titers. Likewise, the vaccine titers in elite athletes following the hepatitis B vaccination were identical to those of the general population. On the other hand, the pain reactions in the area of six hours post-exercise were significantly lower than in a vaccination directly post-exercise or in a period of 24-48 hours afterwards. For this reason, a timing of at least six hours post-exercise is preferable.

2.4 ALLERGIES

Allergies are inflammations that are not caused by pathogens. The immune system overreacts, in a way. For this reason, there is no danger of any direct damage to organs not affected by the allergy, not even from intensive exercise. As the game of football puts great stress on the respiratory tract and requires good eyesight, the usual allergic reactions (conjunctivitis; rhinitis = sneezing) can significantly impact playing ability. However, airborne allergens (e.g., pollen), in particular, are almost impossible to avoid in football, so a rigorous anti-allergy treatment is often required. The topical application of drops and sprays is usually preferable to systemic treatment with tablets, because anti-allergy drugs can cause fatigue and exhaustion. Only in the event of allergically-related exhaustion and a serious reduction in general wellbeing a systemic treatment with tablets is preferable. Elite athletes should remember that corticosteroid medication (i.e., cortisone) is on the doping list (only in-competition) when administered systemically, so a TUE (therapeutic use exemption) must be obtained.

2.4.1 BRONCHIAL ASTHMA

The percentage of asthmatics in the German population is around 4-5%. Even though other stimuli may play a role, the allergic component is the most important trigger in the typical age range of an active football player. It is, therefore, usually seasonal, occurring mainly in the spring and summer. Symptoms can usually be sufficiently eliminated and full match fitness restored by the consistent administration of corticosteroid sprays (local "cortisone" to reduce inflammation; red inhaler) as a basic treatment, along with beta2 agonists (blue bronchodilator inhaler) when required or before the game. Despite other opinions, it can be considered a fact that the use of asthma inhalers has no performance-enhancing effect on healthy athletes.

2.5 DIABETES MELLITIS

Whereas type 2 diabetes (also called adult-onset diabetes) is usually associated with obesity, type 1 diabetics (insulin-dependent) are usually younger and slimmer and, therefore, more frequently found on football teams. There are a lot of examples of diabetic elite athletes, including those in team sports. Although the practise of sports complicates the management of diabetes, with a little experience, even matches do not represent a significant risk. Exercise reduces the insulin requirement so that doses should be adapted accordingly. For this reason, a well-trained diabetic football player will tend to suffer from hypoglycemia. As the presence of adrenaline can lead to an increase in blood sugar levels, the opposite is even possible during very intensive exercise. Such a high blood sugar level is known as hyperglycemia. However, this phenomenon is rare and to be found in the case of an insufficiently managed player who goes into a game with a raised blood sugar level.

2.6 MEDICATION

Of course, there are a great number of drugs that cannot be discussed in detail here. But we have chosen the most important ones according to whether they are compatible with or detrimental to the sport of football. Again it should be emphasised that, with the exception of chemotherapy to treat cancer (in these cases the issue usually does not arise) and substances that are subject to the individual sanctions by national doping agencies (e.g., 72-hour suspension after taking systemically administered corticosteroids), the drugs themselves never cause a lack of training or match fitness. It is always the underlying condition that must be evaluated.

2.6.1 PAINKILLERS (NSAIDS = NON-STEROIDAL ANTI-INFLAMMATORY DRUGS)

This drug group is by far the most frequently used and does not need a prescription in most countries. They include Aspirin, Diclofenac (Voltaren, widely used in football), ibruprofen and paracetamol. It is worth noting that as well as acting as analgesics, these drugs also possess varying anti-inflammatory properties, as their name suggests. Assuming that their use is justifiable to reduce pain or to alleviate inflammatory conditions, it should first be noted that these drugs do not cause a problem for playing football. However, as they suppress the body's warning signs, they could lead to a worsening of injuries. They also reduce the symptoms of head colds or similar infectious ailments. This may give the impression that the player is fitter than he actually is, resulting in the abandonment of a natural, cautious approach to an infection.

The occasionally expressed view that painkillers should be on the banned doping list because they could potentially enhance performance by masking pain is mistaken. If they are used by athletes who are not in pain, they do not enhance performance. Also, if they were placed on the banned list, there would probably be an inundation of applications for exceptional permission to treat such banal things as headaches, which could not really be turned down.

2.6.2 ANTIBIOTICS

Antibiotics only help bacterial infections and should, therefore, only be prescribed in these cases. However, this is not what happens in reality, for antibiotics are taken far more commonly and sometimes even used preventively. It has been established that taking antibiotics is never a reason not to practise sport. The only reason would be the underlying infection. So it is incorrect for a player to say 'I can't play because I'm taking antibiotics.' Instead, he should say 'I can't play because my infection is so serious that my physician has even prescribed antibiotics.'

2.6.3 ANTIALLERGENICS

Antiallergenics can cause fatigue and should, therefore, be taken in the evening, even if the latest generation does not cause this side-effect. It is always justified in football players to consider whether a topical treatment may be a more effective treatment with fewer side-effects.

2.6.4 NASAL DROPS AND SPRAYS

Nasal drops and sprays, particularly those containing xylometazoline or related substances, are (too) frequently used by football players. These drugs dry out the nasal mucous membrane if they are used too often. Furthermore, they lead to a certain familiarisation so that without drops or sprays the nose always feels blocked. Occasionally, extra mucous membrane moisturising drugs are even used. The rule is that a blocked nose caused by a head cold should only be treated with nasal drops at night, in order to ensure that the ears and nostrils are pleasantly clear and a sinusitis is avoided. Treatment with nasal drops should cease once symptoms have subsided.

CHAPTER 3

THE INJURED FOOTBALL PLAYER

3.1 HOW OFTEN DO FOOTBALL PLAYERS GET INJURED?

In Germany, roughly 1.5 to 2 million sports injuries occur every year, and 0.5 million of these happen in football. Whether in clubs, schools or in *unorganised sports*, football is always top of the list when it comes to sports injuries. A major reason for the high number of injuries is the sheer number of players. The German Football Federation (DFB) is the largest sports federation in Germany with 6.8 million members, meaning 1 in every 12 Germans is a member of this organisation.

There are two different types of sports injuries: Traumatic injuries are caused by a single identifiable event such as stepping into a hole and twisting the ankle. On the contrary, overuse injuries are provoked by repeated small, so-called microtraumas. The single injury itself is not a problem, however, as they happen repeatedly, at some point they exceed a *critical limit* and then become symptomatic. (Think of the analogy of a few extra drops of water causing a full bucket to subsequently overflow.) They are also called *chronic injuries*. A typical example is the irritation or overuse of the patella tendons (known as patella tendonitis, see chapter 3.6.2, page 77).

Accident-related injuries are by far the most common in football, making up 66 to 84% of all injuries.

3.2 WHERE DO FOOTBALL INJURIES OCCUR?

Of football injuries, 60 to 90% affect the lower extremities. In children and youth players up to the age of about 14, as well in adults over the age of 50, arm and shoulder injuries (up to 43%) and head injuries (up to 20%) are also common. In the younger age groups, collisions during tackles and uncontrolled falls are the main proposed causes. Falls are also considered a major injury risk in older football players due to their often reduced flexibility in combination with an impaired ability to support the fall.

The knee and ankle joints and the thigh muscles are the mainly affected body parts. 16-33% of the injuries tend to occur in any of those regions. Some studies report an even higher proportion of ankle injuries of up to 67%. The **top three football injuries** are knee and ankle ligament injuries as well as thigh muscle injuries, as they are common and require the longest break from football training. Injuries like bruises, blisters or grazes may well happen more often but rarely require a long break.

Tab. 1: The top three football injuries

Injuries	%
Thigh muscle injury	24-26
Hamstring injury	12
Ankle ligament injury	9-12
Knee ligament injury	11
Anterior cruciate ligament	5

The hamstring muscle is the most vulnerable to injury. In European professional football, every team will suffer about five hamstring injuries per season. This results in a total of 90 lost days or 5 missed matches (all thigh muscle injuries: 15 per season, 270 lost days, 45 missed games). Professional English football players together miss on average 133 days (22 games) per season due to ankle ligament injuries. In the premier German women's league, there is an average of one anterior cruciate ligament rupture per team and per season.

3.3 WHY DO FOOTBALL INJURIES OCCUR?

Risk factors exist for sports injuries. An independent risk factor for injuries is a prior similar injury. This particularly applies to the top three football injuries mentioned above: injuries to the knee and ankle ligaments and hamstring muscle injuries.

Furthermore, the injury risk during a game is higher than during training. The ratio in German pro football is approximately 9:1, for example.

Risk factors can be roughly separated into external (extrinsic) and internal (intrinsic) factors. External factors act from the outside onto the player, so the surrounding environment is key. Internal factors can be found within the player. Both factors comprise suggestible and non-suggestible aspects. Suggestible factors are particularly important in the light of injury prevention. There is usually no one single risk factor, but a combination and interaction of different points is responsible. Several players will usually hit a hole in the pitch during a game, but it will cause only one of them to twist his ankle and injure himself.

The hole in the pitch is not responsible for the injury; otherwise, all the players who stepped in the hole would have suffered injuries. Typical examples of risk factors are listed in the following table. One risk factor stands out, which is a previous similar injury. This can increase the risk of a new injury—a new ankle ligament injury or a new muscle injury of the hamstring by up to a factor of six, for example.

Tab. 2: External and internal risk factors for injuries

External (extrinsic) risk factors	Internal (intrinsic) risk factors
	Prior (similar) injury!
Training error	Deformity (e.g., bowed- or bandy-legged)
Playing surface (cinders, artificial/grass pitch)	Difference in leg length
Kit (boots)	Muscle imbalance, weakness
Environment	Lack of flexibility
Weather	Gender, age
Nutrition	Psychology
	Body composition (musculature, fat)
	Other: hormones, genetics (inheritance), metabolism

In scientific studies, the risk factors are further divided into other subgroups. More on this in chapter 4, Injury Prevention.

Friction between the playing surface and the shoe is an important external risk factor. Football players look for as good a grip as possible between shoe and ground. However, this can increase the injury risk: If movements are abruptly stopped, even more powerful forces are exerted. In the past, the use of particularly blunt artificial pitches and sports hall floors caused a higher injury rate as compared to natural grass pitches.

The risk on the new generation of artificial pitches is now similar to that of grass.

A certain **cleat arrangement** was made responsible for an increased number of anterior cruciate ligament injuries, particularly in women. Cleats were arranged perpendicular to the running direction in the ball or middle of the foot, but this has now been changed as a result. Also a defective or old shoe, one with worn-down studs, can contribute to an increased injury risk, as this makes stopping more difficult or even impossible and can cause collisions, as can sliding on icy, snowy or wet pitches. A poorly-fitting shoe (kids' shoes bought with room for the feet to grow) can also cause problems because of the lack of stability.

Correctly-sized **shin guards** offer protection from the bruising and grazes that can typically occur in tackles. Furthermore, they also offer some protection against shin fractures. The current trend in shin guards is moving in the opposite direction, though—the smaller the better, which from a sports-medical perspective, is alarming. A lack of 'feel' for the ball with regular-sized shin guards is regularly cited as a reason for not using them. A lifelong user of regular shin guards will be less inclined to heed this point of view, and the foundation for this should be laid at an early age. Ankle protectors are also recommended from a medical point of view, although here the argument of reduced feel due to the protection is (more) understandable, as the foot is the football player's real tool.

Jewelry has no place on the football pitch. This applies to training and games alike. According to FIFA regulations, the wearing of jewelry is banned. Jewelry includes wrist watches, earrings, necklaces, rings, piercings (including abdominal, tooth and tongue piercings) and hair clips. Jewelry increases the risk of injury for the wearer and those around him. Taping over it is not a safe alternative. A ring that cannot be removed or cut off should the fingers swell up following an injury can, in the worst case scenario, cause the loss of a finger. Catching an earring can lead to the (partial) loss of an earlobe, to cite just a couple of drastic examples.

When wearing **accessories**, such as bandages, orthèses, facemasks, glasses (sports glasses or contact lenses are a must) and (plastic) casts, make sure that they have no hard or sharp edges that could increase the risk of injury. Bandages should not be fastened with (metal) clips; tape is a possible alternative. Before a game, any accessories should checked by the referee.

A healthy **diet** is essential for physical and mental performance. For example, carbohydrates (sugars) are the primary source of energy for the muscles and brain. An (acute) deficiency can result in a loss of strength, increased fatigue protracted recovery and also a deterioration in co-ordinative skills. (You can read more about nutrition in chapter 7.)

Leg axis deviations alter the normal load distribution. For example, bow legs increase the pressure load on the inner (medial) knee joint cavity. The latter should be avoided, particularly if there is existing damage to the inside of the knee joint (e.g., meniscopathy or operation with [partial] removal of the medial meniscus). Insoles that raise the outer edge of the shoe can help in these cases. Conversely, knock-knees increase the pressure load on the outer (lateral) knee joint cavity, amongst other things. Damage, existing or new, to the lateral meniscus increases the problem. Insoles that raise the inner edge of the boot are required in this case. Good muscular control of the knee joint is an important additional measure in both cases.

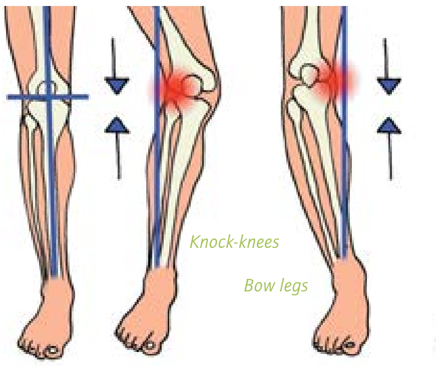


Fig. 1: Knock-knees and bow legs with associated increase in stress

Leg length differences, particularly if greater than 1 cm, can cause an unphysiological load. A leg length difference can be temporary or permanent. This should be investigated by a physician or a physiotherapist. In the case of a structural difference, one thing that usually emerges from detailed questioning is that when walking on one side, the shorter leg treads on that trouser leg, and here the trousers wear out more quickly.

In the case of structural shortening, such as a length difference of the femur, it may be advisable to wear a shoe raise, depending on the extent of the medical condition. If a shoe raise is used, make sure that the heel does not slip out of the boot. The acceptance of insoles in football is often limited regardless of whether the insole contains a shoe raise. This is usually due to the changed, unfamiliar fit ('slips out of the shoe', 'squeezes', 'no more feel when kicking the ball'), which usually disappears after a few weeks with the help of an orthopaedic technician (with a particular interest in sports) and a suitable familiarisation phase.

3.4 FIRST AID FOR FOOTBALL INJURIES

The first aid measures in an (acute) football injury follow the PRICE sequence:

P = Protection
R = rest
I = ice
C = compression (e.g., with a pressure bandage)
E = elevation

Protection could be achieved e.g. by the use of crutches, bandages or tapes.

The R means **rest** from any activity that could worsen the injury.

Instead of actual **ice**, you should ideally use ice-cold water (a mixture of ice cubes and cold water) at a temperature of 4 to 8° C. It should never be placed directly onto the skin as this can cause frostbite. For the same reason, the ice should not be left on for longer than 15 minutes. In the first 72 hours, ice should be applied regularly, although there are no hard scientific studies that prove the effectiveness of icing, particularly over several days. In acute cases, icing dampens the pain in nerve pathways so that it is not felt so strongly. Also in acute cases, icing causes the blood vessels to contract (vasoconstriction), which reduces swelling. However, this cooling phase is followed by a reflex expansion of the blood vessels (vasodilation), which counteracts this effect.

Compression causes a mechanical reduction of the swelling. It is recommended for all acute injuries where swelling is involved. The swelling arises when an injury damages blood or lymph vessels and their fluid can escape. Furthermore, in the case of an acute (and chronic) injury, running repair mechanisms (inflammation reactions) are also involved, causing a fluid discharge and an increased vascular permeability amongst other things. It is most important for compression to take place quickly, in the first minutes after an injury. It should be done as soon as possible in order to minimise the amount of swelling. In the case of a typical twisted ankle, a foam pad cut into a J or U shape and fastened tightly is ideal. But even pressure created by normal bandages from the first aid kit or from socks are better than nothing. During compression, make sure that sufficient blood is still circulating to the feet and hands. Any loss of feeling or increasing pain, if the limbs turn blue, white or cold, the compression is too strong and must be reduced and possibly redone less tightly. The compression should, if possible, be left for at least 24 hours. If there is still swelling after that, the compression should be continued until it has disappeared. For this you can use compression socks or compressing bandages. The use of kinesio tape (lymphatic technique) is also recommended.

Elevation means raising the injured part of the body above heart height in order to reduce the swelling and accelerate the elimination of metabolic products. Swellings obey the law of gravity, which is why, for example, after an ankle injury, bruising and swelling can spread throughout the foot if no countermeasures are taken. In this type of injury, the affected player is typically laid on the ground and the affected ankle rested on a bench, bottle crate or similar. It is important to not bend the knee to avoid restricting the blood and lymphatic vessels in the hollow of the knee. In the case of injuries below the elbow joint, avoid a bent position of the elbow for the same reason. Actively holding up the injured arm is an effective method, so is laying the patient on the ground with the injured part of the body raised, if necessary. Elevation is advisable as long as the swelling exists. This could be as long as several weeks.

3.4.1 BONE FRACTURES AND DISLOCATIONS

In the case of a (suspected) bone fracture or a (suspected) dislocation, if the player is in (a lot of) pain or is unable to walk or stand, an ambulance should be called. In such cases, the injured player should be made as comfortable as possible without being moved too much. In addition, care should be taken that the player suffers no further injuries because he is lying in the way. Stop the player from getting cold and wet, especially if he is sweating and the ambient temperature is low. If possible, these injuries should already be immobilised on the pitch or in the gym. A triangular bandage can be used for injuries to the shoulder and elbow joints. It is much harder to immobilise the lower extremities. The player should not put any weight on the affected part of the body. He must either be supported or use crutches or even a wheelchair, if they are available. Caution is essential if the player is not used to walking with crutches. Additional treatment should then be in line with the advice of the attending physician.

3.4.2 OPEN WOUNDS

Gloves should be worn when treating open wounds. They should be disinfected (preferably with a non or only slightly stinging disinfectant spray), cleaned and then covered with a sterile, non-sticky wound dressing. Self-adhesive bandages or (closed) tube bandages are recommended to secure the dressing. Plasters are not usually sufficient by themselves as the skin will usually be sweaty and wet. Players with bleeding wounds should not be on the pitch until they have been adequately treated and dressed, as they represent a potential source of infection for the affected player and for all the other players and officials on the pitch. Make sure that tetanus vaccinations are up to date (i.e., every 10 years for adults and every 5 years for children). In the case of larger, open wounds, this should be done more often for all age groups. Larger lacerations or deep cuts should be seen by a physician and may need stitches.

3.5 BASIC INFORMATION ABOUT DIFFERENT INJURIES

3.5.1 SOFT TISSUE INJURIES

BRUISES

Bruises arise from a blunt force, such as a kick, hit, fall or pulled thigh muscle. Pain, swelling and the formation of a hematoma are typical consequences. First aid treatment should follow the PRICE model. In the case of more severe bruising, the player should rest.

BURSITIS

Bursae are fluid-filled sacs that service to reduce friction mainly between bones and tendons over bony protuberances. They are most commonly found in the knee joint but are also in the vicinity of all large joints (hip, foot, elbow, shoulder). In football, it is mainly the bursa in front of the patella and the one at the back of the elbow that are affected by a direct fall. Elbow pads can protect goalkeepers from this kind of injury.

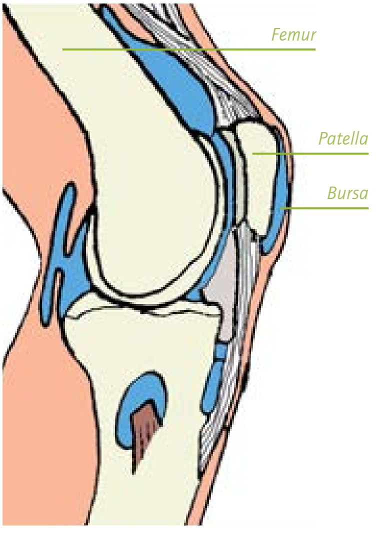


Fig. 2: Bursa at the knee joint

3.5.2 BONE INJURIES

FRACTURES

Fractures can be caused by direct (e.g., a step on the foot) or indirect force (e.g., falling on an outstretched hand resulting in a fractured collarbone). Typical results of a fracture are listed in box 1.

When a bone fracture occurs close to a joint, there is a danger that the joint cartilage will also be damaged (see also cartilage injuries, page 57). This can then lead to premature wear and tear. A high mechanical force is usually required to cause a fracture, so concurrent injuries to the surrounding tissue (muscles, tendons, blood vessels and nerves) should also be expected. The therapy of fractures requires weeks of mechanical rest. Depending on the location of the fractures, plaster, splints or taping may be used. If activity is resumed too soon during the healing process, the bone will heal more slowly, or possibly not at all.

FRACTURE

- Local pain
- Pain on palpation (local tenderness)
- Hematoma (bruising)
- Swelling
- Restricted movement

DEFINITE FRACTURE SYMPTOMS

- Deformity
- Visible bone ends (open fracture)
- Abnormal flexibility at the fracture gap
- Crepitation

Box 1: Fracture signs and symptoms

Fig. 3: X-ray of fracture of the third metatarsal, right foot

STRESS FRACTURES AND BONE BRUISES

Stress fractures are overuse injuries caused by an imbalance between the load placed on a bone and its loading capacity (e.g., a sudden increase in training volume from two to five sessions a week). They typically affect the metatarsals, the tibia and fibula. In 50% there is a gradual onset of the injury, in the other half the injury starts acute with sudden pain and swelling. An X-ray may not pick up on the early stages of the injury, therefore an (additional) MRI scan should be performed if a stress fracture is suspected.

a *b* *c*

Fig. 4: X-ray versus MRI scan of stress fracture of the right tibia

A preliminary stage of stress fracture is known as a **bone bruise**. This can also accompany other infuries (e.g., a torn anterior cruciate ligament). In the case of a bone bruise, the fluid content of the bone is increased. This can only be seen in an MRI scan, not in an X-ray. Stress fractures, like bone bruises, require rest and restricted or maybe even no load bearing. The adaption of the load bearing, which has to be pain-free at all times, is the main therapeutic goal. Depending on the severity of the injury, sometimes all that is required is a change in the type of exercise (e.g., cycling instead of running). Serious cases may occasionally require lengthy treatment, including offloading with crutches and immobilisation in a plaster. If the bone does not repair itself, occasionally an operation is required to stabilise it.

Fig. 5: MRI scan of bone bruise of the right tibia

3.5.3 MUSCLE AND TENDON INJURIES

Muscle injuries are divided into different groups, using a variety of classifications, and are essentially differentiated into *functional* and *structural* muscle injuries. *Functional muscle injuries* are caused by muscle overuse and describe muscular lesions that can only be identified through microscopic analysis (i.e., the removal of a tissue sample and subsequent examination under a microscope). Functional injuries include muscle cramps, soreness, stiffness and strains (pulled muscle).

Structural injuries, on the other hand, can be seen in ultrasound or MRI scans. Structural injuries are more serious than functional ones.

FUNCTIONAL MUSCLE INJURIES

Muscle soreness usually occurs with a delay of one to two days, particularly after unaccustomed exercise. A typical example is the first football training session after the six-week summer break. There is no immediate pain. Muscle soreness usually lasts two to three days, and in rare cases up to five days. The muscle concerned usually exhibits pain on palpation. Recommended treatment is light exercise in the pain-free range.

A muscle cramp is acute and intense. It is associated with a sudden muscular myogelosis that can be felt when touched. The muscle is suddenly shortened due to the cramp. Exercise usually must be stopped immediately and should be ceased thereafter. The pain usually leads to the cessation of the activity anyway. The careful stretching of the muscle concerned, along with gentle heat, are good ways to self-treat.

Dehydration is the main cause of cramping, hence the importance of an adequate fluid intake. Without sports, that equates to roughly 4 pints per day, and with sporting activity, the water lost when sweating must be replaced, plus an extra 10%. An easy way to establish the amount of fluid lost during exercise is weighing immediately before and after the workout or game. If cramping is a regular problem, other measures may need to be taken. For example, the training intensity, volume and frequency should be reviewed. This is a particular arrangement problem for young (female) players, as they may sometimes be part of up to four teams simultaneously (girls, youth, regional and national youth teams). Mineral levels, acid–base balance and tooth condition can be checked in the case of frequent cramps. It is rare to find anything obvious here, though. Care should be taken with regards to the inconsiderate consumption of (excessive amounts of) magnesium. Magnesium can occasionally cause an iron deficiency, as magnesium competes with iron for absorption into the body. Apart from this, magnesium can also cause diarrhea.

Both muscle soreness and cramps usually heal with no lasting consequences.

Muscle stiffness occurs during or immediately after exercise. The player can usually identify exactly which part of the muscle is affected. Players complain about pain and local muscle tightness. The muscular tension is palpably higher. Furthermore, the spot is painful to touch. In the case of muscle stiffness, it is possible to carry on exercising in the pain-free range (e.g., gentle cycling or jogging). Other treatment options are similar to those for muscle cramps. Care should be taken during the return to full training and match playing; the principle of freedom from pain should absolutely be adhered to, in order to avoid serious muscle injury or to avoid prolonging the recovery process.

A sudden, pulling pain sustained during exercise which still allows exercise to be continued despite some pain is a sign of a **pulled muscle**. A localised increase in muscle tension in the affected area can be felt; it hurts to contract the muscle. Subsequent exercise should only take place in the pain-free range. Physiotherapy (including electrotherapy) can also be used. There is a smooth transition to a muscle tear, and the risk of worsening the injury to a muscle tear means that care is required when resuming full sporting activity.

Common to all four aforementioned injuries is that they usually heal without further consequences and that they are not visible in the commonly used imaging modalities, like ultrasound and MRI scans. This is not the case for muscle bruises, muscle tears, muscle bundle tears and musculo-tendinous avulsions, which are detectable in images when viewed by an expert.

STRUCTURAL MUSCLE INJURIES

Muscle bruising is caused by a blunt force, e.g., due to a collision between knee and thigh, leading to bruising as well as pain. Muscle function is reduced by pain. First aid treatment includes the PRICE model, with a compression bandage being the more important measure. Heparin ointments should be avoided in the first two to three days, as they increase the risk of (secondary) bleeding. Kinesio tape (lymphatic technique), physiotherapy (lymph drainage) and, if necessary, puncturing the bruise ('extracting' the blood with the syringe) are other possible treatments for more severe injuries. Directly massaging the bruise location is not recommended, as this can cause calcification in the muscle that permanently restricts muscle function.

Muscle tears are further subdivided according to the extent of the muscle injury. They have in common a sudden sharp pain and that the activity must usually be stopped immediately. A more severe muscle tear may cause a sudden fall in full movement. Active contraction and stretching of the muscle is painful. If the affected muscle lies superficially, a dip or hole can be felt or sometimes even seen. If there is reason to suspect such an injury, a physician should be seen quickly. The use of crutches can be considered for a while. Physiotherapy treatment is recommended. Subsequent (excessive) scarring of the injury should be avoided. Scar tissue restricts muscle function and power. It also increases the danger of another injury in the same place. Regular ultrasound monitoring is advisable. Four to six weeks of rest (even months in the case of a total rupture) are common. Do not resume training too soon in order to enable the injury to heal properly.

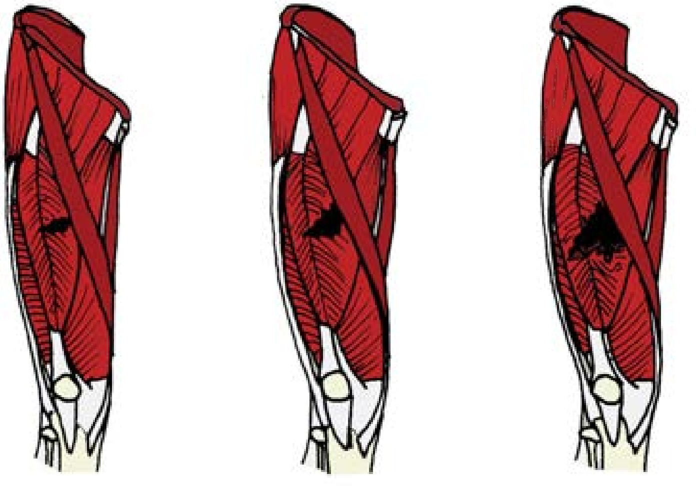


Fig. 6: Different degrees of severity of structural muscle injuries, using the quadriceps muscle as an example

On the spot, and shortly after the injury, it is occasionally impossible to make an accurate diagnosis. The type (sharp, pulling), intensity (exercise possible or impossible) and the timing of the occurrence of the pain (immediate, delayed) can help to diagnose the underlying injury. The following muscle tests can be carried out:

- **Active contraction:** e.g., quadriceps muscle: sitting position, thigh completely supported by the table, knee joint bent, request to straighten the knee joint.
- **Resistance testing:** e.g., quadriceps muscle: starting position same as for active contracting. Provide resistance with the hand against the lower leg near the foot, and then request to straighten the knee joint while gradually increasing the resistance.
- **Stretching:** e.g., quadriceps muscle: lying prone, legs straight, the athlete pulls his heel towards the buttocks.

Fig. 7: Resistance testing of the quadriceps muscles in the sitting position

If the muscle tests are pain-free, then walking and finally gentle (straight-line) jogging can be tested before increasing the pace and trying changes of direction, as long as there is no pain. Then football-specific movements follow, adding a ball and then an opponent. Only one component should be changed at a time, either the pace is increased or a new element is added.

Especially if, as is usually the case, no imaging process has been used (e.g., ultrasound), the extent of the injury can only be accurately assessed with time. If three days after a sharp pain in the muscles the player is able to return to play pain-free, then it is extremely unlikely that the injury was a tear.

3.5.4 JOINT INJURIES

Joint swelling (joint effusion), pain, locking, misalignment, a reduced range of motion or signs of acute inflammation can all indicate a joint injury.

Joint dislocations are rare, but serious injuries. Great force is usually required for these injuries to occur. In the case of a dislocation, the contact between both parts of the joint is lost. Box 2 contains typical dislocation signs and symptoms. Spontaneous relocations are possible, however, if that does not happen, a physician should be seen as soon as possible.

DISLOCATION: SIGNS AND SYMPTOMS

- Local pain
- Pain on palpation
- Swelling or articular effusion
- Restricted flexibility

DEFINITE DISLOCATION SIGN

- Joint misalignment

Box 2: Signs and symptoms of a dislocated joint

All dislocations should be seen by a physician as they entail a risk of associated ligament, muscle, tendon, bone or nerve injuries. Long-term consequences can include premature joint wear and tear and a permanent instability (sometimes with repeated dislocations even in everyday movements). An adequate diagnosis and treatment is, therefore, very important, even if 'only' a finger joint is affected.

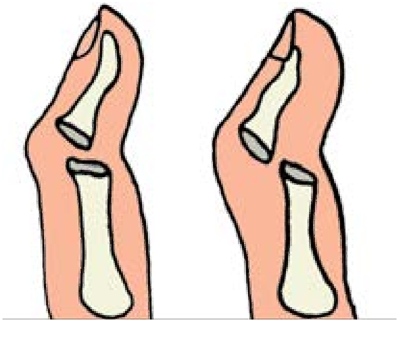


Fig. 8a: Subluxation   Fig. 8b: Luxation

Partial (8a) and complete (8b) dislocation of the thumb joint (schematic)

Cartilage injuries can be acute or chronic (long-term injuries called **arthritis**). Twisting a joint or fracturing a bone near a joint can cause an acute injury. Previous injuries or an *idiopathic wear and tear* (unknown cause) can be responsible for the long-term damage. Cartilage injuries do not heal well and are problematic for this reason.

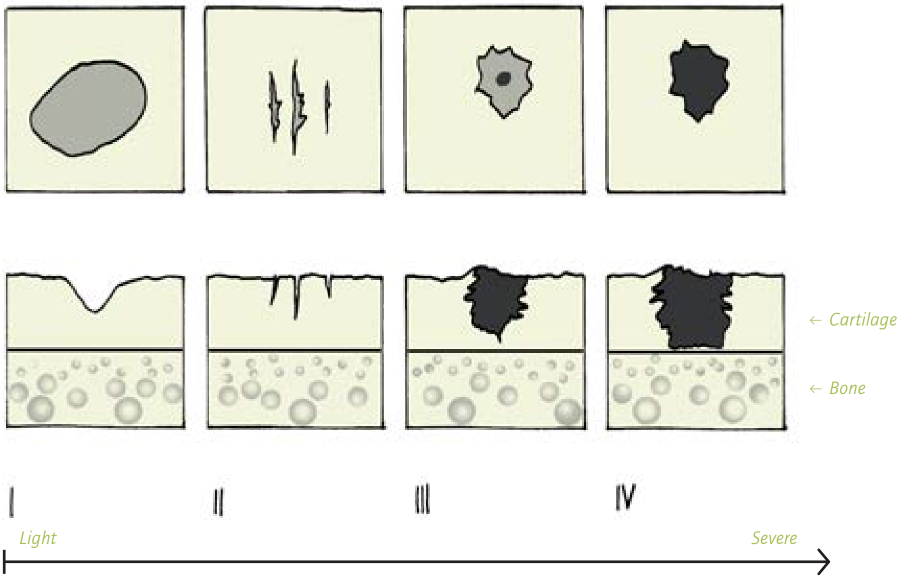


Fig. 9: Different degrees of cartilage injury viewed from above and from the side

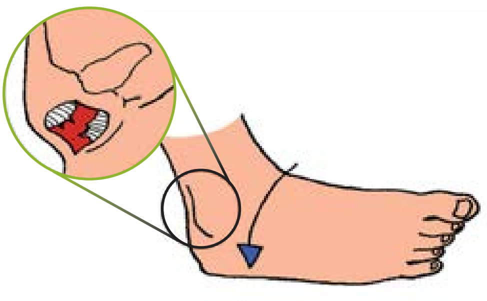


Fig. 10: Lateral ligament injury in the ankle (schematic)

Ligament injuries occur when the tension exceeds the tensile strength of the ligament. A typical injury mechanism is twisting the foot or ankle (see figure 10).

While the muscles are responsible for active joint stability, the joint capsule and ligaments are responsible for passive joint stability. In addition, the ligaments contain proprioceptors (sensors) that give the central nervous system information about the joint position, forces and movement direction. A ligament injury can cause this information to be lost. After an injury, this must be relearnt, through balance training, for example, ideally under the instruction of a physiotherapist, at least initially. More severe injuries result in an instability of the joint that can go unnoticed by the athlete, which is why any suspected ligament injury always requires a visit to the physician.

If these injuries are not treated properly, there is a risk of permanent joint instability. One consequence of this can be premature wear and tear *(post-traumatic arthritis).* It only occurs years or decades after the actual injury, but can lead not only to retirement from sports but also to significant handicaps in everyday life. First aid should follow the PRICE model. Depending on the extent of the injury, it should then be treated with either bandages or orthosis. An operation may be necessary in severe cases.

3.6 INJURIES BY BODY REGION

3.6.1 HEAD INJURIES

Head injuries typically occur in the context of tackles, particularly in header duals. In the case of all head injuries, the first thing to look out for is concussion (more detail on concussions on page 60).

Head lacerations are among the most common head injuries in football. They should be treated the same as other open wounds. They should be disinfected, cleaned and then covered with a sterile dressing. A pressure bandage (e.g., turban) is usually advisable, as the scalp is rich in blood vessels and can, therefore, bleed heavily. Larger wounds must be stapled or stitched, and signs and symptoms of concussion should always be watched out for. Whether the player can carry on playing depends, among other things, on the size and location of the head wound and on the existence of associated signs and symptoms. If they are present, the player should stop playing and should be seen by a physician. If a return to the pitch is planned, bleeding must have been stopped and bloody kit must have been changed.

Fig. 11: Turban bandage

A **concussion** is an injury to the brain caused by acceleration. (Short-term) consequences can be physical, mental (cognitive) and emotional disturbances. A loss of consciousness can but need not necessarily occur. Confusion, disorientation, amnesia for the time immediately before, during and/or after the accident, delayed reactions or changes in behaviour (patients appear 'spaced out', 'strange', 'slowed down') can (co-)exist.

Tab. 3: Concussion signs and symptoms

Physical symptoms	Mental, emotional change
Headaches	Emotional instability
Dizziness	Increased irritability
Nausea	Aggression
Vomiting	Passivity
Sensitivity to light and noise	Fatigue
Impaired vision	Sadness
Sleep disturbances	Fear
	Confusion
	Disorientation

Players who have a suspected concussion should not be left alone. If such an injury is suspected and the player is unconscious, first check whether the breathing and cardiovascular system are functioning. If not, the player should be resuscitated. If the player does not react when spoken to or touched, he should be pinched so that it hurts. Unconscious but breathing players should be moved onto their sides in the recovery position, with their upper body slightly elevated, if possible. Particularly when a player's consciousness is clouded, the possibility of other injuries should be considered, especially if there is a subsequent fall. Do not just concentrate on the first, most obvious injury. Due to the trauma mechanism alone, the cervical spine deserves special attention irresepective of an ensuing fall or not (see chapter 3.6.4, Spinal Injuries, page 89).

If a concussion is suspected, e.g., due to the mechanism of the injury, the player should be carefully assessed for it even in the absence of obvious signs and symptoms. Simple questions about the current date and place, personal data and the course of the accident are a starting point. If the player is able to answer these satisfactorily, more difficult tasks should be set, such as counting backwards from 19 or doing some maths. At this point, it is also important to ask about previous head injuries. Should the player have suffered one in the past three months, he should not continue to play, even if he does not display any signs or symptoms. If there are no obvious signs or symptoms they might be provoked by a brief physical test of oncreasing intensity (e.g., standing on one leg, jumping in place, short sprints).

In the case of suspected concussion, sporting activity should be stopped immediately and a physician's opinion sought. Resuming football or any physical activity the same day is out of the question, even if any signs and symptoms have disappeared after a few moments. It is subsequently allowed if

- there are no more signs and symptoms in everyday life;
- there are no more mental (cognitive) deficits present;
- physical activity does not provoke any signs and symptoms; a short provoking test is advisable (e.g., 5 push-ups, 5 squats, 5 jumping jacks and 5 sit-ups), and
- approval from appropriately qualified medical personnel has been given.

The return to playing football should be gradual, with increasing intensity. Moving on to the next stage is only allowed if there are no signs and symptoms at the current stage. The rest between each stage should be at least 24 hours, but could also last days, weeks or months depending on the individual's course. The following return schedule has been recommended by a commission of experts on the topic of concussion in sport:

- No activity (physical and mental)
- Light aerobic activity: walking, swimming, bike ergometer with less than 70% maximal heart rate (HRmax), no strength training
- Sports-specific exercises: running drills, dribbling with the ball, no heading
- Training with no tackling, more complex than in stage 2 (e.g., passing, different types of kicks); still no heading and it's possible to start strength training
- After medical approval, full training, including heading and tackling
- Return to match play

Other time guidelines apply in the case of repeated incidences of concussion. In the event of a second incidence of concussion within three months, the player should rest for at least four weeks and for three months, if there have been three incidences within a year.

Risk factors that delay recovery include:

- Previous concussions: the higher the number, the shorter the gap between injuries and the longer the duration of symptoms, the higher the risk
- Symptoms: the higher the number, the more pronounced and long-lasting the problems
- Loss of consciousness > 1 minute
- Age: child, youth, young adult
- Pre-existing illnesses: migraine, depression, anxiety and panic attacks, attention deficit disorder, learning difficulties

Long-term consequences of concussion can be protracted physical problems. In addition, mental capacity, sensitivity, speech and mood can be negatively affected. Progressive 'wear and tear' of the brain, which usually manifests itself decades after the actual injury, is a known possibility. It can involve an increasing loss of short-term memory and capacity for action, even mood and behavioural anomalies through to depression with suicidal thoughts.

A concussion may well be considered initially in the event of a head injury, but often not thoroughly diagnosed as such and, therefore, not properly treated. This is unacceptable in view of the possible serious consequences.

Unlike a concussion, a **contusion to the head** ("head knock") only hurts at the place of collision (pain, swelling). There is never a loss of consciousness. In order to contain the swelling, a compression bandage can be used. Icing is also a short-term option. It is sometimes not so easy to differentiate between concussion and head contusion. If there is any doubt in the event of a head injury, you should always start by assuming the more severe injury and take the necessary measures.

Bone fractures to the head usually affect the face, most frequently the nose. Nose bleeds and a swollen or misshapen nose can result. Nasal breathing may also be hindered. If such an injury is suspected, an ear, nose and throat specialist should be seen who can realign the nose, if necessary. It takes about four weeks for the bone to heal. Despite the injury the player might still be able to play, e.g., due to the use of a face guard. The physician in charge is responsible for this decision. A nose plaster only offers limited protection in football, however.

Aerial duels or elbow checks are typical causes of a **broken cheekbone**. There is pain on palpating the fracture point and usually a more or less pronounced swelling. Among other things, the cheekbone forms the bottom of the eye socket. If the bone is broken at this location, it can result in restricted eye movement if eye muscles are trapped. This is why, when looking upwards, the patient may see double, and he should, therefore, be asked to move his eyes in all directions while keeping his head still.

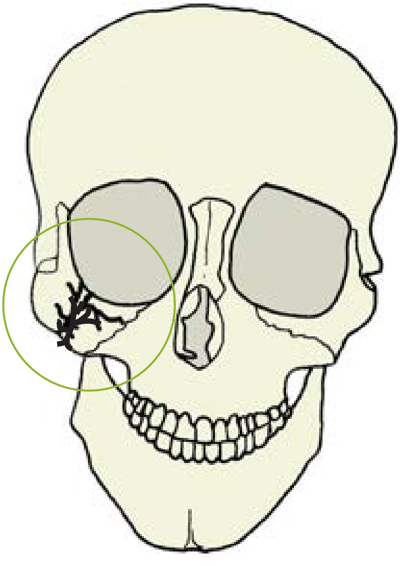


Fig. 12: Broken cheekbone right

The cheekbone also forms part of the jaw, so chewing may also be problematic. A nerve may also be trapped, which provides sensitivity for the skin below the eye (on the cheek). This can be tested by carefully touching the skin in this area and asking for a reduced or a lack of sensitivity as compared to the opposite side.

NB:

A fractured bone and a concussion can co-exist!

Box 3

At the slightest suspicion of this injury, an oral and maxillofacial surgeon should be consulted and asked whether an operation is necessary. Healing time is six to eight weeks. There are specially-prepared face masks that enable a return to football training sooner than this, but this should be agreed with the (team) physician in charge.

3.6.2 LOWER-BODY INJURIES

BONE AND JOINT INJURIES

Bone fractures mainly affect the toes, metatarsals and lateral malleolus. Lower-leg fractures are also possible. Patellar fractures are rare in football. With the exception of broken toes, a rest of at least six weeks is required, and 12 weeks for the lower leg. After this time, usually weight-bearing is gradually increased, first on walking before allowing a return to running. The return to full sporting performance can take just as long (or even longer) than the bone healing itself. Should an operation be neccessary, implants such as screws or plates may need to be removed months or years later.

Stress fractures are significantly more common in the lower body than in the upper body, due to the greater load on the lower body (it carries the bodyweight). The existence of the female athlete triad should be kept in mind (see also chapter 8, Special Features of Women's Football). This is a combination of an eating disorder, lack of menstruation (amenorrhea) and osteoporosis, which favours the appearance of stress fractures. The metatarsals, the tibia and fibula are most frequently affected by these injuries. Pain on weight-bearing worsening on continous loading of the affected bone is typical. However, they can also present with a sudden pain. Rest respectively off-loading will usually enable a complete recovery by means of conservative therapy. Rest/off-loading must be continued until pain is no longer felt.

Swimming, aquajogging, cycling or cross-training are possible alternatives if running is still painful, in order to maintain general fitness.

Wear and tear (arthritis) is a big problem (not only) for football players. Hip, knee and big toe joints are most frequently affected. The cause of **idiopathic wear and tear** is usually unknown and affects people over the age of 60, in particular. Genetic factors and unphysiological load are possible causes. Obesity is not a triggering factor but can make existing arthritis worse due to the increased mechanical strain. Premature joint wear and tear can be caused by injuries that damage the joint cartilage or joint stability. In the case of an anterior cruciate ligament with no associated injury, premature arthritis must be expected after 10 to 15 years in 20% of cases. If there is a simultaneous injury to the (medial) meniscus (= cartilage disc between the upper and lower leg on the inside of the knee) and medial collateral ligament, the risk increases to up to 80%.

Initially, pain is felt when the joint is loaded. The greater the strain, the harder the training (e.g., frequent changes of direction, sudden stops at high speed), the stronger the pain. Initially, the pain disappears at rest, in more advanced cases it remains. Start-up pain can occur and typically goes away after a few minutes. Pain at rest is quite rare. Joint swelling can also occur. In (very) advanced stages, the affected joint has a limited range of movement. As these develop gradually, they are often only noticed by the person affected very late on. It is then usually teammates who notice an uneven running style or an uneven movement pattern. The evaluation as to whether and to what extent football can continue to be played with this condition should be taken in consultation with a physician. In order to offload the joint, it is advisable to ensure that the muscles around the joint are well developed and that there is good core stability and good single leg balance. Look out for compensatory movements in other joints caused by a loss of flexibility in the damaged joint.

a b

Fig. 13: X-ray of hip joint: Normal hip joint (13a), hip joint with arthritis (13b)

MUSCLE INJURIES

Thigh muscle injuries are amongst the most common injuries in football, and the muscles mainly affected are the hamstrings, quadriceps and adductors. The hamstrings are particularly at risk during sprints, the quadriceps from the instep kick and the adductors from passing the ball. The different types of muscle injuries have already been described in the general section in chapter 3.5.3. Injuries occur either during active contraction and/or passive stretching of the muscle concerned. An injured **hamstring muscle** hurts when the knee joint is bent. This muscle also extends the hip joint so this movement, too, will cause pain. For less severe injuries, these muscles may have to perform against resistance (second person tries to block this movement direction), in order to provoke pain. Stretching can also cause pain. The principle of stretching is to lengthen the muscle. The hamstring can be tested in a standing position (try to touch the floor with your hands with your legs straight) or lying on your back (straighten your legs and raise one of them to the ceiling).

If the **quadriceps muscle** is affected, then it is painful to straighten the knee joint and flex the hip joint. Whether stretching is painful can be tested by lying prone, bending one leg at the knee joint and then pulling the heel towards the buttocks.

The **adductors**, for example, can be stretched in a side lunge. Pain can also be provoked when the player pulls one leg towards the other (best tested when lying down).

If the **calf muscle** is affected, pushing the foot off the floor (standing on tip toes) and stretching in the lunge position will cause pain.

Sometimes a dip can be felt in the muscle. Muscle injuries that do not improve after several days of rest should definitely be seen by a physiotherapist or physician. When training is resumed, no pain should be felt so as not to risk worsening the injury with the possibility of then being out of action for weeks and/or of causing suboptimal healing.

There is a muscle injury unique to children and young people. Muscles are attached via their tendons to bony protuberances (apophyses). In children and young people, these apophyses are still not firmly connected to the bones underneath, and, in addition, the stability of the tendons (and ligaments) is greater than bone stability. This can result in an **apophyseal (avulsion) fracture**. The injury mechanism is the same as in adults, and it predominantly affects the quadriceps muscle, and also the hamstrings and adductors, but the latter two are rare. These injuries can usually be treated conservatively. An operation is rarely required. Traction, stretching or actively contracting the muscle concerned, should be avoided to promote healing. A four- to six-week rest is usually necessary.

Fig. 14: Apophyseal fracture of the right rectus femoris muscle (part of the quadriceps)

GROIN AND HIP PAIN

There are many causes of **groin pain**. The exact location of the pain ('point with a finger') can provide valuable information. Pain that is dependent on movement or on loading point to an origin in the musculoskeletal system, although there are a number of other causes to be considered.

The cause of groin pain can be **muscular**. The adductors, originating at the pubic bone, play an important role. The abdominal muscles, the hip flexors *(iliopsoas)*, the *rectus femoris* muscle of the quadriceps should also be considered.

As mentioned, the muscle involved can be tested by active contraction, against resistance or by stretching. In addition to the tests for the quadriceps, the hamstrings and the adductors that have already been described, tests for the abdominal and hip muscles are described here:

- **Abdominal muscles:** test with straight and twisting sit-ups. Stretching: form a bridge.
- **Hip flexors:** lie on your back with one leg straight. Bend the knee of the other leg, grasp it with your hands and pull it towards your nose. Stretching: a forward lunge with the back leg extended at the hip joint.

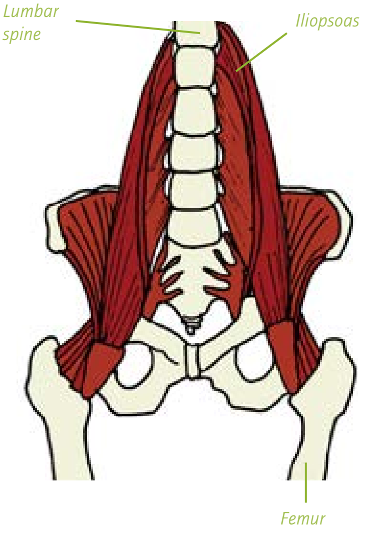


Fig. 15: Hip flexor muscles

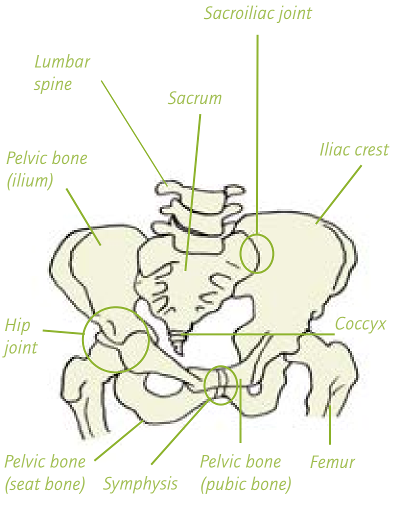


Fig. 16: Skeletal anatomy of the hip and groin region

Injuries to the **hip joint**, the (upper) **lumbar spine**, the **sacroiliac joint** and the **symphysis** (joint of the two pelvic bones at the front of the pelvis) can cause pain in the hip or groin.

In order to further isolate the cause, the relevant **joints** should moved in all three planes first actively (the player himself performs the movement) and then, if necessary, passively (someone else performs the movements, respecting the pain threshold). For the hip joint, flexion, extension, abduction and adduction and external and internal rotation should be tested. The latter can be tested both in extension and flexion. The lumbar spine should be tested by bending forwards, backwards, to the left and to the right right as well as twisting the upper body to the right and left. It is hard(er) for a layperson to test the sacroiliac joint and symphysis. The most practical way is to exert pressure on the sacroiliac joint when lying prone. The treatment is dependent on the cause (see also chapter 3.5, Basic Information About Different Injuries).

The term **ostitis pubis** literally means inflammation of the pubic bone. This is a collective term for pain that is declared at the pubic bone or the symphysis, irrespective of whether a real inflammation exists or not. The pain is initially exercise-related, particularly in the repeated use of the adductors (passing with the inside of the foot, changes of direction, slide tackles). Later on, pain may also be felt at rest. A true ostitis pubis can first be identified by means of imaging (X-rays or especially MRI scans).

a *b*

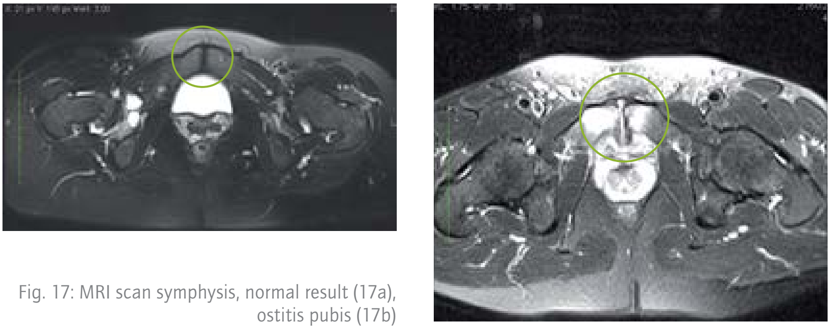


Fig. 17: MRI scan symphysis, normal result (17a), ostitis pubis (17b)

However, before using imaging modalities, a thorough history should be taken followed by a detailed clinical examination in order to exclude other diagnoses. The therapy is often not very different to that for sportsman's hernia (see page 73). It involves compensating for muscular imbalances and strength deficits of core muscles and those attached to the pelvis (hip adductors versus abductors, hip flexors versus extensors, internal versus external hip rotators, abdominal muscles). Naturally, the entire functional movement chain must also be included in the treatment (e.g., foot position, (one) leg balance, leg alignment). The injury is often slow to heal and can go on for months.

Fig. 18: MRI scan

Fig. 19: X-ray

Sportsman's hernia describes a weakness of the rear wall of the inguinal canal. Pain in the groin area, above the pubic bone, at the top of the quadriceps muscle and in the genital area can occur. These are exclusively exercise-related and are felt particularly when changing direction suddenly and when turning. There is no pain at rest. The diagnosis is usually made by exclusion (i.e., it is the only remaining diagnosis when all other causes have been eliminated). In the hands of a very experienced examiner, the injury might be visible on an ultrasound scan. If a real weakness of the inguinal canal exists, an operation may be successful. Otherwise, the treatment aims to compensate for a possible muscular imbalance between abdominal, back and hip joint moving muscles. Usually the abdominal and hip abductor muscles are (relatively) too weak.

Outside the musculoskeletal system, the existence of groin pain may indicate a groin (inguinal) hernia. Pain is typically felt when coughing, sneezing or lifting heavy objects (raising the pressure in the abdominal cavity). In severe cases, a protrusion above the inguinal ligament may be visible. Men are affected much more often than women. Treatment usually involves an operation.

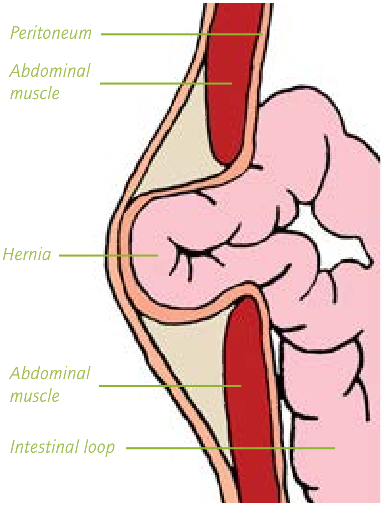


Fig. 20: Inguinal hernia–schematic

KNEE INJURIES

The most common knee injuries affect the **medial meniscus** and the **medial collateral ligament**. Twisting the body when the foot and lower leg are planted is the typical injury mechanism for a **meniscal lesion**. The thigh is twisted against the lower leg. The medial meniscus is most commonly affected.

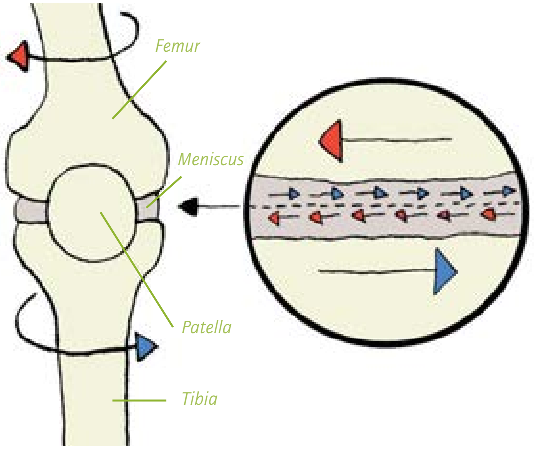


Fig. 21: Typical meniscal lesion injury mechanism

Pain in the medial (in the case of the medial meniscus) or lateral (in the case of the lateral meniscus) joint line, a joint effusion (accumulation of fluid in the knee joint) or symptoms of knee locking can occur. Most meniscus injuries require an operation followed by approximately six weeks to three to six months of rest, depending on whether a part of the meniscus is removed or whether the meniscus was stitched.

Those with knock-knees increase the pull and stretch on the **medial collateral ligament (MCL)**, and those with bow-legs increase the pull and stretch on the lateral collateral ligament (LCL). Should the pull or stretch exceed the resilience of the ligament, it can rupture or tear. These injuries typically occur when tackling, blocking a kick or getting a foot caught in the pitch. The MCL is usually treated conservatively with a hinged knee brace, which provides stability of the knee joint at the side. Depending on the severity of the injury, the **LCL** more likely requires operative treatment. The healing time of the collateral ligaments is usually between six to eight weeks.

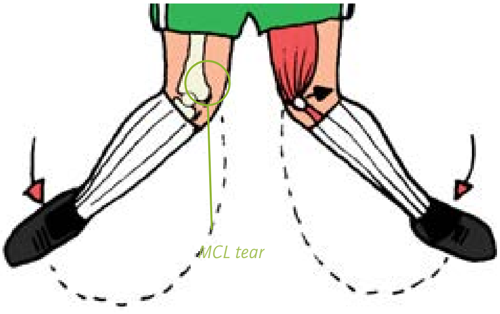


Fig. 22:
Knock-knees MCL tear

The most serious knee ligament injury affects the **anterior cruciate ligament (ACL)**, for which the recovery period is several months. A return to the original sporting level is not always possible. In the long term, in about 20% (only ACL injured) to 80% (combined with other injuries, such as MCL and meniscus) of cases, premature wear and tear of the joint should be expected. The term *unhappy triad* is used to refer to the simultaneous injury of the ACL, MCL and originally the medial meniscus but the lateral meniscus could be affected instead. About 80% of injuries happen independently of an opponent (non-contact injury). Changes of direction, sudden stops and landings with a hip and knee joint in an almost straightened position and/or a knocked-knee position, are typical situations in which this injury can occur.

Fig. 23: Dynamic knock-knees, right

An outward twisted lower leg in a knock-kneed position with a relatively extended knee joint is very dangerous for the anterior cruciate ligaments (also referred to as *dynamic knee valgus*). The same also applies when the knees buckle.

At the moment of the accident, sometimes a snapping sound is reported. This may even be audible for bystanders. As well as pain, there may be swelling of the knee joint (knee joint effusion) and the joint may feel unstable.

The younger and more active the patient, and the more pronounced the concomitant injuries, the greater the tendency to treat the injury operatively.

The **posterior cruciate ligament (PCL)** is more rarely affected. Collisions with an opponent or a buckling of the knee are possible accident scenarios. These injuries often do not look like much from the outside. There might be a slight swelling of the joint or a feeling of instability. These injuries are currentley still mainly conservatively managed. If there is a bony avulsion of the ligament or instability, an operation is usually performed, but here, too, the decision is influenced by activity and performance level. Both an anterior and posterior cruciate ligament injury require a recovery period of at least six to nine months.

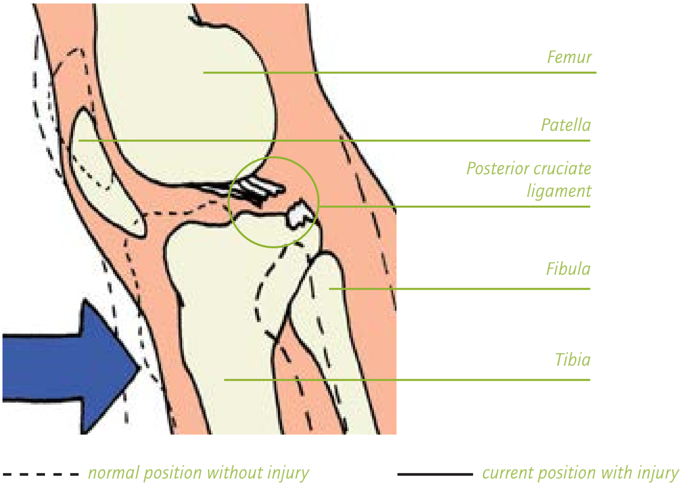


Fig. 24: Ruptured posterior cruciate ligament

Dislocation of the knee cap (patella luxation), like the cruciate ligament injuries, is one of the most serious knee injuries, requiring many months recovery. They may even be career-ending. The dislocation is almost always outwards (lateral). Enabling factors are being very knock-kneed, a malformation of the joint with poor bony joint control, reduced ligament stability and a poorly-developed quadriceps muscle, especially the *vastus medialis*. These preconditions are frequently found in young girls and young women so that the incidence of this injury among these populations is significantly more common. Repeated dislocations entail a high risk of cartilage damage with premature wear and tear and should be avoided by means of appropriate treatment (the younger and more active the sufferer, the more likely it is that an operation will be required).

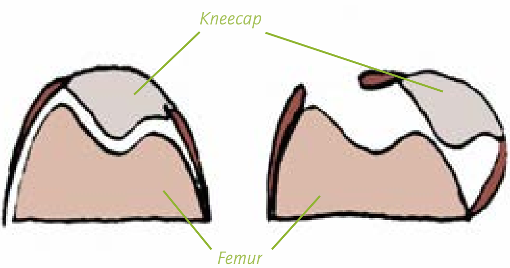


Fig. 25: Dislocation of the knee cap (patella luxation)

Patellar tendinopathy (jumper's knee) is a common overuse injury in football. As the continuation of the quadriceps muscle below the kneepcap, the patellar tendon is responsible for knee extension. Pain in patellar tendinopathy is mainly felt when kicking the ball (especially an instep kick), when sprinting and when stretching the quadriceps muscle. Initial treatment measures include modifying the type of sporting activity (avoid pain-inducing movements) and stretching the quadriceps muscles. Experiment with taping or a knee support worn below the patella. A balanced strength ratio between the quadriceps and hamstrings (about 60:40) should be aimed for. This injury is often very slow to heal.

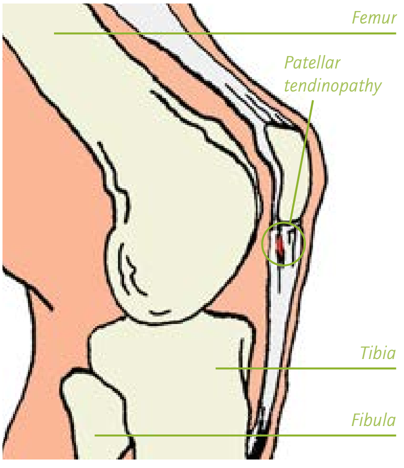


Fig. 26: Patellar tendinopathy

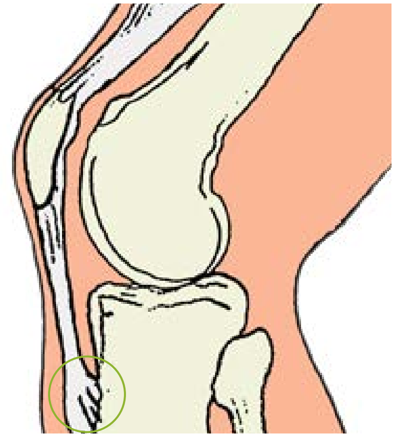


Fig. 27: Insertion of the patellar tendon in the tibia

The patellar tendon is attached to the tibial tuberosity (at the front of the tibia). This is an apophysis. Constant pulling (frequent sprints, jumps, kicks) can cause part of the apophysis to break off (**Osgood-Schlatter-Disease**, see fig. 28). Unlike the aforementioned apophyseal fractures that occur acutely, this injury creeps up gradually. It particularly affects boys between the ages of 12 and 16. The clinical picture mimics the one of patellar tendinopathy, but with the pain located somewhat deeper (i.e., located somewhat further down the leg). The treatment is also the same. The problem is solved when the apophysis stops growing. However, a permanent swelling of the tibial tuberosity can remain and can cause life-long pain on kneeling.

Fig. 28: Osgood-Schlatter-Disease

ANKLE INJURIES

The majority of twisted (sprained) ankles happens 'outward' (lateral, supination trauma). Stretching the ligament as well as (partial) ruptures can result. In the event of an injury, a swelling and bruising in the area of the lateral malleolus or the hind foot (due to the effect of gravity) can occur. Depending on where the ligament is damaged, pressure pain can be felt along the ligament or at its attachment points to the bone. Ankle joint mobility and weight bearing can be restricted or impossible due to the pain. These injuries are usually treated conservatively, especially if only one ligament is injured or the tear is only partial. First aid treatment should be in line with the PRICE principles.

A lack of stability and persistent propioceptive deficits (feedback on joint position, strength, movement direction) are the main reasons for recurrent sprain injuries, with the possible consequence of chronic instability and premature joint wear and tear. As well as the thorough healing of the injury, ankle stabilisation (balance) training is, therefore, particularly important. (see also chapter 4, Injury Prevention).

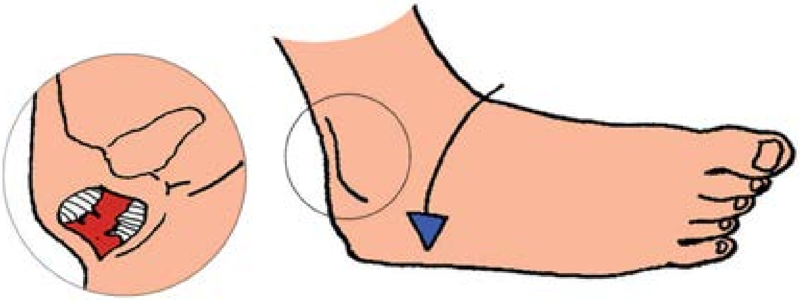


Fig. 29: Supination trauma of the ankle joint with injury to the outer ligaments

A sprained foot or ankle can also damage other structures, one example being the **syndesmosis**. This is a tight ligament connection between the bottom of the tibia and fibula, which runs almost horizontal to the floor. An (almost) complete tear of the syndesmosis is usually operated on to avoid a persistent instability later on.

In addition, this injury mechanism can also lead to the fracture of the lateral malleolus or the base of the fifth metatarsal, hence they need to be excluded. The location of the main tenderness can give valuable information. Fractures often require an operation.

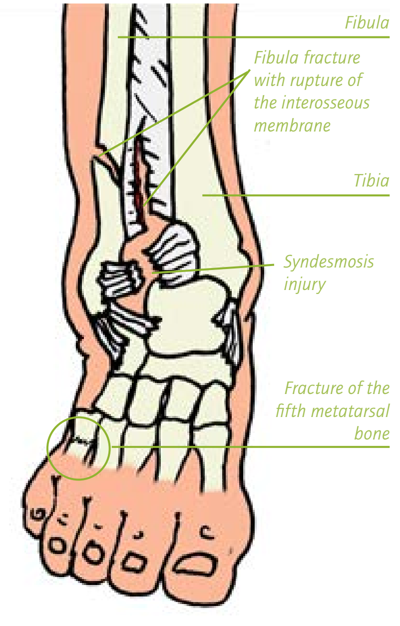


Fig. 30: Other possible injuries caused by a sprained ankle

And of course, do not forget the **stress fractures** that frequently affect the tibia, fibula and metatarsals.

ACHILLES TENDON INJURIES

Achilles tendon injuries are common sports injuries in ball games and sports that involve running and jumping. The worst case scenario is that the tendon tears, often accompanied by an audible crack at the moment of the injury. The athlete often reports the feeling that someone kicked his Achilles tendon. A typical accident situation is a powerful foot placement when accelerating or taking off for a header. There has often been a history of previous Achilles tendon pain (pulling, hurting, swelling), which indicate that possible previous damage is a predisposing factor. This injury typically affects athletes over the age of 40 (after 25 years of age, initial symptoms of wear and tear of the Achilles tendon are possible).

Fig. 31: Achilles tendon tear

Fig. 32: Partial achilles tendon tear

A torn Achilles tendon significantly reduces respectively eliminates power when rising onto tip-toes (plantar flexion). It is impossible to rise onto tip-toes on one leg, although it may still be possible on two legs. There is a visible and/or tangible dip above the heel bone. A swelling followed by bruising is possible. Apart from the moment of the tear, pain is not a major issue. The injured person can usually walk (almost) without pain. Operating is the treatment of choice, particularly for the younger and more active patient with torn ends that are far apart. A long rehabilitation time of 6 to 12 months should be expected. It may not always be possible to return to the original performance level.

A tear is usually easy to diagnose even for a medical layperson, but not a **partial tear**. It is not unusual for these to be diagnosed as an **Achilles tendinopathy, inflammation of the tendon sheath or bursitis**. These injuries manifest as exercise-related pain, particularly when the foot pushes off the ground. There may be swelling, either of the Achilles tendon or the peritendinous region. In the case of a partial tear, continued sporting activity entails a risk of provoking a complete rupture. The injuries are usually managed conservatively; larger partial tears may sometimes require an (immediate) operation. Irritation or inflammation of the Achilles tendon sheath is managed by (often long-lasting) conservative therapy. Great use is also made of the PRICE model in the acute condition. Any sporting activity that causes pain should be avoided, and the entire muscle chain of the back of the leg (from the sole of the foot to the back extensor muscles) should be kept sufficiently stretched. The short-term use of a heel wedge of 5 to 10 mm (both sides, so as not to cause a difference in leg length), is an option. After the acute phase, the next step is to improve one-leg balance and strengthen the calf muscles. Eccentric exercises have proved to be a particularly good way of doing this. It is also a good time to optimise footwear (throw out old shoes, and consider buying shoes with pronation support or shoe insoles or changing shoe brand). All therapeutic options should be made in concordance with a medical professional.

Achilles tendon injuries are often slow to heal and, if not treated correctly, can get much worse with possibly serious consequences (e.g., Achilles tendon tear). An early medical opinion is advisable. In the event of an irritation of the insertion of the Achilles tendon, a heel spur or bursitis should be eliminated, as these may sometimes alter the treatment procedure, particularly if conservative treatment has not been successful.

3.6.3 UPPER-BODY INJURIES

The injury spectrum of the upper body is not fundamentally different from that of the lower body. Goalkeepers are particularly vulnerable and are put out of action much more frequently by upper-body injuries than field players. **Bruising and contusions** are usually caused by falls or kicks. The same applies for **bone fractures**. However, unlike bone fractures affecting the lower body, particularly in the case of field players and simple fractures, sporting activity can still be continued as long as an appropriate protection is worn. This should be discussed with the team physician. However, wearing sharp, pointed or heavy immobilisation devices is prohibited. The device must be shown to the referee at the start of the game in order to obtain his approval. Goalkeepers with **finger injuries** can wear specially reinforced gloves to allow them to carry on playing. Fractures mainly affect the fingers, the metacarpal bones and the end of the radius bone near the wrist. Fractures of the scaphoid bone (carpal/wrist bone) are also a possibility.

The latter often cause relatively little pain. However, incorrectly treated fractures can lead to **necrosis** (dying) of the bone and to a permanent restriction of wrist function. Pain on palpation over the bone or pain when pushing the thumb against the first metacarpal bone are symptoms of such an injury.

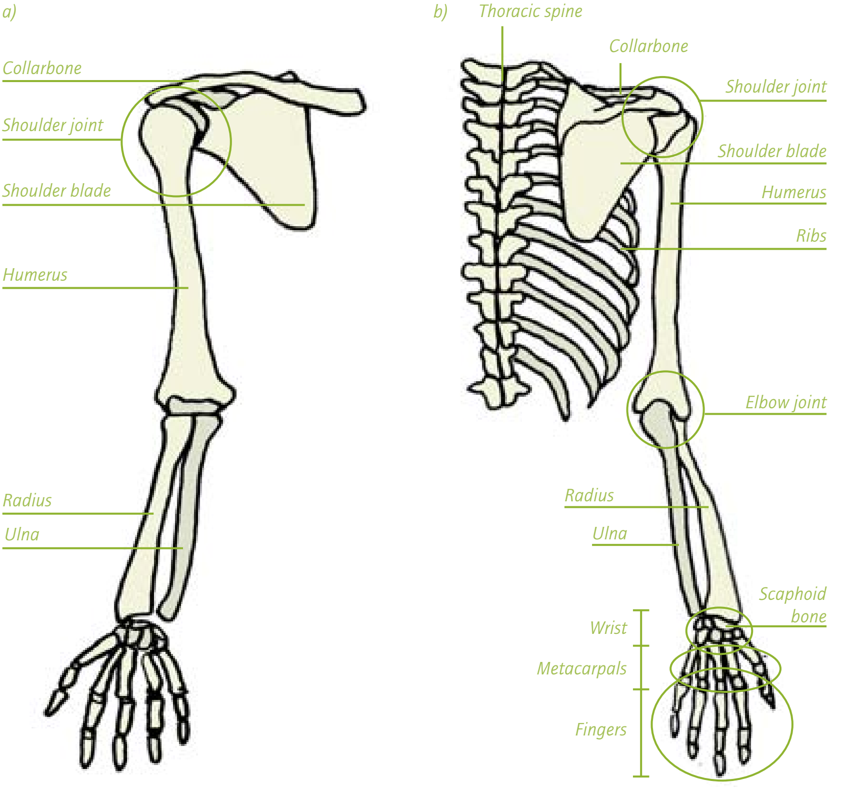


Fig. 33: Bones of the upper body
a) Front b) Back

Falls are responsible for the majority of fractures, particularly falls onto the outstretched hand. Fractures can occur at the location of the original impact (fracture of the radius or scaphoid), but there is also the possibility that structures farther up the body can be damaged, such as the head of the radius (usually in adults), the end of the humerus near the elbow or the collarbone. The latter can also be broken in a direct fall onto the shoulder. This mechanism can also lead to ligament injuries in the shoulder joint (see Shoulder Injuries section).

SHOULDER INJURIES

A fall onto the shoulder or an attempted save by the goalkeeper with his arm turned out and abducted can cause a **dislocation of the shoulder joint (shoulder luxation)**.

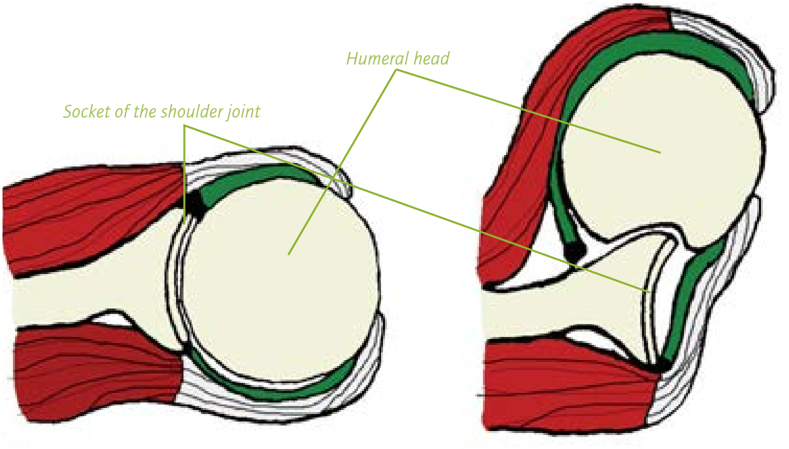


Fig. 34: Schematic presentation of a shoulder dislocation

This injury is usually very painful, and the pain is so great that it is impossible to move the arm in the shoulder joint. The shoulder silhouette is changed compared to the other side of the body. There is a swelling in the armpit, where the dislocated humeral head is located. The slipped humeral head can restrict the vascular and nerve bundles in the armpit. For this reason, tests must be done to establish normal sensation in the whole arm (by careful touching) and active mobility (the injured player carefully performs the movements by himself) of the elbow, hand and finger joints. A dislocated shoulder joint should be put back in place by a **physician** as soon as possible. This should never be attempted by a layperson. First aid measures consist of immobilisation with a triangular bandage (or an arm sling, which is not ideal). A three- to four-month break from football should be expected, somewhat longer for goalkeepers.

A sideways fall onto the shoulder joint can result in a **fracture of the humerus** or **the collarbone** or in a **ligament injury of the AC joint** (the joint between the humeral end of the collarbone and the shoulder blade). The location of the tenderness and of a misalignment help to differentiate between these injuries. In the event of an AC joint injury, a *piano key phenomenon* can occur. The AC joint is held in place by means of ligaments. If these ligaments tear, the trapezius muscle can 'pull up' the collarbone. Downward pressure on the outer end of the collarbone near the shoulder will move it back to the normal position.

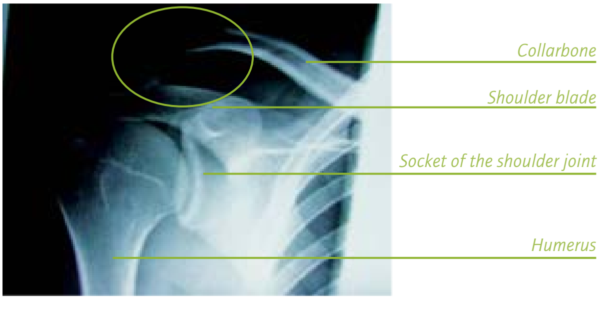


Fig. 35: Piano key phenomenon in the case of torn ligaments at the acromioclavicular joint

These injuries should be diagnosed by a physician. First aid treatment can be given with a triangular bandage (or arm sling, which is not ideal). In the case of minor injuries to the AC joint, a return to sporting activity may be possible after less than two weeks, pain permitting. In all other cases, an operation and at least six to eight weeks of recovery time should be expected.

FINGER INJURIES

Finger luxations (dislocations) are also easy for medical laypeople to see due to the malalignment. These are NOT minor injuries. Insufficient treatment may cause permanent joint instability and premature wear and tear, as this injury always involves damage to the joint capsules and the ligaments. Cartilage damage can arise from the injury itself or as a consequence of instability. The finger luxation must be put back in place and treated by a physician. A field player is usually able to play with an appropriate finger splint (football compliant!), but for a goalkeeper, a break of up to six weeks before resuming goalkeeping-specific training may be necessary. Medical advice should be obtained and adhered to.

Fig. 36: Finger dislocation in the proximal joint

Goalkeeper's thumb (also known as *skier's thumb*) refers to an injury to one of the ligaments (the ulnar one) at the base of the thumb. Getting the thumb stuck in the ground or falling onto the thumb are possible causes.

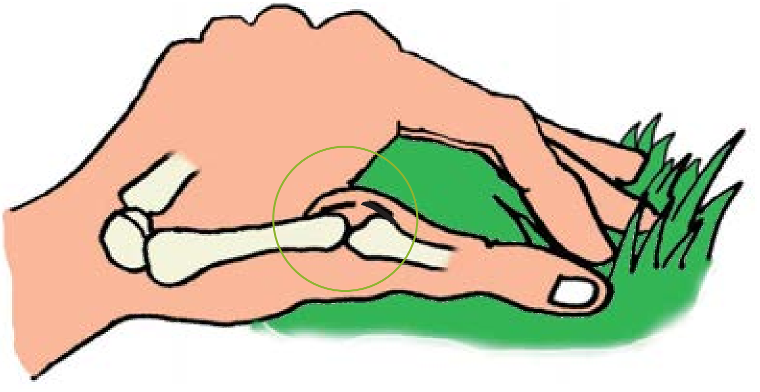


Fig. 37: Injury mechanism for goalkeeper's thumb

Depending on the degree of instability, an operation may be unavoidable. A temporary splinting of the ligament is always necessary, irrespective of the chosen form of therapy (with or without operation). Inadequate treatment could lead to a permanently reduced grip strength of the thumb.

Extensor tendon injuries are usually caused by direct trauma, such as the impact of the ball against an outstretched finger. However, it can also happen when putting on (football) socks. In the event of an injury, extending the affected finger can be painful or even impossible. A complete rupture of the extensor tendon of the distal phalanx of the finger causes a *hammer finger*, in which the distal phalanx hangs down towards the palm of the hand. This can be passively, but not actively, corrected. Treatment is usually conservative: the finger is immobilised for six to eight weeks in a splint in a hyperextended position. This hyperextended position should be maintained during this period of time, even when the splint is temporarily removed to clean the finger.

Inadequate treatment could lead to a permanently hanging distal phalanx, which could be a handicap in daily life and in sporting activities. It could repeatedly get in the way of a goalkeeper while catching the ball, for example. In such cases, an operation may still be required subsequently.

3.6.4 SPINAL INJURIES

An injury that typically occurs in automobile accidents can also occur in football: **cervical spine sprain**.

Possible causes are a collision with an opponent, a fall or hitting the head on a post. Bone, ligament and muscle injuries are possible. Accident mechanism, speed, collision with an opponent or object, anticipation of the accident, age of the injured person (the older, the more severe the injury in the same accident) and the onset of pain after the accident (duration of the pain-free interval after the accident) are important facts that help to judge the force of the impact. Typical complaints are listed in box 4.

CERVICAL SPINE SPRAIN SIGNS AND SYMPTOMS:

- Neck, shoulder, head and arm pain
- Restricted movement of the cervical spine
- Globus sensation or feeling of a lump in the throat
- Difficulty swallowing
- Tingling and loss of strength in the arms, including the hands
- Earache
- Sweating
- Tendency to collapse

Box 4: Typical cervical spine sprain signs and symptoms

In the event of a suspected cervical spine sprain, the player should leave the pitch and be examined by a physician and only resume training again on medical advice.

The most common causes of back problems are **mechanical dysfunctions** (i.e., **blocked joints**). They can affect any age group and any part of the spine, cause extremely intense pain, cause relieving postures (wryneck, torticollis) and mimic disorders of the internal organs (e.g., symptoms similar to that of a heart attack), particularly when they occur in the thoracic spine. Unlike disorders of the internal organs, musculoskeletal problems are usually **movement related**. They either only occur in one direction of movement or are significantly worse in one direction.

Pain occurs only on breathing in, but not also neccessarily when breathing out. In addition, the pain does not necessarily worsen during intense physical activity. In the event of a narrowing of the coronary arteries (precursor of a heart attack) during intense physical activity, there may be a reduction in the oxygen supply to the heart, which can in turn cause the pain to increase. As the cause of a joint disfunction is mechanical in nature, it is almost always provoked by a specific movement. A mechanical cause (e.g., 'wrong lifting' of a load, 'funny turn with the body') should, therefore, be sought. It may be accompanied by severe muscle hypertonus, which will usually clear up by itself after a few days. Should the pain be stronger or more stubborn, a visit to the physician or physiotherapist is advisable.

Muscle injuries can also affect the back muscles, and, as in the extremities, can range from an increase in muscle tone to a muscle strain or tear. Tendon insertion irritations can also occur.

3.6.5 TORSO INJURIES

CHEST

Rib and chest contusions due to falls, kicks or impact are common injuries. **Broken ribs** can also be caused by the same mechanisms. Pain, point tenderness, a swelling or a haematoma may appear at the point of impact. In the event of simple bruising, it is usually possible to carry on playing as soon as the pain has diminished. In the event of a broken rib, medical permission should be obtained before football training can be resumed.

If the chest injury is more severe, the possibility of a concomitant injury to the **internal organs** located within the ribcage must also be considered. The lungs, in particular, but also the liver and the spleen may be affected in the event of an injury to the lower ribs. A displaced rib fracture may puncture the lungs. As well as pain, shortness of breath must be expected. Spleen injuries can provoke both abdominal and **left** shoulder pain due to the close proximity of the diaphragm (to the spleen) and its nerve supply. Injuries to the internal organs are potentially life-threatening and, therefore, should receive immediate medical attention.

Mechanical dysfunctions of the thoracic spine or the costovertebral joints are common and have already been described in the section on spinal injuries.

STOMACH (ABDOMEN)

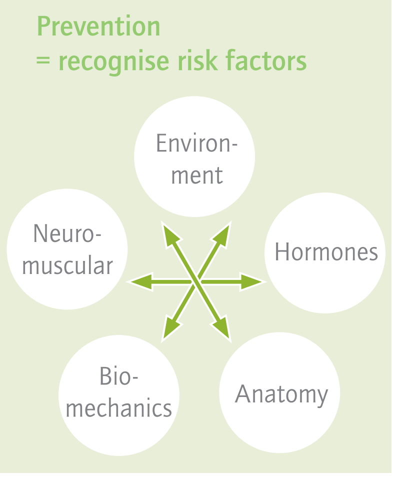
Strained muscles or tears affecting the muscles of the abdomen are caused by the same injury mechanisms as muscle injuries in the extremities. In the case of direct hits and kicks in or to the abdomen, the possibility of injury to the deeper internal organs should be considered. As well as injuries to the spleen, the liver, kidneys or testicles may be affected. An injury to the latter can result in infertility. Wearing a jock strap is advisable for goalkeepers. Injuries to the internal organs are potentially life-threatening, which is why immediate medical attention should be sought.

CHAPTER 4

INJURY PREVENTION

Ideally, an **injury prevention programme** can prevent the occurrence of all injuries. However, in a contact sport like football, this is wishful thinking as it is hardly possible to avoid contact-related injuries (e.g., an (unfair) tackle to the legs from behind). This is why prevention programmes focus particularly on non-contact injuries. Furthermore, they specifically address injuries that are common and/or long-lasting as they affect the players' health, sport and finances the most.

Successful prevention always starts with as accurate a risk factor analysis as possible. The question of why a certain injury has occurred must be answered as accurately as possible. For most injuries, there is no one single reason, but several risk factors, which are also mutually influential.



Neuromuscular:
Interaction between central nervous system and the muscles (e.g., activating muscles at the right time).

Anatomy:
Study the construction and structure of the human body (e.g., bandy legs).

Biomechanics:
Sports biomechanics examine human sporting movement and the mechanical conditions of these movements (e.g., increased knee extension on landing).

Fig. 38: Risk factors for injuries and how they are mutually influential

Likewise, a common feature of several injuries is that a prior similar injury represents an independent risk factor. Other typical risk factors have already been mentioned in chapter 3.3 and will not be repeated here. The subchapter, Risk Factors and Prevention of the Top Three Football Injuries (page 108), presents the latest scientifically-proven risk factors (including their prevention) for these three injuries in particular.

BASIC PRINCIPLES OF PREVENTION PROGRAMMES

Prevention programmes that have proved to be successful had to be carried out at least twice per week for about 20 minutes over at least six to eight weeks. Afterwards, they should be performed at least once a week for the rest of the season. Unfortunately, you cannot keep the effect 'on reserve,' as the effect of the programme significantly wears out, roughly within the same time period.

Successful prevention programmes almost without exception include the entire kinetic chain.

If, for example, a knee injury is to be prevented, not only exercises for the knee joint and its directly related muscles are carried out, but so also are exercises for the hip and ankle joints and the core. The stability and functionality of the whole chain is necessary for effective movement. Both aspects are essential for a correct **movement pattern**.

DEFINITION OF THE TERMS OF THE KINETIC CHAIN

A combination of several joints connected in sequence, including their associated muscles as a motor functional unit for complex movement sequences. This is enabled by a co-ordinated interaction of functional systems of the central and peripheral nervous systems (cerebral cortex, cerebellum and spinal cord, including the associated pathways).

Box 5: Definition of the term kinetic chain (adapted from the Roche Medical Dictionary)

The core and the ankle joints/feet have a key role to play. A lack of core stability reduces the effectiveness of the power transfer from the extremities to the trunk and vice versa. In addition, it can negatively impact joint control. Both result in a suboptimal movement pattern. As a simple (DIY) test, try taking a kick with your trunk inclined slightly to the left. In this position, it is much more difficult to play a powerful pass with the outside of the right foot than with a correctly aligned upper body.

The ankle joints also have a major influence on the movement sequence. The worse the (one leg) balance, the harder it is to play an accurate or powerful pass, for example. In addition, the way the bodyweight is distributed on the foot affects the alignment of the leg and, subsequently, the trunk position. Ideally, the foot should point straight forward with the weight evenly distributed on the inside and the outside of the foot.

(See also fig. 49 foot with three contact points, page 106). The aforementioned DIY test can be repeated. This time, though, the upper body remains upright, but the position of the foot is changed. The first time, kick with the correct weight distribution on the foot, and the second time, the weight is consciously shifted to the inside or outside of the foot.

Figure 39 shows the effect of the position of the hindfoot on the course of the Achilles tendon. The Achilles tendon follows the movements of the hindfoot and ankle joint. However, this displacement of the Achilles tendon does not necessarily need to result in symptoms or an injury respectively. Figure 45 is a good illustration of how the hindfoot position affects the position of the joints farther up the body, such as the knee joint. For this reason, in the event of an injury—not only the site of pain but also the joints above or below—, the muscles and the trunk should also be examined.

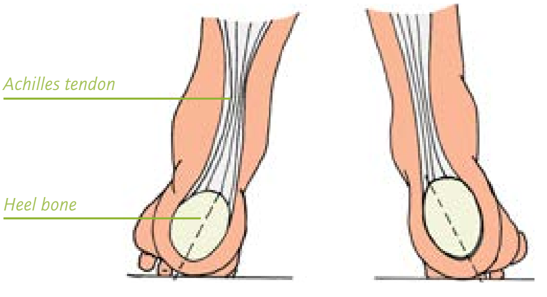


Fig. 39: Displacement of the Achilles tendon according to hindfoot position

Conversely, incorrect movement patterns, bad posture or a suboptimal leg alignment can cause uncoordinated activation of the (stabilising) muscles and, therefore, result in uncoordinated movements. Should this exceed the normal range of motion, there is a risk of abnormal strain on the musculoskeletal system, which in turn increases the risk of injury. Furthermore, this also reduces movement efficiency and diminishes performance.

Fig. 40: Effect of lack of stability of the lumbarpelvic area on the leg alignment

(sinking of the pelvis on the left side, turning inwards of the right leg with increased knock-knees. The arms must be used to stabilise.)

Fig. 41: Incorrect landing after a jump and its effect on the whole kinematic chain

PREVENTION PROGRAMMES TYPICALLY TRAIN OR ADDRESS THE FOLLOWING COMPONENTS:

- Core stability (in all three planes)
- Leg alignment, functional knee stability respectively
- Correction of incorrect movement patterns (e.g., avoiding dynamic knock-knees; landing on two feet, not one foot)
- Elimination of impaired function of joints and soft tissue
- Improvement of (one leg) balance (in all three planes, including rising onto tip-toes)
- Endurance

Box 6: Typical components of a prevention programme

Figures 42-52 represent typical examples of preventive exercises. The figures display both correct and incorrect movement patterns. These exercises are only intended to be an initial guide; it would exceed the scope of this book to go into further detail, but this may be found in other literature. Certain logical principles should be adhered to when planning injury prevention exercises.

- From simple to hard or complex.
- From familiar to unfamiliar.
- From two legs to one leg.
- From firm to increasingly unstable surface (tarmac vs mat).
- From open to closed eyes (initially make use of visual control).

Box 7: Basic principles for increasing difficulty of prevention programme

Athletes, in particular, often tend to start with complex exercises, as they believe they are very well trained. Unfortunately, this is often not the case in the context of injury prevention. The typical 'entry-level' balance exercise for athletes looks like this: Stand on one leg on an unstable surface (e.g., balance mat) with closed eyes, doing an additional task (e.g., circle a football around the hips). The basic pre-requisites for correct movement execution, e.g., the correct weight distribution on the foot while standing on one leg, are often not present, and the effect of the hindfoot position, e.g., on the alignment of the Achilles tendon, has already been described. If the athlete is not able to stand balanced on one leg with the eyes open on a firm surface, there is no reason to add further difficulty to the exercise. This would increase both the risk of injury and the athlete's frustration. The goal must be to start as simply as possible and then gradually increase the difficulty once each step is mastered, adding or complicating only one component at a time. Aim for increasingly functional exercises that simulate more and more the typical demands of football.

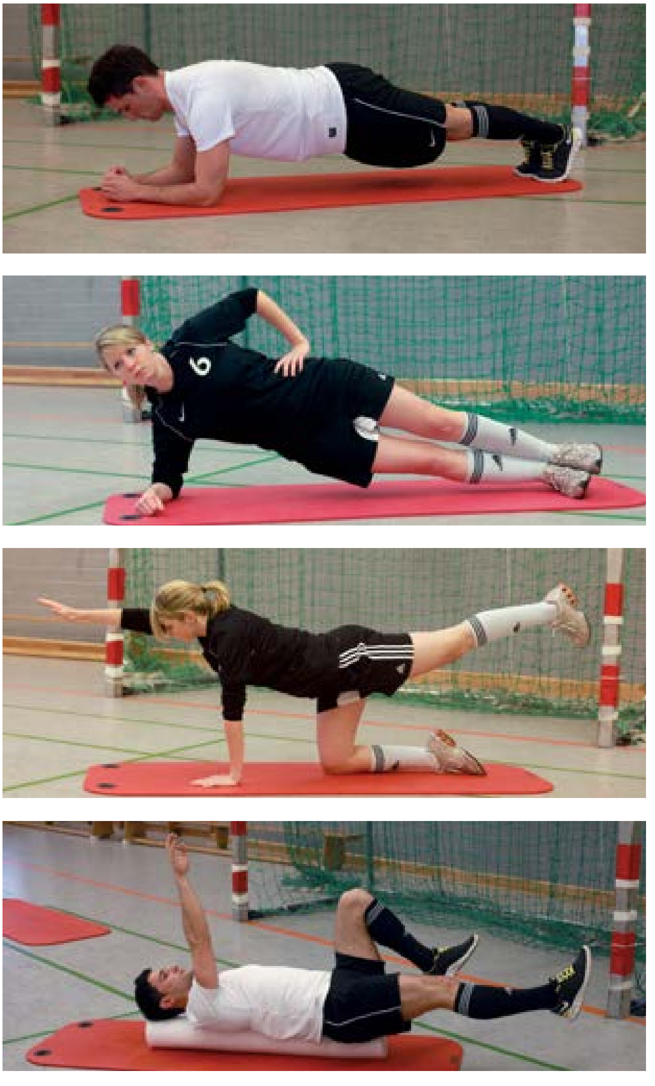


Fig. 42: Exercises to reinforce core stability in all three planes–front plank, side plank, quadruped moving opposite arm and leg and 'dead bug' exercise on foam roller

Fig. 43: Training the hip abductor muscles

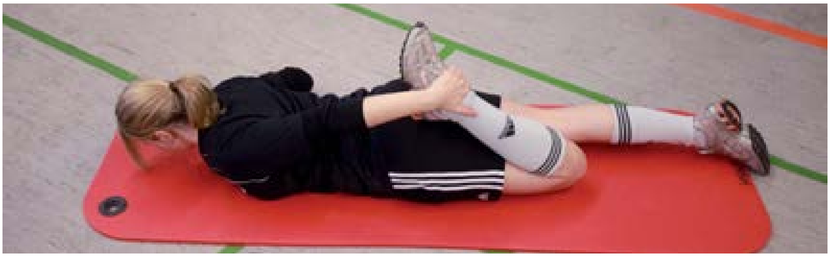
a) Standing

b) Side plank position, abducting the leg remote to the floor

Fig. 44: Change of direction with correct and incorrect leg alignment

Fig. 45: Landing with correct and incorrect leg alignment

Fig. 46: Squat with barbell (side and frontal view) with correct technique: straight back, straight leg alignment



Prone position

Lateral position

Standing

Fig. 47: Exercises to stretch and loosen the quadriceps muscle (avoid hollowing the back during the exercises).

With a foam roll

Fig. 48: Exercises to stretch the gluteal muscles

Fig. 49: Correct loading points on the sole of the foot for balance training

Fig. 50: Balance training with correct and incorrect technique while raising onto tip-toes

Torso moves back and forth

Twisting motion of the torso

(the foot remains planted)

Lateral inclination of the torso

Fig. 51: Balance training in all three planes

RISK FACTORS AND PREVENTION OF THE TOP THREE FOOTBALL INJURIES

The current, scientifically-proven risk factors for the top three football injuries are presented here.

Of **anterior cruciate ligament** injuries, 80% occur without contact (non-contact injury). They mainly affect females between the ages of 14 and 19. This aspect is also addressed again in chapter 8, Special Features of Women's Football.

Tab. 4: Risk factors for an ACL injury

Risk factor	Problem
Anatomy	Inward tilt of the foot (pronation)
Biomechanics	Forward (anterior) orientated shear forces on the lower leg • Slight flexion in knee and hip joint • Inward twist of the knee and hip • Adduction of the hip joint • Sidebend of the torso
Neuromuscular [nervous system—muscles co-ordination]	Altered activation pattern of the stabilising muscles • Activation of the quadriceps ↑ • Activation of the hamstrings ↓ • Delayed activation of the calf and thigh muscles • Shortened activation of the gluteal and core muscles Fatigue: Mental [central] Muscular [peripheral]

The main aims of prevention are to avoid the **dynamic knee valgus position** while running and jumping and to strengthen the hamstrings, as they can protect the ACL. The correct leg alignment on cutting and landing is also very important. Excellent functional knee-joint stability (i.e., the stability of the knee joint while moving) is essential for this. Prerequisites for this are strong and balanced muscles around the knee joint, good one leg balance and good core stability in all three planes. Successful prevention programmes are, therefore, carried out as multimodal (i.e., including several aspects) concepts, taking into account the whole kinetic chain. These programmes contain the following components:

- Plyometrics for the lower extremity
- (One leg) balance and strength training
- Core stability (in all three planes)
- Stretching
- Endurance training
- Anticipation (of game situations)

Box 8: Elements of a prevention programme—anterior cruciate ligament

Plyometrics refers to exercises in which a muscle is first stretched immediately before being contracted (e.g., quadriceps muscle: jump from a box onto the floor, then immediately jump up onto another box).

These multimodal programmes were mainly tested on young females, and the risk of an ACL injury was reduced by 41 to 89%. There was little point in young women with a low risk for this injury carrying out a prevention programme as it did not reduce their injury risk. For high-risk women, the risk could only be lowered to that of untrained men.

80% of the **ankle ligament injuries** are caused by a supination twist (i.e., the inside of the foot loses contact with the ground). In field players, contact injuries in particular are responsible (59%), while for goalkeepers, the majority occur without contact (79%). These injuries heap up (44%) in the first three months of a season. There is conflicting evidence as to whether these injuries are more common in training or matches (66% in a game versus 69% in training). After the first injury, there is a 9 to 60% chance of a similar second injury. The risk increases by a factor of 1.8.

Tab. 5: Risk factors for an ankle ligament injury (first occurrence)

Risk factor	Problem
Anatomy	Wide foot
Biomechanics	Big strength difference in the muscles that move the ankle Dominant leg Being overweight Skewed foot position on landing Delayed reaction of the peroneal muscle (pulls up the outer edge of the foot) One leg balance ↓ No stretching in warm-up Fatigue > mental (central) > muscular (peripheral)
Women	Passive supination joint position sense ↓ Range of motion of the base joint of the big toe ↓ Postural control ↓
Men	Running speed ↓ Endurance ↓ (One leg) Balance ↓ Strength and range of motion for pulling up the foot in the ankle (mortise) joint ↓ Co-ordination ↓ Reaction time of the calf and shin muscle ↑

A number of risk factors have also been identified for a recurrent injury. These do not necessarily match those of the first incident.

Proprioceptive training (balance training, improvement of feedback to the central nervous system regarding joint position, movement direction and strength, improvement of co-ordination between nervous system and muscles also in relation to strength) can reduce the number of (first time) twisted ankles.

Tab. 6: Risk factors for an ankle ligament injury (recurrent injury)

Risk factor	Problem
Anatomy	Forward shift of the fibula Bony radius of the ankle joint ↑
Biomechanics	Drawer test of the ankle (mortise) joint ↑ Supinated position at ankle joint ↑
Neuromuscular	Stabilisation time after jump ↑ Active finding of the neutral ankle joint position ↓ One leg balance ↓ Concentric supination ↓

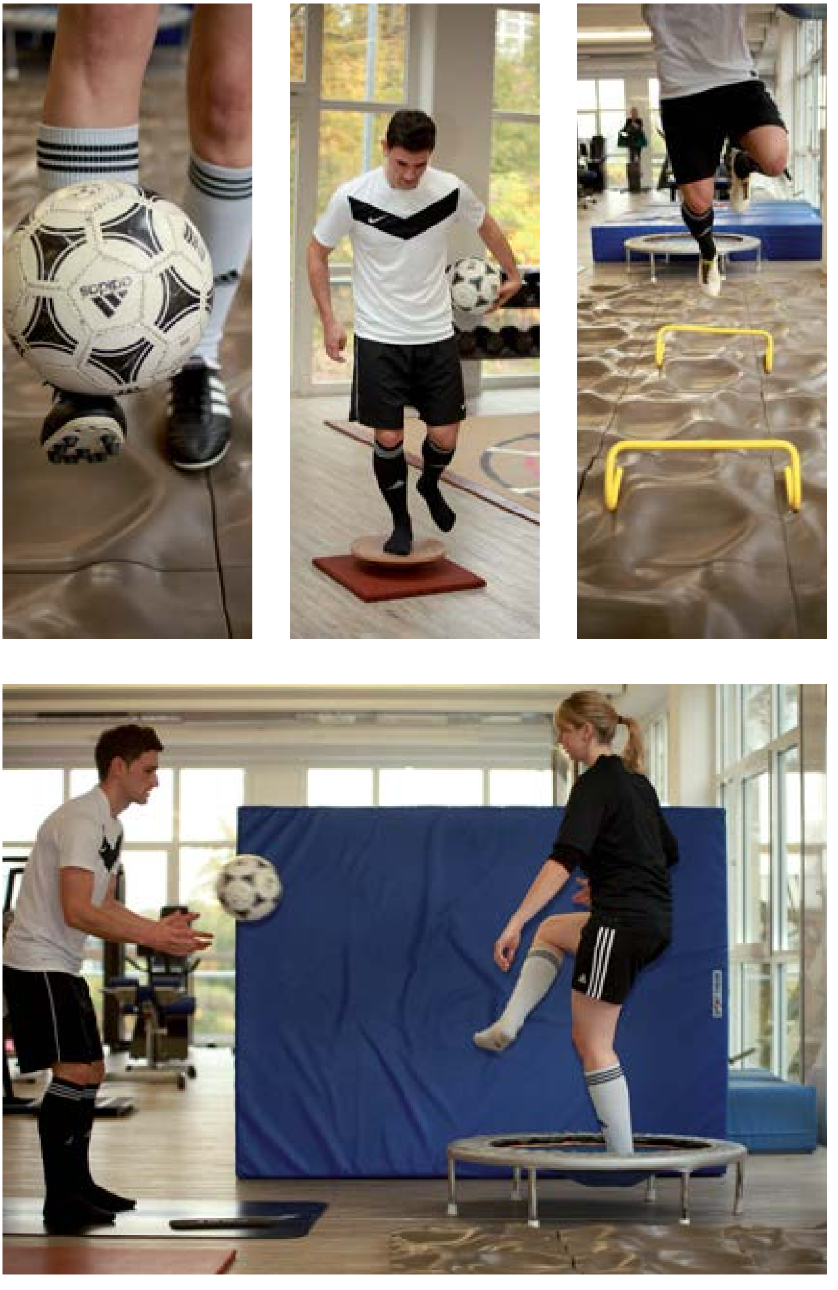


Fig. 52: Typical examples of proprioceptive training in various advanced levels of difficulty

It has been shown that stabilising measures, such as taping or the use of foot orthotics, in combination with neuromuscular training, can successfully reduce the number of recurrent injuries. In the latter, improving balance is more important than improving strength. The reduction in injury risk reached 50-80%. Unfortunately, there are very few high-quality studies dealing with this particular injury. Firstly, ankle injuries are often just touched on in studies of other injuries, and, secondly, as in studies of ACL injuries, all too often there is a compliance issue.

It is hard to talk about scientifically-based recommendations for the prevention of **thigh muscle injuries** in general and the hamstrings in particular. There are (still) no high-quality studies on this subject. It is, therefore, not surprising that in the last 30 years, no significant progress has been made with regard to the frequency and severity of this injury. The biceps muscle is most often affected (57% of the injuries occur while running, 62% happen during a game). Premier League players, field players, dark-skinned players and those over age 23 are significantly more often affected. The risk of a recurrent injury is 12 to 31%. A prior, similar injury increases the risk by a factor of 2-6.

Age and prior injury are independent risk factors. Conflicting results exist with regard to a lack of strength and flexibility or an increased level of fatigue. The influence of genetic, environmental and behavioural aspects is unknown. There are indications that the use of manipulative techniques on the spine is able to reduce the incidence of back and muscle injuries. Core stability training appears to reduce the risk of a recurrent injury, although further high-quality research into these statements is still required.

THE 11+: FIFA'S STANDARDISED WARM-UP PROGRAMME

The **11** warm-up programme, which was further developed into the **11+**, is a standardised injury prevention programme designed by FIFA (Fédération Internationale de Football Association). It starts with an 8-minute running section (running straight ahead, running sideways with and without shoulder contact, hips turned in and out, forward and backwards sprints), and finishes with a 2-minute running section (running straight ahead, running bounding and running plant & cut). The middle section consists of strength exercises (side and front bench, hamstring strengthening exercises), balance and plyometric exercises (squats and jumping) and lasts 10 minutes. For the 11+, which was developed later, three different levels of difficulty were introduced for the middle section. (Previously, there was only one level.) The running sections were not changed. The goal of **the 11+** was to reduce the amount of non-contact injuries to the lower extremity.

When practised consistently (at least 2x per week over a period of at least 6-8 weeks), the rate of injury to the lower extremity can be cut by up to 29%. The proportion of serious injuries (injury downtime > 28 days) falls by up to 45%, and the proportion of non-contact injuries by up to 49%. The last percentage also relates to players incurring more than two injuries per season. In one study, overuse injuries were even cut by about 53%.

Fig. 53: The FIFA 11+


FIFA 11+
PART 1 RUNNING EXERCISES · 8 MINUTES
1 RUNNING STRAIGHT AHEAD
2 RUNNING HIP OUT
3 RUNNING HIP IN
4 RUNNING CIRCLING PARTNER
5 RUNNING SHOULDER CONTACT
6 RUNNING QUICK FORWARDS & BACKWARDS
PART 2 STRENGTH · PLYOMETRICS · BALANCE · 10 MINUTES
LEVEL 1
LEVEL 2
LEVEL 3
7 THE BENCH STATIC
7 THE BENCH ALTERNATE LEGS
7 THE BENCH ONE LEG LIFT AND HOLD
8 SIDEWAYS BENCH STATIC
8 SIDEWAYS BENCH RAISE & LOWER HIP
8 SIDEWAYS BENCH WITH LEG LIFT
9 HAMSTRINGS BEGINNER
9 HAMSTRINGS INTERMEDIATE
9 HAMSTRINGS ADVANCED
10 SINGLE-LEG STANCE HOLD THE BALL
10 SINGLE-LEG STANCE THROWING BALL WITH PARTNER
10 SINGLE-LEG STANCE TEST YOUR PARTNER
11 SQUATS WITH TOE RAISE
11 SQUATS WALKING LUNGES
11 SQUATS ONE-LEG SQUATS
12 JUMPING VERTICAL JUMPS
12 JUMPING LATERAL JUMPS
12 JUMPING BOX JUMPS
PART 3 RUNNING EXERCISES · 2 MINUTES
13 RUNNING ACROSS THE PITCH
14 RUNNING BOUNDING
15 RUNNING PLANT & CUT
MY GAME IS FAIR PLAY
FIFA
F-MARC
FOOTBALL FOR HEALTH
FIFA

CHAPTER 5

PERFORMANCE DIAGNOSTIC MEASURES

Well-developed physical fitness on different levels is vital to be able to play football at a high level. From a sports medicine perspective, it is, therefore, important to find out each player's current physical performance capacities and, particularly if weaknesses are identified, to improve it.

Here we present the physiological profile for football, in order to illustrate the necessary physical performance requisites. Building on this, we then present different test procedures that can be used to record the identified performance requisites.

5.1 PHYSIOLOGICAL PROFILE

Football is a high-intensity team sport, which is characterised by the high demands it makes on a player's physical capacities. Frequent changes of direction and intensity combined with direct contact with the ball and opponents require highly-developed competence in all relevant physical capabilities.

During a football game, players run an average of 10 to 12 km, which can vary considerably depending on the tactics of the home or opposing team or playing position. The majority of this total distance is in the low-intensity domain (walking, slow jogging). Up to 30% of the whole running distance is run at high intensity (> 14 km/h) or sprinted. The greatest running distance is usually covered by central and wide players (midfield and defence), while forwards and central defenders on average run the shortest distances.

However, forwards and wide players sprint most often and fastest. This means that players on the wing, in particular, must have both great speed and great endurance. Goalkeepers are usually considerably weaker in both areas.

As well as distance analyses, other activities typical of a football game should also be considered. For example, a football player performs an average of about 1,400 different actions per game, which are not necessarily of high intensity. However, this does mean that a change of intensity or action takes place every 4 to 6 seconds. Highly intensive actions occur on average every 70 seconds. Various other actions are incorporated into these constant changes of movement direction and speed, such as turns, jumps, short accelerations or decelerations, which can be very intensive, particularly when combined with opponent contact during tackles.

It is generally accepted that these brief, intensive bursts of action are especially important in game-deciding situations. It has been demonstrated, for example, that straight line sprints without contact with opponents and ball are vitally important when it comes to goal-scoring. This allows the striker to reach the anticipated place on the pitch at the right time (as quickly as possible) in order to go on to score a goal before the defender has time to stop him. Sprints over distances of up to 10 m, which above all require good starting or acceleration ability, are, therefore, considered to be particularly important. But also longer sprints (good basic speed) are essential in other situations (wing play and counterattacks).

Conversely, agility sprints, jumps and turns are less important when it comes to scoring goals. However, such actions can be more important in game-deciding defensive actions, when it is vital to react appropriately to the actions of opponents and prevent them from scoring goals. Jumps are particularly

important in set pieces (corners and free kicks from the sidelines), both in attack and defence. These different actions require good levels of speed (both linear and agility sprints) as well as explosive strength.

This typical structure of football, with frequent changes of intensity and highly intensive actions in important situations, requires a high average playing intensity (even when the majority of the distance is covered at a moderate speed). The energy consumption during a football game at the highest level can be up to 1,500 kcal (i.e., 1,000 kcal/h). High demands are, therefore, placed on the players' metabolism. Although, due to the high and variable intensities, most of the required energy is produced by carbohydrates; it is important that in less intensive phases, the fat metabolism takes over a relevant part of the energy supply so that carbohydrates are saved for important phases of the game.

Good basic endurance is an important prerequisite in order to draw on the fat metabolism during less intensive phases of the game.

The high intensity of football is also demonstrated by the fact that the average intensity corresponds to approximately 70 to 75% of maximal oxygen uptake or 80 to 85% of maximal heart rate. This intensity is around the anaerobic lactate threshold (maximal lactate steady-state). During this 90-minute high demand placed on the cardiovascular system and metabolism, frequent loading peaks of up to 100% of maximal heart rate are also observed. These peaks are particularly common in intensive playing phases when continual pressing is practised in order to keep the opponent under constant pressure.

There is a visible drop in playing intensity during the course of the game. Various different scientific studies have shown that an appropriate endurance training programme counteracts this drop in intensity to enable a high intensity to be maintained until the end of the game. Players with good endurance are also able to perform more sprints and have more frequent ball contact. Even fatigue-induced losses of concentration and technical difficulties at the end of a game (often the most decisive phase of the game) can be reduced. Because of improved endurance levels, these aspects widen the coach's choice of tactics.

Intensive, situation-appropriate pressing, continual shifting of player positioning and resulting overcrowding in attack and defence are characteristic tactics of modern football. Good **endurance**, therefore, forms the foundation of successful modern football. Within this overall structure, single, highly intensive actions, both in defence and in attack, often make the difference between winning and losing a match. So **strength**, especially **explosive strength**, as well as **speed** are also very important. In order to be able to develop these physical performance prerequisites optimally for each individual player, an essential part of modern football is the early identification of any physical weaknesses so that they can be improved by means of targeted training. The most up-to-date test procedures currently used in elite international football are presented in the following chapters.

5.2 ENDURANCE TESTS

In recent decades, a number of different test procedures have been developed for football in the field of endurance diagnostics. The simple field tests originally used to evaluate endurance ability, such as the Cooper Test (12-minute run), were superseded by laboratory tests or test procedures that were closely based on laboratory methods. In the last decade, the trend has reverted to easily implementable field test procedures designed for the specific demands of football, particularly the intermittent loading structure and varied movement patterns.

5.2.1 LAB TESTS

This chapter explores different lab tests and test procedures that are closely based on laboratory methods, but which can also be implemented as field tests.

In the 1970s, the German national football players were tested on the *bicycle ergometer*, when *maximal oxygen intake* (VO_2max) was identified as the gross criterion of endurance capacity. However, as the bicycle ergometer represents a very unspecific form of exercise for football players, this form of performance testing is now only of historical importance. However, the bicycle ergometer is still very important as a way of measuring cardiovascular health (exercise ECG), and it is part of the compulsory screening test for professional players (see chapter 1).

Running is the typical form of movement in football, which is why the *treadmill ergometer* is still a widespread method of testing endurance capacity in football players. Usually this is done by means of an incremental multi-stage exercise test (fig. 54a). At regular intervals of time (e.g., every 3 or 5 min) or distance (e.g., 800, 1,200 or 1,600 m), the running speed is increased by a pre-determined amount (0.5 m/s or 2 km/h). There is a short rest between each stage to allow a drop of blood to be taken from the earlobe or fingertip. The lactate concentration in this drop of blood is then measured.

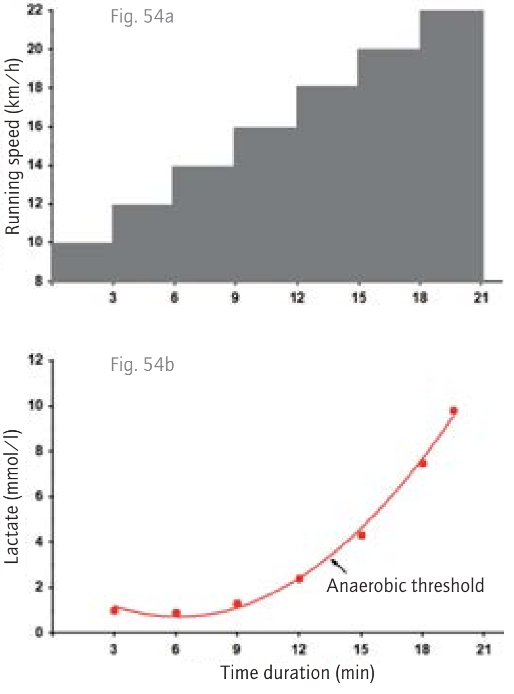


Fig. 54: Characteristic exercise protocol of a running field stage test (a) and the lactate performance curve with anaerobic threshold resulting from this (b)

From the lactate curve obtained in this way (fig. 54b), different methods can be used to determine the lactate or anaerobic threshold. The running speed at the anaerobic threshold is a good criterion for endurance capacity. In addition, intensity recommendations (speed or heart rate targets) can be derived from the figures obtained in this way for endurance training (see chapter 6.1).

This procedure allows for the test to be performed submaximally (i.e., the player need not exercise to exhaustion).

Nevertheless, relevant information regarding anaerobic mobilisation can be derived from the maximal speed achieved in such a test, so it is recommended to also perform incremental lactate tests to subjective exhaustion (if there is no contraindication, such as an acute infection or acute injury). In the treadmill ergometer test, the VO_2max can also be determined, if appropriate equipment for measuring gas exchange parameters is available. A stage test in the lab takes between 30 minutes and 1 hour for one player, including warm-up, so for a team with 24 players, at least a whole day must be set aside if no more than one treadmill is available.

The *incremental lactate test* can also be conducted as a field test on a track (ideally an athletics track: 400 m outdoors or 200 m indoors). The speed can be set by using marked sections on the pitch (e.g., cones placed every 55 yards, fig. 54) together with appropriately-timed sound or light signals, or by using a bike with a tachometer. The exact implementation depends on the test protocol selected (duration and speed increment for each stage).

For more than 20 years, the performance testing protocol used by the German Football Federation has been very strongly influenced by laboratory testing. The stage duration is set at 3 minutes, and the stage increment is 2 km/h.

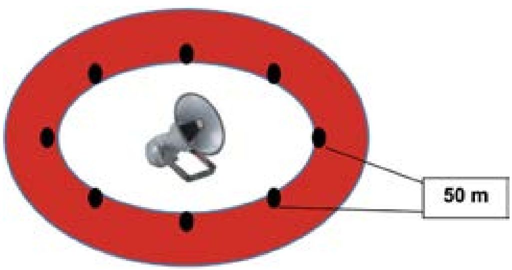


Fig. 55: Test setting for a running field stage test on a 400-m track in an athletics stadium (cone markings set every 50 m)

The starting speed is 10 km/h, and the test is usually carried out until exhaustion. Using this protocol, the first stage covers a distance of 500 m and increases by 100 m per stage. A test lasts about 30 to 40 minutes, including warm-up and cool-down. Using this organisational form, an experienced testing team can test up to eight players at the same time so that a complete team of about 24 players can be tested in less than three hours. The availability of portable equipment means that a spiroergometry test is also theoretically possible, whereby the expense involved would, in this case, be outweighed by the benefit derived from conducting it as a field test.

5.2.2 SPORTS-SPECIFIC FIELD TESTS

Lab tests or lab-test-based testing procedures allow for a very standardised performance diagnosis. Usually, the results are easy to interpret and comparable between different testing centres. A central point of criticism of this type of procedure, which was originally developed for classic endurance sports, is that it does not reflect the typical intermittent activity structure found in football. For this reason, different testing procedures have been developed that are clearly based on the football-specific activity structure and are intended to allow intermittent endurance to be measured accurately.

One part of these more sports-specific testing procedures is based on the principle of the well-known *Cooper Test* (12-minute run)—covering as much distance as possible in a given time. Other testing procedures are based on the testing structure of lab tests, with a constantly increasing exercise intensity. The duration is usually measured until fatigue-induced exhaustion. In addition, there are other testing procedures that attempt to reflect the activity structure of football as exactly as possible. Testing procedures and their basic concepts are described in more detail here.

The *Bangsbo Test* comprises different running forms that also occur in the sports-specific structure of football, such as forward, backwards slalom running and sidesteps. Fifteen-second, high-intensity periods alternate with 10-second recovery breaks, thus simulating the interval character of football (fig. 56a). The total distance covered in 16.5 minutes is used as a criterion for endurance capacity. The net exercise time (not including active recovery) is 10 minutes.

The *Hoff Test* also uses a circuit, although this time it is covered with a ball in different movement forms (e.g., slalom dribbling, crossing hurdles, dribbling backwards) (fig. 56b). The distance covered in 10 minutes is measured.

These types of testing methods are an easy way of obtaining a rough estimate of endurance ability, whereby different factors can distort the result (e.g., incorrect pacing due to

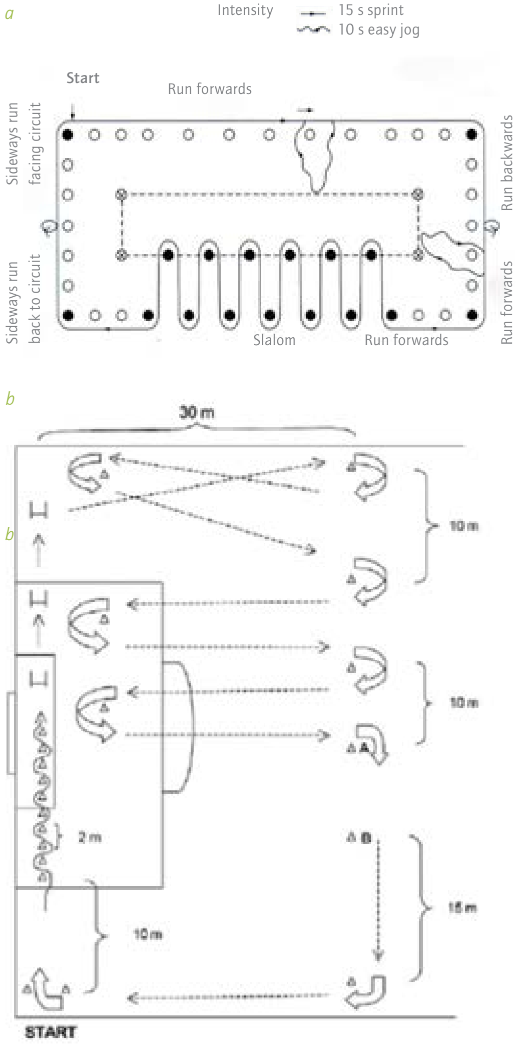


Fig. 56 a + b: Examples of football-specific endurance tests: (a) Bangsbo Test (by Bangsbo and Lindquist, 1992), (b) Hoff Test (by Hoff et al, 2002). Further explanations are given in the text.

inexperience, deliberately slow start to the test at the start of the pre-season preparation and much more intensive execution afterwards in an attempt to simulate great training progress). In the lower amateur ranks, these test methods are a simple form of performance testing, while their value at elite level is more questionable. However, this kind of circuit with football-specific movement forms is nevertheless a suitable endurance training method (4 x 4-min interval training in the Hoff Test) (see chapter 6.1).

In recent years, *intermittent Yo-Yo Tests* have been used in football and in other team sports. These tests are closely based on the *shuttle run test*, in which athletes have to run back and forth between two lines 20-m apart. As in an incremental lactate test, the running speed is increased at regular intervals (here by 1 min) by a given amount (0.5 km/h). In the Yo-Yo Tests, after every 20 m + 20 m interval, a short, active recovery break is incorporated in order to simulate the intermittent activity structure of team sports (fig. 57).

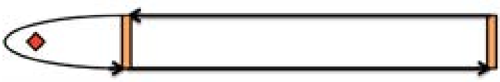


Fig. 57: Yo-Yo Test

In total, there are five different types of Yo-Yo Test, which essentially differentiate with regard to starting speed and stage increment. While the slowly increasing *yo-yo endurance tests* mainly focus on measuring sports-specific basic endurance, in *yo-yo recovery tests*, the intensity is increased much more quickly so that instead the anaerobic capacity and recovery ability between intensive bursts of activity are measured. The intensity is controlled by audio signals ('bleeps') that are played on a commercially available CD. The criterion for measuring endurance ability is the maximal number of stages attained.

These tests usually show a high correlation to running performance in a game and successfully differentiate between players of differing playing levels. They are relatively simple to implement and, therefore, represent an economical and practical alternative to lab tests. However, it is almost impossible to derive training recommendations for endurance training (at most, from the maximal heart rate). Specific Yo-Yo Tests can be selected that are appropriate for different age groups and performances levels.

As well as these test procedures, there are still other variants that essentially aim to imitate the typical activity structure of a game as accurately as possible. These tests are characterised by a constantly changing running pace, lasting between 45 and 90 minutes and either carried out as field tests or on a treadmill. While the suitability of such tests for use in sports should be assessed very critically, their effectiveness has been scientifically proven for testing different methods of influencing playing performance (e.g., by nutrition or methods for influencing temperature regulation).

It is vitally important in all these test procedures that the athlete actually exercises to the point of exhaustion. This means that the individual motivation of each player on a team must be equally high to ensure that any comparison between players is reliable. Should there be a meaningful comparison over a certain period of time for a player (e.g., training progress to be recorded), it should also be ensured that the player has exercised equally hard in all tests. It is, therefore, advisable to record the athlete's exertion using objective parameters. A good example of this is maximal heart rate (HRmax = at least 220 – age) or blood lactate concentration (> 8 mmol/l), possibly combined with the player's own subjective feelings (Borg Scale of Perceived Exertion).

A comprehensive summary of the specific advantages and disadvantages of lab tests compared to supposedly more football-specific testing methods can be found in table 7.

Tab. 7: Comparison of the advantage and disadvantages of traditional (laboratory) tests and more football-specific testing procedures

	Traditional (lab) tests	(More) Football-specific tests
For	• Well-evaluated, standardised • Testing of separate physiological components • Clear training consequences • Comparability between testing centres • A lot of experience	• Simulation of football-specific exercise pattern • Possibly better motivation • Little or no technical equipment required
Against	• Need for laboratory and equipment • Not a football-specific exercise pattern	• Lack of standardisation • Dependent on motivation • Traditional tests often necessary for clear interpretation or training consequences • Little experience

5.3 SPRINT TESTS

As well as endurance, speed is also an important performance prerequisite in football. We usually distinguish between three different components of speed: *straight line speed* (linear sprints), *speed with change of direction* (= agility) and *repeated sprint ability* (RSA). These three forms represent different aspects of speed, and ability in one of the three components is not necessarily transferable to another component. A player who can run fast in a straight line does not necessarily have good agility or cannot necessarily perform several sprints consecutively in a short period of time. For this reason, these different forms of speed must be tested, and also trained, separately. In sprint tests, players should be sure to warm up properly in order to reduce the risk of muscular complaints or injury and to ensure that the prerequisites for meaningful tests are given.

5.3.1 LINEAR SPRINTS

Linear sprints are sprints with no obvious change of direction (that also includes a slightly curved track without a second acceleration). In football, almost all sprints are shorter than 30 m and, of these, approximately half are short accelerations over distances of 10 m. The fastest professional football players can reach maximal speeds of more than 33 km/h during a game.

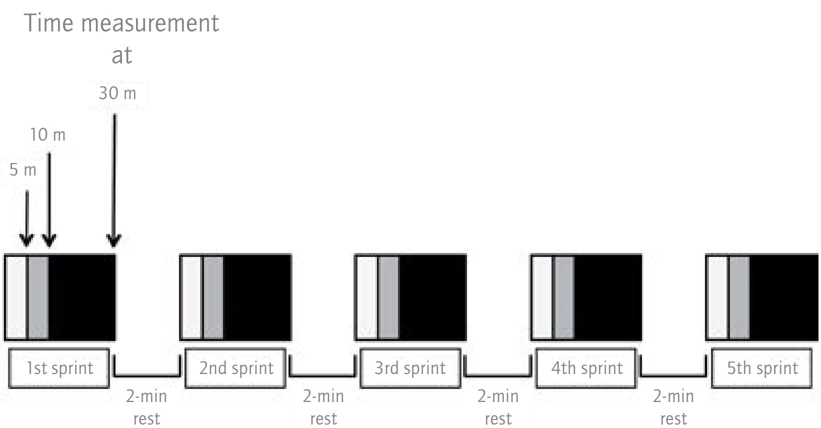


Fig. 58: Format of a 5 x 30 minute sprint test (according to Kindermann, 2006)

For this reason, in the most up-to-date sprint tests, the norm is to measure total distances of 30 or 40 m with split times taken at 5, 10 or 20 m. For the past 20 years, the German Football Federation has used a 30 m sprint test with split times of 5 and 10 m (fig. 58). The 5 m time is a measure of starting ability, the 10 m time of acceleration and the 30 m time (better: 10-30 m time) a measure of basic speed.

When carrying out this kind of sprint test, it is very important to observe methodological standards, as differences may significantly influence overall sprint times. Times should be measured electronically by photocells, as hand timing at the speeds achieved in such a short time is too inaccurate. Several attempts should always be made so that the maximal speed can be identified. Sufficient rest (about 2 min) should be allowed between the attempts in order to ensure a complete recovery.

For evaluation purposes, it is advisable, on the one hand, to take the average of several attempts, as this increases reliability and allows training-related changes to be documented better. On the other hand, the best sprint times give relevant information about a sprinter's maximal achievable speed. The photocells should, if possible, be set at hip height. It can also make a significant difference whether the test is conducted on a synthetic (athletics) track or on the pitch in football boots. While testing on the pitch approximates more closely to normal match conditions, tests on synthetic tracks are much more standardised, as weather-related influences (e.g., hardness of the pitch in the summer compared to winter) are eliminated. This is particularly important if multiple tests are planned during the course of the season, in order to obtain a longitudinal comparison for each individual player. In this case, it is ideal if tests can take place under the same conditions, in an indoor track and field arena, for example.

5.3.2 AGILITY

As well as linear sprints, agility is also an essential component of football-playing performance. This kind of sprinting is characterised by short starts with abrupt stops and then new starts in a different direction. Players who are very quick at linear sprints are not necessarily as quick when it comes to agility. Strong, heavy players are often at a disadvantage here as their mass must be accelerated every time they change direction. On the other hand, light and nimble players are at an advantage.

There are a great many ways of testing agility, which were originally developed for the specific requirements of different team games. There are often significant differences between these tests with regard to the number or severity of the changes of direction. It is, therefore, unsurprising that the results of these tests are not always comparable. Possible laterality differences must also be taken into consideration when interpreting the results, and the tests should always contain changes of direction in both directions.

Fig. 59a

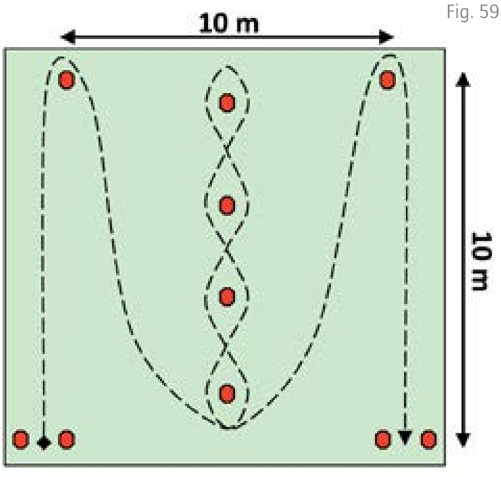


Fig. 59b

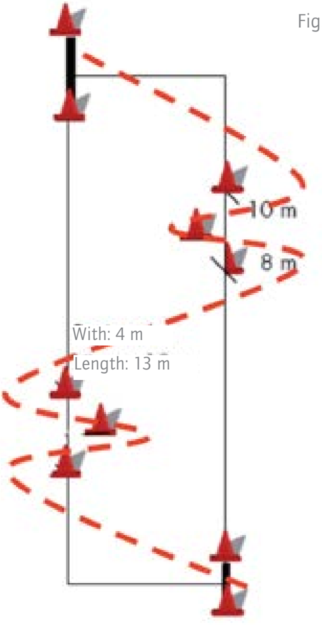


Fig. 59: Test layout ot two agility tests: (a) Illionois agility test, (b) German Football Federation (DFB) Talent Centre test

The German Football Federation (DFB) uses two different tests for agility. One test is the *Illinois agility test* (fig. 59a). This test consists of several accelerations over about 10 m with abrupt 180-degree changes of direction and a slalom sprint. The total distance is about 60 m, and the time duration is about 15 seconds. Another test has been developed especially for the *DFB Talent Centre* (fig. 59b). This circuit consists of three short accelerations of 5 m, interspersed with short, closely-positioned slalom movements. The total distance covered is about 20 m, and the test lasts about 7 to 8 seconds.

The large number of different tests and the sometimes limited comparability between them means that in practise, people have tended to design and implement new tests that are especially suited to particular requirements.

Experience has shown that this process only serves to exacerbate the problem of lack of comparability and possibly that of clear interpretability. Agility occurs in a match in very different forms so that it is questionable whether a single test procedure can be developed that conforms to the specific requirements of football. The use of established and scientifically well-researched test procedures is therefore recommended instead of developing and using new tests.

5.3.3 REPEATED SPRINT ABILITY (RSA)

As well as the two types of speed mentioned previously, *repeated sprint ability* (RSA) also plays an important role in football. RSA is the ability to perform several consecutive sprints with no significant loss of intensity. Particularly in intensive, possibly decisive phases of a game, it can be necessary to perform several sprints in a short period of time in order to create important breakaway runs or push forward into critical spaces.

In recent years, increasing numbers of RSA tests have been developed and also formed the subject of scientific research. They usually involve sprinting over distances of between 20 and 40 m. The number of repetitions can vary greatly between 6 and 20. The rest between each sprint is relatively short (20-45 s), making complete recovery impossible. The most important measurements to be collected are the fastest and slowest sprint time as well as the percentage deterioration in performance over all the sprints. It is important to ensure that all sprints are performed at maximum intensity (flat out), meaning that the player does not start off running slowly in order to save strength for later runs. This can be prevented by conducting a pure sprint test prior to the actual RSA test, in order to obtain realistic times for the initial sprints.

5.4 PLYOMETRIC TESTS

As well as speed and endurance, *explosive* power of the leg muscles are very important when it comes to performing well in a game, especially in explosive moves like sprints or jumps.

A standard jump test to establish basic explosive strength of the leg extensor muscle chain has proved to be effective. This consists of three components: the *squat jump*, the *counter movement jump* and the *drop jump*. This test sequence allows the measurement of purely concentric explosive strength ability and explosive strength ability in the slow and fast stretch-shortening cycle. The aim in all jump forms is to jump as high as possible. In order to measure the pure explosive strength of the leg extensor muscle chain, it is recommended that the player leaves his hands on his hips during the jumps. Otherwise, co-ordination skills (e.g., arm-leg co-ordination and transfer of arm impulses) will contribute to the height jumped.

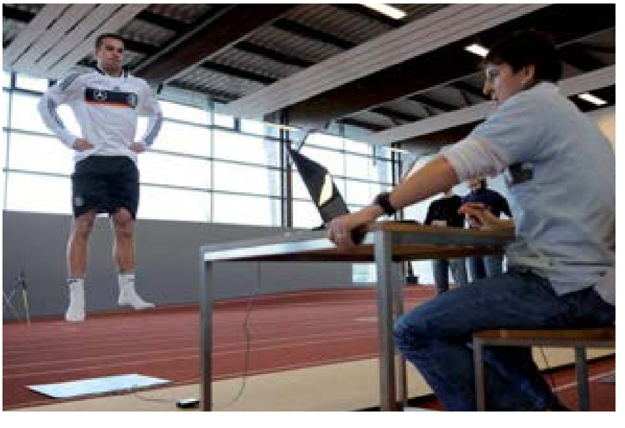


Fig. 60a-c: Starting position for jump tests in the standard jump test sequence: (a) squat jump, (b) counter movement jump, (c) drop jump

The *squat jump* is a basic jump with no countermovement from a squatting position (knee and hip angle approximately 90 degrees; fig. 60a). The power development involved is purely concentric. This is not usually the case in sports and is a very untypical movement form in football. These test results are usually used to compare the explosive strength performance in the stretch-shortening cycle (counter movement, jump and drop jump) compared to purely concentric power development. From a methodological point of view, it is very difficult to perform the jumps without a (slight) countermovement of the legs, thus making it difficult to interpret the test result. For this reason (and for reasons of test economy), this test tends not to be used.

The *counter movement jump* is performed from a standing position (fig. 60b). A quick countermovement of the legs (up to a maximal knee angle of about 90 degrees) is followed by an explosive, vertical take-off. The *drop jump* is a depth jump. The athlete drops from a pre-determined height and, after landing with the shortest possible ground contact, must jump up as high as possible (fig. 60c). As well as jumping height, in this case, the ground contact time and the reactivity index (ratio of jumping height to ground contact time) is also used to measure reactive force in the short stretch-shortening cycle. When a comparison of different tests by the same athlete is required, the drop height must be identical. For football players, the drop height used is usually between 30 and 40 cm.

It is important to perform all jumps technically correctly. This means that at both take-off and landing, the ankles, knees and hips should be extended. If these criteria are not met during a jump, the jump should not be rated. In order to judge this reliably, some experience is required on the part of the test leader. As in procedure for the sprint tests, it is advisable to perform several technically

correct jumps. The height jumped is usually measured by means of contact mats (which usually just measure the length of time that the athlete is in the air or in contact with the ground) or with a force plate (here it is also possible to determine the height jumped from the force impact at take-off and landing). Such measurements are technically demanding and time consuming.

At amateur level, a simpler test method, such as the *jump and reach test (vertical or Sargent jump),* can be used. This involves standing against a wall and marking the maximum vertical reach height of one arm. The athlete then jumps up and touches as high up the wall as possible with one arm outstretched and the tips of the fingers coloured with chalk. These markings allow the jumping height to be measured. It is obvious that several factors (e.g., spatial and chronological co-ordination, influence of arm swing) could influence the test result. Nevertheless, these tests obtain very useful information about the explosive strength of players on a team at amateur level.

Another way of measuring the explosive strength of the leg extensor muscle chain is the *standing long jump test*, in which the athlete jumps horizontally as far as possible from a standing position, e.g., into a long jump pit. The jump can be measured with a simple measuring tape. In this test, strength development in the horizontal plane and, therefore, the typical movement direction in running and sprinting, plays a significant role. This test can, therefore, be considered a useful complement to purely vertical jumping, particularly as the horizontal distance jumped also has a close correlation to sprinting speed.

To summarise, it can be said that plyometric tests are a simple and practically relevant way of measuring the basic explosive strength of the leg extensor muscle chain. These tests are standardised, and the movements involved are functional; in other words, they are not guided, as is the case with exercises on weight training machines.

5.5 SPORTS-SPECIFIC TESTS

As well as the previously mentioned test procedures that are used to test single physical performance prerequisites, other test procedures are used in football that test a combination of all conditioning components plus technical skills. The reasoning behind this is that during a game, all performance prerequisites are solicited at the same time, and such tests are, therefore, considered more sports-specific.

These types of test usually take longer and the players move continuously, so the endurance is suitably performance relevant. They also include sprints and jumps, and the ball is always involved, or at least in certain exercises. Some tests also comprise technical exercises, such as shots at goal and passing drills, which are either evaluated by points for goals scored or qualitatively by the coach. At the end, a total score is calculated, which is intended to provide information about players' football-specific performance levels.

Those kinds of tests are often really arbitrary collections of individual exercises that are considered relevant in football and are consequently poorly evaluated scientifically. That means that the extent to which the test results are, for example, independent of the test administrator is often unclear (though partial test results can be based on the coach's subjective impressions) and therefore reproducibility is questionable. Only a reproducible test would enable a reliable assessment of the results. In most tests, it is also unsure whether actually football-specific performance ability has been measured more successfully. The game of football is very complex and varied, so it is questionable whether it can be reproduced in one single test (however complex).

Another problem of that kind of football-specific test procedure is that no performance breakdown is apparent from the total score. A player can, therefore, compensate for a weakness in endurance by above-average performances in other areas, so while endurance may be another player's strong point, both players may have the same total score. It is, therefore, impossible to state clearly in which areas there are weaknesses that could be improved with appropriate training methods. In such tests, as well as the total score, all physical and technical partial components should be measured and evaluated separately.

If there are results for tests to measure individual physical performance prerequisites (as described in the previous chapters), such sports-specific tests can provide interesting additional information on the performance level of each player on a team. However, a prerequisite for this is that the test is conducted under standardised conditions. As these tests are usually relatively simple and can be administered without any major technical resources, they are attractive alternatives to traditional laboratory-based tests, particular at amateur level.

CHAPTER 6

SPORTS MEDICAL ASPECTS IN FOOTBALL TRAINING

Modern football places high physical demands on every single player. As well as the physical exertion involved in training and in matches, from a certain playing standard, other pressures (not necessarily of a sporting nature) are also added, including financial or media pressure, extreme importance of individual matches or competition periods, private or professional conflict with the practise of sport and frequent travel—sometimes over long distances. The fear is often expressed that players can no longer cope with this multitude of different pressures, particularly in sensitive competition periods, such as when both mid-week and weekend league games are played, and that the demands might be too high in some cases. For this reason, the chapter is intended to assess the pressures that players face. It is important that the coach or team medical staff—team physician, physiotherapists, fitness trainer—are able to measure players' stress or recovery levels accurately. There is also a presentation of successfully-used regeneration methods.

Well-developed fitness is a tried and tested way of protecting against excessive stresses and injuries; also, it is an important prerequisite to reach a high sports-specific performance standard. That is why this chapter starts by presenting appropriate training methods for improving physical performance prerequisites in the areas of endurance, speed and explosive and plyometric power.

6.1 ORGANISATION OF ENDURANCE TRAINING

Endurance is one of the most important physical prerequisites in football. For this reason, endurance training typically forms an important part of the preparation phase. While originally this involved a lot of classic endurance training, nowadays, the trend is to work with small-sided games and (high-intensity) interval training on the football pitch. Such sessions can be integrated into workouts on the pitch and are time efficient. The various different endurance training methods are presented next. In addition, practical tips for the transfer into daily training and an evaluation of the pros and cons of each method are also given.

6.1.1 CLASSIC ENDURANCE TRAINING

Classic endurance training is a commonly-used method that improves basic endurance, particularly at the start of the preparation phase of training. It involves long runs of differing durations and intensities. These training sessions usually last between 30 and 60 minutes and are performed at low to moderate intensity between 70 and 85% of maximal heart rate. A better, but much more complicated to measure, marker from which to derive training intensity is the maximal lactate steady-state, or anaerobic threshold.

Longer training sessions (about 1 h) are run at about 80% of the lactate threshold (extensive endurance training), while the shorter, intensive tempo runs are performed at 95 to 100% of this value. In *fartlek* training, the intensity is deliberately varied between these two poles, and sometimes beyond. Regenerative endurance runs, which are integrated during intensive training phases or after training games in order to promote recovery, are performed at 80% of the lactate threshold. Make sure that the duration (max. 30 min) as well as the intensity are kept low.

With two to three endurance workouts per week, the required training effect can be achieved in the preparation phase. During team training, it is advisable that either every player runs alone according to individually-calculated heart rate values or divide the team into several groups according to performance level, and let the groups then run at the same speed (Note: not at the same heart rate).

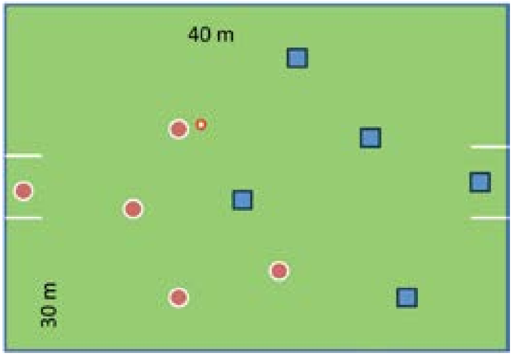
Traditionally, long-distance training was often used to train basic endurance. This was also because interval training involved a high lactate accumulation, and many coaches and also many sports physicians were afraid of overtaxing their players due to the associated acidosis.

In recent years though, the endurance method has attracted increasing criticism because it is more time consuming than interval training and is less sports-specific, as it lacks the football-specific, intermittent exercise structure, alternating between very high and very low intensities. However, scientific studies have hitherto been unable to demonstrate that interval training enables better basic endurance adaptations than long endurance runs.

Among other things, endurance runs have the advantage that they can be done outside the official training times, as 'homework', as it were. They, therefore, do not take up team training time, thus eliminating any effectiveness disadvantages due to their time-consuming nature. Modern heart rate monitors enable these training sessions to be recorded and later downloaded to a computer to be evaluated.

6.1.2 INTERVAL METHODS

As well as continuous endurance training, interval training has become increasingly popular in high-performance football in recent years. The structure of different training sessions can vary greatly. One method that has become very widespread is intensive interval training with an interval duration of 4 minutes (and a rest of 3-4 min) at 90 to 95% of maximal heart rate. While this training method was originally performed as a purely running workout on the treadmill, there are now several different organisational forms. It is, therefore, possible to perform this kind of workout in a football circuit (e.g., Hoff test; fig. 56b in chapter 5.2.2) with a ball, thereby working on technical elements as well as conditioning. Even more sports-specific still is this type of training in the form of small-sided games (fig. 61).



- 4 x 4 min (4-min rest), HR > 90% HRmax
- Motivation by the coach
- Ball always in play
- Pitch sufficiently large:
  2v2 (20 x 25 m)
  3v3 (25 x 35 m)
  4v4 (30 x 40 m)

Fig. 61: Layout (top) and organisational form (bottom) in the implementation of endurance training in form of small-sided games

In this organisational form, it is important to make sure that a sufficiently high exercise intensity is reached every time. These days, with modern heart rate monitors, it is possible to check the whole team 'online' during training, so it is very easy to determine whether every single player is training in the (preset) heart rate zone. In addition, with simple organisational measures, a high playing intensity can be achieved.

From a practical point of view, it is important that a coach is present for this training to motivate the players and ensure there is constant movement. In addition, it should be ensured that enough balls are available so that there is always a ball in play and unnecessary delays are avoided due to having to retrieve a ball. A sufficiently large pitch size also ensures that the playing intensity remains high. If the pitch is too small, there is a danger that there is less room to run in, and the focus will move to increased technical skills (shift in training emphasis).

Small team size can also keep the playing intensity high. If teams are too big, there is a danger that some players can take a back seat and not achieve the required training stimulus. Teams of between two and five players seem to be ideal. Fig. 61 gives an overview of important organisational measures that should be kept in mind when conducting interval training in the form of small-sided games.

Even if 4 x 4-minute intervals have become very popular, the exercise–recovery structure can vary greatly. Interval durations can, therefore, range from 10 seconds to 8 minutes. There is, as yet, no evidence that any one form of interval training is better than any other. One example of an organisational form that can quickly and easily be transferred to the football pitch consists of two sets of 12 to 15 intervals with 15 seconds exercise and 15 seconds rest. This training session takes about 25 minutes, including all recovery breaks, and the whole team can train at the same time. For this training form, it also makes sense to split the team into several groups of roughly the same ability according to their endurance levels. The intensity or running speed is either based on the maximal speed attained during a stage test (about 110% of this speed) or the lactate threshold (about 140% of the speed of the lactate threshold). Elite football players run about 75 to 95 m per interval (fig. 62). It is easy for the coach to blow a whistle to indicate the start and finish of each interval.

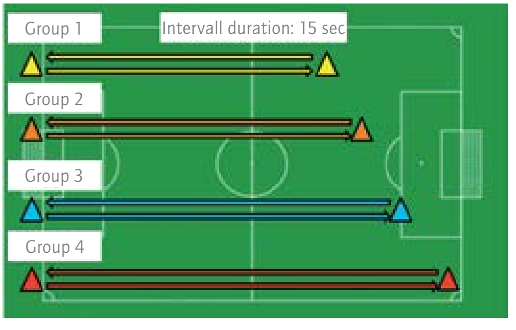


Fig. 62: Example layout of an interval workout on the football pitch (15 s exercise, 15 s jog recovery). For further explanation, see text.

This kind of workout will automatically create a higher lactate accumulation in the blood compared to normal endurance training. The blood lactate concentration can climb to values of 10 mmol/l, depending on interval duration and exercises–recovery ratio.

Both from a sports medicine and coaching perspective, there used to be a fear that this high lactate accumulation (acidosis) coupled with the higher muscular effort could have a negative impact on players' performance levels. For this reason, interval training was not recommended. However, such fears are usually unfounded. A correlation between blood lactate values and fatigue only exists at very high exercise intensity, such as in a 400-m race (lactate values up to about 25 mmol/l). The lactate values attained during football matches or in the interval workouts described previously are unremarkable in comparison. Nowadays, there are even indications that lactate promotes positive training adaptations (e.g., better blood flow and, therefore, a better oxygen supply to the recruited muscles).

It has been demonstrated that a twice-weekly interval workout over a period of between 7 and 13 weeks ensures the required endurance training effects. This is also realistic during the playing season. No signs of excessive fatigue or a reduction in playing performance have been observed. As the necessary energy during interval training is mainly supplied by carbohydrates, during intensive training phases, it is essential to ensure a balanced diet with sufficient carbohydrate intake.

6.2 TRAINING EXPLOSIVE POWER AND SPEED

Speed, or explosive power, is often particularly important in match-deciding situations in football. These usually involve explosive power and multidimensional sprints up to a distance of 30 m. It is, therefore, advisable to attach the necessary importance to these physical abilities in the training process. This section presents training methods to improve sprinting speed and explosive power in the leg extensor chain. There are two main methods of improving sprint starts and acceleration (the first 10 m of a sprint) and methods for improving basic speed (maximal sprinting speed).

Acceleration can mainly be improved by training forms in which the resistance for the driving muscles is increased, for example by *harness training*. An external resistance is created, for example, on a sled that the player pulls behind him while sprinting as fast as possible (distances of 20-50 m, approximately 4 reps, 5 kg resistance). Similar effects can also be achieved with small parachutes attached to the athlete's torso. In these sprint starts with added resistance, running speed, stride length and frequency are all reduced, while the knee and hip extensors solicited by the driving process are activated much more strongly. Uphill sprints can cause comparable stimuli so that these methods can also be used in acceleration training.

Strength training is another effective training form for improving sprint starts. It is important to emphasise that free squats with the long bar achieve better adaptations than guided squats on the machine. Also, methods that influence the neuronal activation of the muscles seem to be more effective than hypertrophy-oriented methods. For example, explosive squats with maximal loads (4 x 4 reps at about 85% of the 1-repetition maximum) have proved to be effective training methods. However, these exercises are very demanding in terms of co-ordination, so the exercises should always be carried out with a partner and inexperienced athletes introduced to the movement gradually. Combinations of neuronal-oriented strength training directly followed by speed work (contrast or complex methods) can be very effective. The aim should be to transfer the neuronal stimuli induced in weight training directly into the desired target movement. As well as the previously mentioned training methods, plyometric training forms can contribute to an improvement in sprint accelerations. An essential feature in all training forms is an increased demand on the driving muscles compared to free sprinting.

Maximal speed training uses the opposite strategy. Here, it is important to keep the resistance as low as possible and enable very high movement speeds so that a maximal final speed can be reached, with a long stride length and fast stride rate. This can be attained by free 'flying' sprints (rolling start) over 40 to 50 m. Supramaximal sprints (i.e., sprints in which the final sprint exceeds that of a free sprint) are also a suitable method for improving maximal speed. Such high final speeds can be attained by assisted propulsion over-speed training (in contrast to harness training, in which the athlete can be pulled along by bungee cords). Downhill sprints also enable a higher final speed. In this type of training, it may also be possible to achieve an additional stimulus for the reactive force important in sprinting due to the stronger eccentric component.

In addition to pure sprint training forms, *jump training* can also have a significant effect on maximal speed. A combination of vertical and horizontal jumps is recommended. The horizontal jumps provide important stimuli for the motion-generating muscles in the actual direction of movement.

The previously presented training methods are especially intended for training linear speed. Linear speed and agility, which is also important in football, are different forms of speed, meaning that pure sprint training will not necessarily improve agility. Agility sprints are characterised by a sequence of stops and starts, with accelerations in varying directions. This typical movement structure should be simulated in training. Ice baths currently appear to be a more practical solution for high-performance sports.

Tab. 8: Training methods to improve speed and explosive power; further explanation in the text

Training goal: Improvement of...	**Training methods**
Sprint acceleration	• Resisted sprints (e.g., sled pulling, brake parachute) • Uphill sprints • Free squats with bar (explosive-strength oriented, heavy weights, low reps, fast execution) • Complex—contrast method • Plyometric training
Maximum speed	• Flying sprints • Supramaximal sprints, assisted propulsion sprints (e.g., bungee cords) • Downhill sprints • Plyometric training (combination of vertical and horizontal jumps)
Agility	• Sprints with changes of direction (stops and starts), varied lengths and different directions and angles
Explosive power	• Explosive strength training • Unilateral (one-leg) strength training • Plyometric training • Contrast training • Loaded squat jumps

For the improvement of *explosive power*, there are essentially three different training methods available. Firstly, different strength training forms can improve explosive strength. Free squats with the long bar (heavy weights, few reps, fast execution) are proven to be very effective. Classic weightlifting exercises (e.g., snatch, clean and jerk) are also effective alternatives. It is important the execution is fast and explosive so as to induce the necessary neuronal adaptations. It is also possible to perform these weight training exercises on one leg, which makes it possible to work with lighter weights, thus reducing the strain on the spine. In addition, many movements in football (particularly running movements and jumps) are also performed on one leg only, thus ensuring direct transferability into the target movement. As well as pure strength training, explosive power *(plyometric)* training, particularly drop jumps, significantly improves explosive power performance. A combination of resistance training and plyometrics training appears to have an even greater training effect. They can also be supplemented by purely concentric squat jumps with additional weights *(loaded squat jumps)* as an effective way of improving explosive strength.

Speed and explosive power training can be integrated with relatively low volumes into the daily training routine at elite level, even during the competitive season. The required improvements can be achieved by performing these sessions two or three times per week over a period of about six weeks. In order to avoid overloading players, it is important that the general athletic training is aligned with the other training contents and especially other (and possibly competing) training contents in the conditioning area or particularly match commitments are taken into consideration. The danger of a drop in performance is still relatively low, though (see chapter 6.4). A comprehensive summary of different training forms to improve speed and explosive strength is presented in table 8.

6.3 INTEGRATION OF FITNESS TRAINING INTO FOOTBALL TRAINING

Usually, a specific, structured athletic training phase is mainly incorporated into the preparation phase before the beginning of the football season and during the winter break. To start with, the focus is on general basic endurance (often as classic endurance training). This is followed by specific, intermittent endurance training with high-intensity peaks, often using interval training or specific small-sided games. The nearer the first game of the season, the more the fitness training focus shifts to speed and explosive power. During the competitive season, general athletic training usually takes a back seat. Isolated sessions to maintain basic fitness are possible, although the training emphasis is on technical and tactical contents.

However, normal football training, together with a match at the weekend, is not always enough to maintain the fitness levels built up in the preparation phase. This is especially true for substitute players who do not get the additional training stimulus of a game. It is, therefore, advisable to continue to carry out fitness training blocks during the competitive season when the match calendar allows.

In modern, elite football, it is increasingly common that players' fitness levels differ due to selection matches, injuries, international championships (which can also take place in the junior age groups and on other continents during the European competitive season) or other commitments. These specific conditions in elite football call for an individualised, or at least group-specific, approach to general fitness training. It should also be noted that regular players need different training compared to those players who usually sit on the substitutes' bench. Similar considerations must also be made in the area of injury prevention (injury history of each player, as older players are more susceptible to football-related muscle injuries). Even in a team sport such as football, it is necessary nowadays to address the individual characteristics and weaknesses in the area of fitness, if resources—enough support staff, time and space—allow.

6.4 STRESS, RESILIENCE AND RECOVERY

Modern elite football is characterised by a high intensity and frequent matches, with the associated travelling and other stress factors. This leads to complaints (particularly in the media) about high workloads and, therefore, reduced regeneration, which may negatively impact playing performance. For this reason, in the following chapters we attempt to answer questions regarding stress due to typical training and match play, possibly sensitive seasonal periods, adequate methods of monitoring stress and also regeneration, and, finally, possible regenerative measures.

6.4.1 WORKLOAD AND STRESS DURING THE SEASON

In general, it can be stated that the typical workloads involved in professional football, even compared to other sports, has no significant impact on physical and mental performance. For example, it has been demonstrated that the average training and playing time per player in teams that compete in the UEFA

Champions League amounts to less than five hours of training time and less than one hour of playing time per week. The total time actually spent playing football is, therefore, less than six hours per week, or less than one hour per day.

These figures are far from remarkable and are considered to be a team average. Accordingly, this also means that in every team, there are some players who have considerably more playing time. Very important players, who also play on the national team, can play in as many as 60 matches per season. This also applies to some national junior players who, in addition to playing football, still need to finish their educational or professional training. Even if the total exposure is, on average, not particularly high, players are reporting increasingly credible subjective impressions of high stress levels. Furthermore, in specific, very sensitive phases of the season and in the case of a few, possibly more vulnerable individuals, stress levels can become critical.

A competition season may contain different critical phases. The first of these is the preparation phase. In this phase, most of the physical performance prerequisites for a successful season must be developed (see 6.3). The inherent danger here is that the high training volumes and intensities cause excessive fatigue. Normally, this risk is low, but it can be increased if players did not have a sufficiently long transition phase (e.g., due to an international selection tournament) or return to training and match play after a long injury lay-off time. The usual temporary fatigue at the end of a long preparation phase is normally very quickly reversed (max 2 weeks), so after a certain time with reduced training intensities in which, for example, the tactical foundations for the start of the competitive season are laid, players can regain their freshness to play matches.

Weeks in which mid-week as well as weekend matches are played do not automatically lead to signs of increased fatigue or a drop in performance (even when repeated for three weeks in a row). However, there are indications that this can lead to an increased risk of injury. In addition, towards the end of the season, significant signs of fatigue may occur. This can be increased even further if matches are particularly important, because the team is playing for the championship or fighting to avoid relegation, for example. Mental stress caused by the media, the club or the fans should also not be underestimated.

Another important, related point is that injuries should be completely healed, even if the affected player has a special value for his team. A premature return to training and match play greatly increases the danger of a recurrent injury, and diminished fitness levels can lead to overexertion. Although the danger of overexertion in normal football-playing activity is usually considered to be low, this should always be taken into consideration by the support staff and by individual players. Personalised training planning and structuring, a well-developed level of physical fitness and an adequate monitoring of both workload and regeneration are, therefore, recommended.

6.4.2 MONITORING WORKLOAD AND STRESS

Stress or fatigue occur on different levels in the human body, affecting the cardiovascular system, the metabolism, hormonal and immunological regulation and the central and vegetative nervous systems. An essential mechanism leading to overloading conditions is a chronically high level of stress, which may or may not be sports-related. This chronic overloading can cause the exhaustion of important resources in the body. Normal stress reactions are then down-regulated so that the body is 'protected' from further excessive strain. This has the effect of reducing maximal performance levels and increasing the perception of exertion under familiar submaximal loading (e.g., in training). In this respect, the current sports-specific performance level is the gold standard for measuring the status of stress and recovery.

As it is difficult and time consuming to measure sports-specific performance levels in football, simple sports-specific motor skills tests can be used instead. For example, simple speed or explosive power and endurance tests allow training-induced fatigue and a subsequent regeneration phase to be estimated. When carrying out these simple tests, it is important that the athlete exerts himself maximally for the test results to be reliable.

Different parameters can also be measured at rest. Mood changes are often the first signs of overloading. However, increases in training volume or intensity often cause similar mood changes even though the situation is far from problematic. Psychometric parameters (e.g., the Recovery–Stress questionnaire for athletes) are also relatively easy to influence, and a conscious or unconscious response to the questions in the direction of a suspected, desired output (e.g., when it comes to team selection) is possible and should be taken into account when interpreting test outcomes.

Other parameters that can be quantified at rest, heart rate variability, for example, have a very wide baseline variability, so it is very hard to draw reliable conclusions in individual cases. Even the regular monitoring of laboratory parameters from venous blood samples, as is commonly practised, is not a suitable way of indicating overloading or phases of high workload. Venous blood sampling should only be carried out if medically indicated (e.g., in the context of a differential diagnosis to rule out other possible causes of a drop in performance such as anemia, mononucleosis or sources of chronic infection) and be reduced to the necessary minimum.

Tab. 9: Practical methods for measuring workload and regeneration in high-performance sports

Tool	Measurement
Recording training workload and stress	• Objective (volume, intensity, HR, lactate) • Subjective (Borg) • Standardised recording in training diaries
Performance testing	• Maximal, standardised testing • As sports-specific as possible • Simple, sports motor skills tests (also co-ordination tests) • Resting baseline values should be known • Regular implementation possibly problematic due to need for maximal exertion
Psychometric questionnaire	• Good measurement of current training load • Timely reaction, but also as a result of changes in training volume and intensity • Individual baseline values should be known • Vulnerable to subjective influence
Blood and lab tests	• No reliable recording of overloading and recovery possible • Provide additional information on health status (if indicated for medical reasons)

Regeneration markers should be as sensitive as possible to small changes to allow the existence of both regeneration deficits and adequate recovery to be accurately detected. Likewise, a potential marker should also be as immune as possible to the external influences that typically occur in high-performance sports, and, as far as possible, should reflect isolated fluctuations in the current recovery status. This is because if an urgent need for recovery is discovered, training will need to be reduced, possibly with far-reaching consequences in some cases. It is also desirable that the method be cost effective and that testing does not impinge on the training process so that performance levels are not compromised and can be tested repeatedly. There is not yet any one single marker that completely meets these prerequisites and can reliably indicate overtraining, and, therefore, recovery, on an individual basis.

Despite these limitations, it is possible to give practical recommendations for ways of adequately monitoring workload and regeneration (tab. 9). Experiences and subjective impressions of the athletes as well as the coaches and support staff (physicians, physiotherapists and sports scientists) are important, but should be measured in a standardised way and complemented meaningfully by objective measuring methods. One first important step consists of a comprehensive and standardised documentation of training loads and exertion, which involves the systematic logging of training contents and intensities of all training sessions. A thorough documentation of physiological parameters during exercise (heart rate, subjective perception of exertion) can help to identify excessively increased exertion under identical training loads. Alongside this, standardised questionnaires under the previously mentioned limitations can constitute a meaningful supplement to the early objective detection of mood changes. Also simple sports motor skills tests (e.g., lower maximal speed in the yo-yo test, slower sprint times and lower jumping heights) can be useful indications of possible overtraining.

6.4.3 REGENERATIVE MEASURES

Nowadays there is a wide range of supposedly effective regenerative measures that are sometimes promoted very aggressively. An entire industry has now grown up in this sector. It is not always easy to distinguish between serious methods or even potentially dangerous ones. When selecting appropriate regenerative measures, it is, therefore, helpful to limit your search to methods with effectiveness that can be proven by scientific studies. An overview of common regenerative measures is provided in table 10.

First to be mentioned in this connection is a balanced diet and fluid intake. The essential points to be taken into account where nutrition is concerned are explained in more detail in chapter 7.

The application of cold/ice to support regeneration has gained widespread popularity in recent years. In most cases, this involves the use of ice baths. This method has the benefit of both combating muscular strain (e.g., muscle soreness) and also drops in performance (particularly in the area of speed abilities) after intensive loads. These effects can last for a few days, making them highly relevant during weeks with mid-week matches. However, cold application can also suppress the inflammatory processes necessary for training adaptations, so the regular use during intensive training phases is, at present, not unreservedly recommended.

Cold chambers (cryotherapy), with temperatures as low as -100° C, are also used, although it has still not been clearly demonstrated that the purported benefits actually occur. They should, therefore, not be used unreflectingly and widely. Cold chambers are relatively expensive (both to buy and maintain), and their use is restricted to certain locations.

Tab. 10: Overview of current regeneration measure and evaluation of the scientific evidence

Regeneration measures	Evaluation and comments
Nutrition	• Carbohydrate intake sufficient to cover individual and sports-specific needs and an adequate fluid intake support regeneration • When the glycogen reserves need to be replenished quickly, as soon as possible after exertion, 1 g carbohydrate per kg bodyweight and hour within the first four hours post-exertion should be consumed. • Nutritional supplements are not usually necessary to support regeneration.
Cold application	• Cold application (particularly ice baths) can reduce muscular strain and performance decline following intensive workouts and matches. • Possible undesirable side-effects and reductions in training adaptions should be taken into consideration.
Active recovery	• Acute effects of active recovery on performance levels are not clearly established. • Glycogen synthesis could be restricted. • Multi-day active recovery phases (low intensity and low volume) after intensive training periods can support regeneration.
Compression	• Positive effects on performance levels possible but still not sufficiently proven. • Suggested positive effects on muscular strain
Massage, stretching, electromyostimulation	• No convincing evidence exists that justifies their use as regenerative measures.
Medication strategies (NSAIDs)	• No unanimous evidence of the effects on sporting performance • Possible undesired side-effects and reduced training adaptations.
Sleep	• Make sure sleep is sufficient and of good quality. • Bear in mind when planning matches and training courses

Ice baths currently appear to be a more practical solution for high-performance sports.

The use of active regeneration measures (e.g., jogging) is also common. Active, relaxed jogging accelerates the breakdown of lactate after intensive exertion compared to purely passive recovery. However, this is negligible in the regeneration process. Both the intensity and volume should be kept low.

Other purportedly regeneration-promoting measures used in high-performance sports are stretching, compression clothing, electromyostimulation and massage. While compression can have positive effects on performance levels, there is currently no convincing proof that would justify the use of the other measures to aid regeneration.

Medicinal strategies, particularly the administering of non-steroidal painkillers (e.g., Aspirin, ibuprofen, paracetamol, Diclenofenac), can occasionally be found, as these medicines both reduce pain and have an anti-inflammatory effect. Positive effects on performance levels seem unlikely. In addition, there is a danger of undesirable side-effects, particularly in the event of frequent or chronic use. Furthermore, they may suppress training adaptations due to their anti-inflammatory effect. Therefore, non-medically indicated use of these drugs should be avoided.

Inadequate sleep over a long period of time can negatively impact performance levels, training quality and overall wellbeing. Therefore, sleep plays an important role in the recovery from or preparation for sporting activity. There is no single answer to the question of how much sleep is enough or what good sleep quality is, as each person's sleep requirements are different. However, a general recommendation would be that you should sleep enough at night so that you feel well-rested during the day. An appropriate choice of room or hotel and their surroundings for matches and training camps with regard to good sleep quality is an important task for coach, player and support staff.

In summary, it can be established that a suitable diet, ice treatments (if desired and tolerated by the individual), active recovery (e.g., easy jogging) at low volumes and intensity as well as sufficient sleep alongside a preventive individual training plan (timely periodisation) and adequate training documentation are currently the most appropriate ways of supporting the recovery process and, therefore, of ensuring the quality of the necessary intensive training and match phases. Regeneration processes require time, and miracle cures that promise a (unusually) speedy regeneration should be treated with the utmost caution in the absence of clear scientific evidence. Possible side-effects and drops in performance as well as potential conflicts with current anti-doping regulations should always be taken into consideration.

CHAPTER 7

SPORTS NUTRITION

In few sports is diet as determined by tradition as it is in football. Steak on match day or the avoidance of drinking during a match are good, if not very sensible (although a little outdated) examples. Fundamentally, the same nutritional rules apply to football players as to practitioners of other sports, as featured in books on sports nutrition. In this respect, there is no such thing as 'football nutrition', but at best a nutrition that is adapted to the real training and match conditions of the sport. Also, the fact that the practise of substitution (polypharmacy) is not uncommon of course says nothing about its meaningfulness. Basically, due to its complex demand structure with no requirement for extreme forms of individual conditioning elements, as well as a moderate energy metabolism compared to other (endurance) sports, football has no special, i.e., critical, nutritional requirements. There is certainly no need for nutritional supplements to be taken in order to cover the energy requirements, not even in very intensive phases of the season.

However, football players certainly do have an increased daily energy requirement. When training once a day, this can be about 1,000 kcal more, when training twice a day, double this. This means that a young, athletic man weighing 75 kg can need to consume as much as 3,500 to 4,500 kcal per day. Whether football increases the basal metabolic rate, which would mean that the energy requirement is also higher on non-training or match days, is not yet clear. Indications from other sports show that this is unlikely. During training and matches, it is predominantly carbohydrates that are burnt for energy supply, with the proportion of fats being considerably lower. A good supply of protein (or amino acids as constituents of protein) is necessary, in order to ensure the maintenance of muscle structures (muscle fibres but also enzyme composition). The dangerous hyponatremia (sodium deficiency in the blood) rarely found in endurance competitions caused by an excessive fluid intake during competitions is not a danger in football, mainly because there is not sufficient opportunity to drink large amounts.

If strength training shall lead to muscle growth, a slight increase in protein intake would be wise. It should be noted that the average central European and Western diet fulfils this requirement, provided that the volume is adapted in line with the calorie requirements. For the (macro) combination of nutrients, the recommendations apply as they also are given for 'healthy nutrition' of the general population.

A pragmatic rule for fluid intake is: the more the better. It is very hard for athletes with healthy kidneys to drink too much in everyday life, particularly because in reality people tend to drink too little. Football players can safely drink at least 3 liters of fluid per normal training day.

7.1 PRE-MATCH NUTRITION

In view of the dynamic nature of football, a time interval of 3 to 3.5 hours between the last large meal and the start of the match or training is appropriate. This allows time for the stomach to be completely emptied, as long as the meal did not contain too much fat. An inactive stomach diverts little blood from the working muscles, and stomach aches are also less likely. Good digestibility should increasingly be a criterion for determining the choice of food, the nearer to the match or training it is consumed. In this phase, the aim is no longer mainly to fill reserves (of glycogen, for example), but to avoid impairing training or match performance.

Suitable foods for this nutrition phase contain a combination of mono- and polysaccharides so that blood sugar levels can be maintained but do not undergo any sudden spikes that could then provoke an unwanted counter regulation. Fatty foods are a bad choice as they remain in the stomach for too long, as are citrus fruits, because the fruit acids they contain may be hard to digest. Ripe bananas, dry cakes (marble/madeira cakes), bread and commercially available sports bars and gels are usually well-tolerated.

Because temperature regulation during matches is mainly achieved by sweating, it is also important to focus on the fluid balance. It is a good idea to drink copiously in the hours before a match. Only in the last 1 to 1.5 hours should the fluid intake be limited to no more than 1 pint per hour to avoid the urge to urinate during the match itself. This is usually ensured due to the players' personal experience, though. Suitable drinks for fluid intake during the final hours before a match are lightly-carbonated drinks, fruit juice spritzers (at least 1:2 diluted fruit juice) and sports drinks that need not necessarily be isotonic. Drinks containing caffeine may have a stimulating effect. This is most effective for players who are not habitual coffee drinkers. If players regularly drink an espresso or coffee before the game, withdrawal can have largely negative consequences (e.g., headache). Basically, caffeine is a diuretic and at best has no effect on the fluid balance and may be detrimental in large quantities.

7.2 MATCH NUTRITION

During the game—in breaks in play and at half-time—the digestibility of the food consumed becomes even more important. Drinks are preferable to solid food as they are relatively quick to leave the stomach, added to which this can also compensate for fluids lost by sweating and heavier breathing (exhaled air contains more water vapour than inhaled air). Small portions of solid food are often tolerated, such as commercially produced bars, small, dry cakes, gels or dried fruit. Nutritional science theories must obviously take a back seat to personal experience.

Essentially, during a game of football the aim is to compensate for the inevitable loss of fluids as completely as possible, as well as consuming a certain amount of carbohydrate. It is unrealistic to expect to cover the turnover completely, though. But carbohydrates that are absorbed via food must not then be taken from the muscles' glycogen reserves or the liver. A rule of thumb for drinks is that they should not contain more than 8% carbohydrate (corresponds to 80 g per 1 l of fluid). Fruit juices usually contain 10 to 12%, so they must be diluted accordingly. To ensure that the fluids also remain in the body, they should contain 1 to 3 g Na /l.

7.3 POST-MATCH NUTRITION

At the end of a match, fluid and glycogen levels should be restored, ideally within the first two to three hours, bearing in mind that alcohol slows down this process (promotes fluid elimination and restricts carbohydrate assimilation into the muscles). Caffeine is detrimental to fluid replacement, as well. Digestibility and low stomach filling are no longer critical, because the next workout or game is some time away. A plentiful supply of fluids and carbohydrate-rich food should therefore be available. Fatty foods should still be absent. For practical reasons (hard to prepare food in the stadium), concentrates can also be used, but normal food also meets the requirements. Considering that even in a tough game it is rare for more than 1,500 kcal to be burned, this replacement is clearly not too difficult.

CHAPTER 8

SPECIAL FEATURES OF WOMEN'S FOOTBALL

8.1 INJURIES

The frequency and pattern of women's injuries nowadays often match the men's. According to FIFA studies, an average for women of 2.3 injuries and for men of 2.5 injuries per game should be expected in international tournaments. Of women's football injuries, 80% result from tackles, and 40% of these from fouls. For men, this figure is 50%. The number of foul-related injuries in the women's game has increased by 10% in the last decade. There is, therefore, now very little difference between the genders in terms of injury mechanism. The same also holds true for the increased injury risk during games compared to training. The risk of injury during a game is six to nine times higher. Even when taking the playing surface into account (artificial versus natural surface), there are no significant injury differences between men and women.

Knee and ankle ligament injuries as well as thigh muscle injuries also constitute the top three football injuries for women. According to the FIFA studies, the most frequently diagnosed injury is the ankle ligament injury. This, too, is in line with experiences in the men's game. However, women suffer anterior cruciate ligament injuries much more often (up to 10 times more). The 14 to 19 age group is most commonly affected. The cause for the sex-specific difference is currently not known, although it is certain that there is no one single risk factor but a combination of several factors. Anatomical (e.g., thickness of the cruciate ligament, knock-knees, foot position), hormonal (injury risk dependent on menstrual cycle) and environmental factors (playing surface, footwear, weather conditions) have all been considered. However, the evidence is conflicting, furthermore, the research quality is often very low so that final conclusions cannot be reached at this point in time.

Fig. 63: High-risk leg axis (right) for an anterior cruciate ligament injury

On a biomechanical level, several risk factors have been identified. All three spatial planes should be taken into consideration (sagittal plane = extension/flexion, transversal plane = turning/rotating, frontal plane = bending sideways). In the sagittal plane, forward-directed shearing forces onto the part of the lower leg just below the knee joint are dangerous. In addition, (totally) extended position of the knee and hip joints, when changing direction or landing, for example, are high risk. Women often change their landing position as they get older in favour of high-risk, straight-leg landing.

An increased adduction of the hip joint, an increased abduction of the knee joint and an increased splay foot position at the ankle joint are also high risk. The same applies to an increased inward-rotation of the hip and knee joints.

Compared to men, women exhibit different muscle activation patterns (neuromuscular aspect). The quadriceps muscle as antagonist of the anterior cruciate ligament (since it pulls the lower leg forward) is more strongly activated. Conversely, the hamstring muscles, as the protectors of the anterior cruciate ligament as they pull the lower leg backwards, are less strongly activated. Another negative aspect is a delayed and shortened activation of the stabilising muscles (particularly the gluteal and calf muscles).

Although women's football has become much faster, more athletic and more professional since the 1990s, there are still greater differences in performance level within a team compared to the men. The higher the league, the smaller this difference is, but even at a high national level it is often still quite obvious. That increases the risk of fatigue-related injuries among less trained female players, due to both physical and mental exhaustion. Both aspects can promote injury-prone movement patterns.

8.1.1 HEAD INJURIES

Irrespective of sex, most head and neck injuries occur in the defensive midfield. Particularly injury-inducing for women are head-to-head collisions from the front (for men: head against upper extremity from the side).

The risk of suffering a concussion is twice as high for women as it is for men. In addition, women often report more serious symptoms and suffer more frequently from long-term consequences. To what extent a poorer heading technique (i.e., not making proper contact with the ball, meeting point of the ball, heading from a standing instead of a jumping position) is responsible has not yet been scientifically proven, but could be a possible explanation.

8.2 FEMALE ATHLETE TRIAD

The **female athlete triad**, composed of eating disorders, absence of menstrual periods (amenorrhea) and associated osteoporosis, causes problems for women that do not affect men. It is not necessary for all three aspects to be present for this occasionally very serious disorder to be diagnosed. It typically occurs in sports with a high endurance component (triathlon, long-distance running), in which low bodyweight is an advantage (gymnastics, ski jumping), or with predetermined weight categories (judo, wrestling). However, it can also be found in football, albeit more rarely. The disorder can be life-threatening in extreme cases.

There are many causes for this disorder.

- Sporting: high physical strain, poor performance
- Mental: high emotional strain (mental stress): private problems, thinking about poor performance, peer pressure ('you're too fat... you must lose weight')
- Personality disorders
- Genetic factors

Box 9: Causes of the female athlete triad disorder

Malnutrition leads, among other things, to an increased susceptibility to infection and muscle loss, as muscle protein must be used for energy production due to the lack of carbohydrate (sugar) intake. Other consequences are disturbances of the hormonal status and of the bone metabolism. Menstruation is irregular or non-existent. Bone density is reduced, increasing the risk of stress fractures. This list of possible consequences is far from exhaustive.

It is advisable to develop an 'antenna' for this disorder. The following points can give the first indications:

- Unexplained weight loss
- Abnormal heightened ambition (extra workouts, longer workouts)
- Lack of recovery
- Missing or irregular menstrual periods
- Conspicuously high fluid intake
- Avoiding previously enjoyed high-calorie treats
- Increased preoccupation with the issue of weight
- Comments such as 'I'm too fat' (when obviously not the case)
- Occurrence of stress fractures (fatigue fractures)

Box 10: Signs that indicate the existence of the female athlete triad

Food and fluid intake is often cleverly disguised, and sporting performance levels often remain high (or very high) for a long time.

If this disorder is suspected, professional help is required (initially psychiatric-neurological, and over the long term, psychological). The social stigma against turning to this kind of help is unjustified. Added to this, the affected woman's understanding of the illness may often be limited. They feel neither ill nor in need of treatment. The first step is to speak to the affected person (the parents in the case of minors). Soon thereafter, the team physician, the general practitioner with a special interest in sports medicine, the Federation physician, university-based sports medicine centres and the medical/psychological departments of the Olympic training centres are other possible points of contact. If possible, a long-known, trusted person should also be turned to. This group of people can then take the required further action.

8.3 MENSTRUATION AND PREGNANCY

The position of research on the influence of **menstruation** on sporting performance is not unanimous. Both personal bests and diminished performances have been reported during this time. Individual feelings appear to be the most important influencing factor. This applies not only to football but to all sports.

There is nothing wrong with regular, moderate sporting activity during **pregnancy** with medical approval and if the woman feels well enough. On the contrary, in most cases it is even recommended from a medical perspective. A few basic principles (and, of course, the limitations of the medical approval) should be adhered to, though. Abdominal injuries must absolutely be avoided during this period. Sports that feature a high degree of vertical movement amplitude (jumping, running) should be avoided, particularly in the last three months of pregnancy. In addition, sports with a heightened risk of kicks, falls or trips should also be avoided throughout the pregnancy. Football, as a contact sport, contains all three aspects and should, therefore, not be practised competitively. Technique and passing drills without an opponent and with self-set tempo are still safe, though. There is currently no 'safe' upper medical limit of physical activity during pregnancy. Good communication between the player and the gynecologist is necessary.

Breastfeeding can be a problem for players continuing their sporting careers at elite levels. Firstly, metabolic waste products (lactate) accumulate in the breast milk, which probably changes the taste and, therefore, reduces acceptance by the baby. Secondly, logistical problems can arise (e.g., fixed feeding programme versus fixed training and match programme). Expression by pumping can be a solution here. The increase in breast size should also be taken into consideration. A well-fitting sports bra is recommended, particularly during pregnancy and while breastfeeding.

CHAPTER 9

FOOTBALL IN SPECIAL CLIMATIC CONDITIONS

9.1 HEAT

Even in the central European summer, afternoon temperatures of over 30° C (87° F) are not unusual and occur at least once per season on average. Certain health risks are associated with this kind of temperature for football players, as well as reductions in performance levels. The main problem is that of rising body temperature, which must be limited as much as possible. An adequate fluid intake is crucial in high temperatures.

Although it is a good idea to drink mineralised water (particularly sodium), it is just the amount of water drunk that matters. The body loses vast amounts of fluids through the evaporation of sweat. However, as this mechanism is the most effective method of heat dissipation and is, therefore, very important, enough water must be present in the players' body for them to carry on sweating. If a player suddenly starts sweating less during a match in hot weather, this is not a good sign from a sports-medicine point of view and is an indication of serious dehydration.

High air humidity hinders effective heat dissipation by sweating, because the high water saturation of the air makes it difficult for the sweat to evaporate. Even when the skin is wet due to heavy sweating, it is not effective, because there is no cooling. For this reason, all other measures to reduce body temperature are especially important when playing in very humid conditions.

Fortunately, football rules do allow a few opportunities to drink fluids. The half-time interval should be used to drink about 1 pint of fluid. Even though still water does not taste as bad in hot weather as is often suggested for commercial reasons, practical experience shows that an alternative drink with a sour/fresh taste should be made available. The taste definitely matters. Some players tend to drink less if the drinks provided are slightly tasteless, or they don't like the taste.

Of course, it is also important to consume carbohydrates during a game. But it should be kept in mind that carbohydrate-containing drinks should not exceed a concentration of > 8%, as higher concentrations may lead to gastrointestinal problems due, at least in part, to the delay in gastric emptying (and therefore undesired increased blood circulation to the stomach as well as stomach aches).

Drinks that are too cold may also cause stomach aches. However, if their temperature is increased too much, this may theoretically and physiologically boost absorption in the body, but if the amount drunk is reduced, the effect is opposite to that intended. Based on players' feedback, this is just something that has to be experimented with in training. It is worth mentioning more recent findings show that drinking cold fluids is one of the most effective ways of preventing a rise in body temperature. This is simply because the gastrointestinal tract is situated in the middle of the body, and this is the only way to apply cold there directly.

Interruptions in play should be used to administer drinks, which should be freely available as needed by the players (explaining the logic behind such measures works wonders). As coach and support staff are only located on one side of the pitch, it makes sense to also place two to three bottles of drink on the other side, too. Also in the event of injuries on the pitch, running physicians and physical therapists should carry drinks with them in hot conditions. Cool (not ice-cold) still water is often a good option when it comes to choosing a drink during a short break of the game. On the one hand, many players shun sweet drinks as it leaves them with a sticky mouth; on the other hand, still water is almost always easy to digest and can also be used to cool the body by wetting the head and back of the neck.

At this point, it should be emphasised that the consumption of liquids by infusion is currently banned by doping regulations. While this rule may at first appear unpleasant because there is no more direct way of administering fluids into the bloodstream, a closer examination reveals that this is not true. As long as a player is not unconscious, there is no quicker way to administer fluids than by the natural method of drinking. It is, therefore, completely possible to drink 4 pints inside an hour. No normal infusion can supply such amounts to the body so quickly and conveniently. Furthermore, when consuming liquids, at least *after* training or matches there is no longer any need to worry about exceeding certain concentrations of dissolved substances (which must still definitely be considered in the case of infusions).

Of course there are other ways of dealing with heat. The first is football jerseys that do not impede the evaporation of sweat and, therefore, do not have a heating effect. Light colours are preferable if the sun is shining, but this obviously depends on the team colours and the need to differentiate between the teams. It should be assumed that a team playing in black in hot weather against a team wearing white will be at a slight disadvantage. As a large part of the absorbed heat comes from the sun, a (ideally white) hat is obviously a good idea. However, field players usually find it restricting to wear a hat (or it is banned by the referee). It can be an effective measure for goalkeepers.

Both the minutes before the game and also the half-time interval generally offer the opportunity for *pre-cooling*—the cooling of the body by external physical measures. The aim is to cause a moderate lowering of the body temperature to delay a later rise due to the external heat. Unfortunately, apart from drinking cold liquids, the most effective measures are also the least practical.

Dipping as much of the body as possible in cold water is particularly effective. On the one hand, this often presents logistical problems for the supporting medical staff; the players often find this measure disagreeable so close to the start of the game or of the second half. An alternative can be wearing a cold vest or other cooling external applications (e.g., applying hand towels soaked in icy water to the back of the neck, legs and arms).

The possible costs as well as the inevitable disturbance of the usual pre-whistle routine and at half-time must be considered. It is precisely for this reason that the very effective pre-cooling probably tends to be reserved for the top ranks of the elites or really extreme weather conditions.

9.2 COLD

Cold environmental temperatures present much fewer problems from a sports-medicine perspective than heat. Although frozen pitches can lead to an increase in skin injuries due to falls, this is still quite a minor practical problem. More serious is the reduced performance capacity of the working muscles if they have not reached working temperature. Nevertheless, this can be prevented by a well-structured and sufficiently intensive warm-up programme as well as wearing appropriate clothing. However, UEFA recommends that matches should be called off in temperatures lower than -15° C (5° F) with a wind-chill factor of -10° C (14° F). This decision is at the discretion of the referee in charge.

Even if many players are of the opinion that shorts are *de rigueur* on the pitch, from a performance-physiological point of view, this is not sensible in cold weather. Not only the muscle temperature but also the sense of wellbeing (including not feeling cold) contribute to preparing the body for optimal performance. In this respect, wearing long pants or tights in very cold conditions is equally important, if not more so than wearing warm clothes on the upper body. The limit of how much warm clothing is worn is determined by whether it reduces mobility. In very cold conditions, a compromise may sometimes need to be found between mobility and warmth. Prejudices against tights, arm warmers and other extra clothing are misplaced, particularly for goalkeepers.

9.3 ALTITUDE

Matches or training camps at altitude represent a special challenge. At altitudes of above about 1,000 m (3,300 ft) above sea level, a slight reduction in performance capacity is to be expected. This may not always be noticeable and may also differ from player to player. Travelling to the venue in advance to acclimatise is just one way of adapting to altitude. Others include drinking plenty of water in order to prevent a cardiovascular response (e.g., increased heart rate as an adaptation mechanism). Care should also be taken to reduce the training load in the first few days after arriving at altitude.

9.4 JET LAG/TIME ZONES

In matches in locations situated several time zones away (from west to east), the biological rhythms of the body, known as the *circadian rhythm*, are disrupted due to changed light transition phases. Travelling in an easterly direction is usually more problematic than in a westerly direction. The associated loss of performance

capacity is difficult to measure exactly. As well as the change in rhythm, lack of sleep is often an issue. Although sleeping pills are very reliable, they do not lead to very recuperative sleep. The same is true for alcohol. Melatonin is sometimes praised as a miracle cure that quickly shifts your personal rhythm. However, it does not seem to work for everyone, and it is not legally available in every country. When bought abroad it may also occasionally be contaminated with banned substances. The most reliable way is to travel well in advance—one day for every one-hour difference in time zone. Not always easy to put into practise, but also effective is the anticipation of the shift in sleeping pattern before the flight. This means that the players go to bed and get up increasingly later in the days preceding a flight in a westerly direction and vice versa for a flight in an easterly direction.

CHAPTER 10

THE PREVENTIVE POTENTIAL OF FOOTBALL

The immense popularity of football across many age groups raises the question of its effectiveness when it comes to preventing disease. It is true that it is more complicated to organise a football game or training session than, for example, jogging or cycling. However, masters football leagues, in which matches and also training organised in clubs take place, are growing in popularity. Games do not always take place on a full-sized pitch with 11 players on each team; small pitches with seven or nine aside are also popular.

In order to evaluate the preventive potential of football, different aspects should be taken into consideration. Playing on the pitch as a field player already contains a significant endurance component. This is important, because there is evidence that endurance-building activities in particular have a preventive effect for cardiovascular disease and apparently also some types of cancer. On the other hand, football also contains components such as speed, strength, co-ordination and mental skills. In this respect, as well as pure endurance, other factors important for physical performance in everyday life are also promoted. Football, therefore, represents a combination of different demand levels, so training effects on these levels should also be taken into consideration if training frequency, intensity and duration exceed a minimum threshold. As typical football training workouts rarely last less than one hour, and the incorporated match-playing segments already reach a significant exercise intensity, both aspects of intensity and duration appear to be in order. Nevertheless, at masters level, as in the lower playing categories, training sessions or a match rarely take place more than once per week, which is below the generally accepted minimum. Scientific research is often based on studies involving three or more training sessions per week.

There are a few indications that playing football regularly has demonstrably beneficial effects on blood pressure, cholesterol levels and other risk factors for cardiovascular disease. Particularly one Danish/English research group is collaborating with FIFA on this kind of issue. These effects on different target groups are now being researched, even though the low sample sizes included in the studies do not allow definitive conclusions to be drawn.

For a good definition of the optimal target group of football as a healthy pursuit, aspects of injury frequency and other health risks should also be taken into consideration. This involves the issue of determining exercise intensity, which is difficult, as in game forms, the frequency and speed of movement cannot be controlled exactly. This can be particularly problematic for patients with coronary heart disease, whose number grows with increasing age, particularly among men. For it is in the nature of this disease that with increasing exercise intensity, limitations of the coronary circulation arise. Patients with relevant cardiac arrhythmia should also be discouraged from playing football without medical permission.

In this respect, the preventive potential of football appears to be associated with increasing risks due to the increasing age of the players and the high disease probability involved. It is probable that the preventive effect predominates overall, but that does not release from an individual assessment under consideration of existing disease and risk factors.

APPENDIX

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