Clinical practice guidelines for physical therapy in patients with chronic ankle sprain

RA de Bie PT PhD[I], MAMB Heemskerk PT[II], AF Lenssen PT MSc[III], SR van Moorsel PT[IV], G Rondhuis PT[V], DJ Stomp PT MSc[VI], RAHM Swinkels PT MSc[VII], HJM Hendriks PT PhD[VIII]

Introduction

These guidelines, which have been produced by the Royal Dutch Society for Physical Therapy (KNGF), describe the diagnostic and therapeutic processes involved in providing physical therapy (physiotherapy) for patients with chronic ankle sprains. The choices made in deriving the recommended diagnostic and therapeutic procedures are explained in the discussion section of the document, entitled "Review of the evidence". The abbreviations and key concepts used are explained in an attached list of abbreviations and glossary.

For whom are these guidelines intended?

These guidelines are primarily directed at physical therapists (physiotherapists) who may have to treat patients with long-lasting ankle complaints that result from inversion injury to the ankle. The physical therapist involved is expected to have knowledge about the various stages of the process of recovery from a chronic ankle sprain and to have the skills needed to distinguish between a correct and an incorrect walking pattern and to apply the principles of appropriate progressive training programs. To aid the healing process, the possession of specific skills, in for example the use of bandages, tapes and braces, is mandatory. Proper use of these guidelines requires the therapist's treatment area, or practice, to be large enough to allow proper analyses of gait to be made and to enable indoor sports and training activities to be performed.

Chronic ankle sprain versus acute ankle sprain

These guidelines on chronic ankle sprain can be seen as a logical sequel to KNGF guidelines on acute ankle sprain, which describe the diagnostic and therapeutic processes involved in providing physical therapy for patients with acute lateral ankle sprains. Recovery from an acute ankle sprain to being able to perform normal daily activities usually takes about six weeks.

The present guidelines describe the treatment of long lasting ankle complaints. In particular, they concentrate on functional instability in chronic ankle complaints. Functional instability is defined as the persistence of residual complaints, such as a feeling that the ankle is "giving way" or a "(a feeling of) recurrent spraining", or both, after an ankle sprain. Usually, pain and swelling are absent, but, when they do occur, they are the consequences of overuse or of a new inversion trauma. Functional instability can lead to behavioral adaptations, such as an aberrant

I   RA de Bie PT PhD, associate professor of clinical epidemiology and chair, Department of Epidemiology, Maastricht University, Maastricht, the Netherlands.

II   MAMB Heemskerk PT, physical therapist and project staff member, Department of Research and Development, Dutch Institute of Allied Health Professions, Amersfoort, the Netherlands.

III AF Lenssen PT MSc, hospital-based physical therapist, research coordinator and human movement scientist, Department of Physiotherapy, University Hospital Maastricht, Maastricht, and lecturer, Faculty of Physiotherapy, Hogeschool Zuid, Maastricht, the Netherlands.

IV   SR van Moorsel PT, hospital-based physical therapist, Department of Physiotherapy, University Medical Center, Catholic University of Nijmegen (KUN), Nijmegen, the Netherlands.

V   G Rondhuis PT, private-practice physical therapist, Hilversum, the Netherlands.

VI   DJ Stomp PT MSc, physical therapist, human movement scientist and project staff member, Department of Research and Development, Dutch Institute of Allied Health Professions, Amersfoort, the Netherlands.

VII RAHM Swinkels PT MSc, private-practice physical therapist and human movement scientist, physiotherapy and manual therapy practice 'de Coevering', Geldrop, the Netherlands.

VIII HJM Hendriks PT PhD, physical therapist, clinical epidemiologist and guidelines coordinator, Department of Research and Development, Dutch Institute of Allied Health Professions, Amersfoort, and Department of Epidemiology, Maastricht University, Maastricht the Netherlands.

walking pattern or the avoidance of normal daily activities, or to problems with physical activities at work or with participating in sport at the desired level.

Factors involved in the occurrence or persistence of functional instability are thought to include: mechanical instability (i.e., loose capsular ligaments in the ankle), disturbed proprioception, reduced muscle strength, slow muscle reaction times, reduced mobility, and inappropriate complaint-related behavior. There are also indications that the inadequate or incomplete treatment of an acute ankle sprain may increase the chance of residual complaints.

Other conditions that may lead to chronic ankle complaints but are not included in the definition of functional instability are: impingement due to osteochondral lesions, osteophytes or 'loose bodies', osteoarthrosis and systemic diseases, rupture of the distal tibiofibular syndesmosis complex, sinus tarsi syndromes, and subtalar instability. These guidelines offer a brief description of these conditions for the purpose of differential diagnosis (see the section on differential diagnosis in the review of the evidence). The treatment strategies usually adopted in these conditions are also mentioned.

Epidemiology
In the Netherlands, about 600,000 people sprain their ankles each year. About half visit a general practitioner or hospital emergency department. Some 75% of sprained ankles are inversion injuries. Irrespective of the severity of the initial trauma and of the type of treatment given, a considerable number of persons with acute lateral ankle sprains experience residual complaints. Literature estimates indicate that the prevalence varies between 10% and 60%, whereas that for functional instability lies between 10% and 40%.

Diagnosis
During diagnosis, the physical therapist assesses impairments in the patient's body structures and in physiological and psychological functioning, and the extent to which the patient's activities and participation in normal life are limited. A proper

analysis of the health problem should enable conclusions to be drawn about its extent and severity and about possible ways of modifying it. Thereafter, a treatment plan is devised in co-operation with the patient. The starting point is the patient's description of the health problem.

Referral
Referral by a general practitioner or medical specialist is required before these guidelines can be implemented. This is mandatory in the Netherlands because, in the country, patients do not have open access to a physical therapist. They must be referred by a general practitioner or another physician. The referral documentation should include data that indicate the existence of residual complaints after an acute ankle sprain. Additional relevant medical data should also be incorporated into the referral documentation.

History-taking
History-taking should include details of:
- demographic factors;
- the health problem as described by the patient, treatment goals, and expectations of treatment.

History of the disorder
Causal factors:
- Did the ankle suffer an inversion trauma?
  - When did the first inversion trauma occur?
  - How did the trauma occur?
- Is the current condition the result of a relapse?
  - When did the most recent inversion trauma take place?
Course of the complaint over time:
- Which medical and therapeutic interventions were employed and what were the results?
- How did the pain and swelling develop over time?
- When was it possible to return to normal daily activities, work and sporting activities?

Assessment of current condition
- Investigate impairments in the patient's body structures and functions, activity limitations, and participation restrictions:
  - body structures (e.g., possible damage to ligaments);
    - Is the patient in pain at present, during or

after exercise, or when resting?
- body functions (e.g., coordination, proprioception and kinesthesia);
  - Does the patient report a feeling that the ankle is giving way or that he or she is actually spraining the ankle?
  - If so, how many times per day or week does this feeling occur, and when does it occur: during normal daily living activities, during exercise, or when tired?
  - If so, does symptom severity increase?
  - If so, which symptoms occur and how long do they last?
- Activity limitations (e.g., in performing specific tasks or activities related to work, housekeeping, sport or leisure pursuits);
- Participation restrictions (e.g., in activities in and around the house, at work, in housekeeping, or in sports at a level that was normal before the initial trauma);
  - If there are problems, what are they?
- Assess use of external support;
  - Does the patient still use tape or a brace to provide support?
    - When, why and how often?
- Assess personal factors;
  - How does the patient behave in response to the condition?
  - Is there a balance between the patient's actual load-bearing capacity and that required for normal daily living activities and work? Is the required capacity level attainable?

Physical examination
Observation:
- pain and its localization;
- the amount of swelling and the reason for the swelling;
- static posture and any postural abnormalities.
Palpation (only required for the purpose of differential diagnosis):
- look for tender spots and signs of inflammation.
Assessment of functioning:
- ask the patient to perform load-bearing movements and pay special attention to dorsal flexion of the ankle;
- Is full load-bearing by the foot possible? Does any pain, giving way, or fear of movement occur

during full load-bearing?
- Is the gait pattern normal (use the recommended gait analysis technique)?
- Is the patient able to stand on the affected leg with eyes open and closed?
- Is the patient able to jump on the affected leg, and subsequently stand still on the affected leg?
- Is the patient able to walk on toes and heels?
- Is the patient able to perform twin tasks during complex load-bearing activities?

Recommended measuring instruments
These guidelines recommend the use of two measuring instruments for assessing and evaluating the patient's functional status:
- An instrument for patient-specific complaints is used to assess the patient's functional status. In practice, the patient is asked to select three daily activities that he or she considers important and that are unavoidable, such as walking, climbing stairs or running. The difficulties the patient has in executing these activities is subsequently scored on three separate visual analogue scales (VAS).
- The Nijmegen gait analysis scale (GALN) is used to assess and describe the patient's gait. It comprises 13 items, each of which refers to an aspect of the patient's manner of walking and involves the evaluation of different anatomical structures (e.g., the trunk, pelvis, knee and ankle).

Analysis
The central goal of the diagnostic process is to determine whether physical therapy is justified and necessary. Physical therapy should be able to influence the factors that contribute to the chronic ankle condition. The relevant factors should be classified according to whether they have a positive or negative influence on the chronic nature of the condition. Because the condition is chronic, the physical therapist must describe the relevant impairments in body function or structure, the resulting disabilities and participation problems, and their interrelationship. When there is no relationship between the relevant impairments, disabilities and participation problems, additional attention should be paid to:
- personal factors;
- external factors, such as a return to work; and

- patient compliance.

Conclusions
- The physical therapist must determine that physical therapy is justified.
- The physical therapist must determine whether functional instability is present.
  - Patients with long-duration functional instability who have recently suffered tissue damage should initially be treated according to the guidelines on acute ankle sprain. When the patient is able to bear full weight on the foot and able to flex the foot normally, and the recent swelling has diminished, the procedures in these guidelines on chronic ankle sprain can be followed.
  - When there is functional instability without new tissue damage, the guidelines on chronic ankle sprain should be applied.
- If there is a concomitant complaint related to a condition specified in the table on differential diagnosis (see the section on differential diagnosis in the review of the evidence), the guidelines on chronic ankle sprain should be applied.

After considering the above-mentioned points together with the patient, treatment goals and a treatment plan can be formulated.

Therapy
Throughout therapy, the patient's description of the health problem is of central importance. The target performance level to be achieved at the end of treatment must be consistent with the patient's individual requirements.

Physical therapy treatment goals:
- to achieve optimal functional recovery in terms of the patient's functions and skills, with a return to the highest achievable or desired level of activities and participation; and
- to prevent relapses, exacerbations and further dysfunction.

Treatment subgoals:
- to optimize load-bearing and load-carrying capacity;
- to achieve a normal dynamic gait; and
- to achieve active stability,

by improving relevant functions (e.g., coordination and balance, strength and endurance).

Structure of physical therapy
Primarily, therapy focuses on the return to a normal mode of walking and to unperturbed functioning of the ankle during normal daily activities. When this has been achieved, therapy could be aimed at attaining a higher level of daily activity, which may include heavy work, physically demanding hobbies or participation in sport.

Throughout therapy, a stepwise approach that is tuned to the increasing load-bearing capacity of the patient is recommended. Therapy can be intensified by increasing the level of difficulty of general exercises and load-bearing exercises, and by increasing the speed, duration and dynamic quality of practiced movements. At a later stage, training of specific skills, such as heavy lifting, climbing stairs, running or jumping, can be carried out. The exercises and training given should be appropriate for the specific demands being made on the ankle. For example, if the patient wants to participate in a particular sporting activity, training of all aspects of the activity in question should be carried out. This involves analyzing both the demands made by the sport and the relevant characteristics of the person participating in it (i.e., the patient). The exercises should gradually be increased to the level the patient wants to achieve.

Content of physical therapy
The physical therapist:
1. gives information and advice;
2. administers the use of tape, bandages or braces, if necessary; and
3. provides exercise for specific functions and skills.

Giving information and advice
- inform the patient about the expected rate of recovery. If incomplete recovery is expected, this should be discussed with the patient. Goals that are achievable, in terms of the patient's functions and activities, should be set together with the patient. The achievement of subgoals should, as far as possible, follow a time-contingent strategy.
- instruct the patient how to adjust the load

imposed by normal daily activities to the load-bearing capacity of the ankle and how to increase load-bearing capacity gradually over time. It should be explained that symptoms or signs such as pain, swelling, stiffness and loss of function can indicate, perhaps temporary, overloading.

- suggest, if necessary, the temporary use of tape, bandages or a brace to alleviate any symptoms occurring during causative movements or when returning to, perhaps heavy, work.
- point out the significance of exercising at home and stress the importance of adopting a correct manner of walking and a good stance during the performance of normal daily life activities.

Use of tape, braces or bandages
- if the patient indicates that the ankle is being, or feels as though it is being, repeatedly sprained, tape, a brace or bandages can be used during therapy.
- the use of tape, bandages or a brace is advisable if the patient returns to, perhaps heavy, work or to sporting activities. When good muscular stability has been achieved and functional exercises can be performed satisfactorily, it is advisable to reduce the use of tape, bandages and braces.

Exercising functions and skills
- a symmetrical and dynamic gait should be strongly encouraged to prevent the patient from causing the condition to persist;
- all relevant daily life activities should be exercised, such as standing up, sitting, and using stairs.

Training coordination and balance
- static balance exercises should have an increasing level of difficulty (e.g., the eyes could be open or closed, the size of the supporting platform could be varied, static and moving surfaces could be used, a wobble board could be used, and external factors could be applied to disturb balance);
- dynamic balance should be exercised (e.g., single tasks or functional exercises with twin tasks on different types of surface). Finally, mental tasks could be incorporated during balance tasks (e.g., calculations);
- simple taping could be used to heighten proprioceptive responses in the ankle while the

patient is standing still or moving.

Training strength and endurance
- the strength and endurance exercises given should also be incorporated into the patient's normal daily activities.

Increasing the range of motion
- any increase in the active or passive range of motion of the ankle should immediately be followed by proprioception training and stability exercises to reinforce the new increase.

Evaluation
In assessing whether the patient is able to perform activities that require an increased load-bearing capacity, the physical therapist can use the recommended measurement instruments (i.e., the measuring instrument for patient-specific complaints and the Nijmegen gait analysis scale) and can directly assess body functions and impairments in body functions. The presence of pain, swelling or a decrease in movement quality after either performing exercises or increasing the level of normal daily activities indicate that the load was too great.

Periodic evaluation of treatment results should take place after three and six weeks, and possibly also after nine and 12 weeks, depending on the duration of therapy. During each evaluation, the patient's progress should be compared with a baseline measurement or with the results of earlier evaluations. Progress can be either subjective (e.g., assessed in terms of changes in the severity of symptoms reported by the patient, such as pain, the feeling that the ankle is giving way, and the ease of performing normal daily activities) or objective (e.g., assessed in terms of gait, muscle strength, coordination, endurance and load-bearing capacity).

After six weeks of therapy, benefits should be demonstrable. If no improvement is registered, the physiotherapist (physical therapist) should contact the referring physician.

Relapses prevention
To reduce the chance of a recurrent ankle sprain, or relapse, the following advice should be followed:

- do not use taping or a brace as a standard precaution during training or regular sporting activities. Reserve the use of these techniques for competition sports and for high-risk sports such as contact or indoor sports. Not only does this reduce the chance of a new injury occurring, but it also reduces the extent of the damage should a relapse occur. A sports brace is preferable to taping;
- advise the patient to buy new sports shoes if the old ones are worn out. No specific advice can be given concerning the use of high-top or low-top footwear;
- advise and instruct the patient, after finishing therapy, to pay attention to sport-specific as well as proprioception training;
- give instruction on a program of home exercises.

Concluding treatment and reporting
If high demands are to be placed on the ankle, for example during professional sporting activities, treatment can continue until the desired load-bearing level has been reached. These demands may be very specific and may, therefore, mean that the therapist has to have special skills.

At the end of treatment, the referring physician should receive a written report detailing the diagnosis, treatment goals, treatment results, and the advice and instruction given to the patient. For details, see the KNGF guidelines on communicating with and reporting back to general practitioners. To ensure good communication between general practitioner and physical therapist, guiding principles are specified on five elements of communication: indication setting, consultation, referral letters, contact during treatment, and reporting.

Review of the evidence

Introduction

Definition of KNGF guidelines
Guidelines produced by the Royal Dutch Society for Physical Therapy (KNGF) are defined as "guidelines whose production is directed by a central body, that are developed systematically, that are written by experts, and that deal with the systematic process of physical therapy in certain health problems and with various (organizational) aspects of the profession".[1,2]

Goals of KNGF guidelines
The general goals of KNGF guidelines can be divided into two areas.[1–3] Firstly, there are goals that are relevant to individual physical therapists and, secondly, there are goals that are relevant to the physical therapy profession as a whole. It is important to note that these guidelines are intended for exclusive use within the physical therapy profession. The KNGF uses guidelines as instruments for ensuring quality control within the profession and for improving the quality of care offered by the profession.

For individual physical therapists, the relevant guideline goals are:
- to support decision-making;
- to provide a point of reference for education and orientation;
- to provide criteria for self-evaluation and peer-group assessment; and
- to guide future developments in the desired direction.

For the physical therapy profession as a whole, the relevant guideline goals are:
- to ensure that evidence-based care is available, and to distinguish between conclusions derived from scientific research and conclusions based on expert consensus; and
- to increase the uniformity of care and, thus, improve the quality of care.

Research shows that there are large variations in the treatment goals, the interventions employed in, and the overall use of physical therapy.[4] Therefore, these guidelines also set out:
- to alter the care provided in a way that takes scientific research into account (i.e., evidence-based care); and
- to delineate the tasks and responsibilities of professional bodies, to provide some insight into the areas of concern of professional bodies, and to stimulate cooperation between practitioners of different healthcare disciplines.

The KNGF guidelines on chronic ankle sprain encapsulate a methodical approach to the diagnostic and therapeutic processes involved in providing physical therapy for patients with chronic ankle complaints. They concentrate on the concept of functional instability, which is defined as the persistence of residual complaints, such as a feeling that the ankle is "giving way" or a "(a feeling of) relapsed spraining", or both, after an ankle sprain. Other chronic ankle complaints are briefly described for the purpose of differential diagnosis.

The goals of physical therapy, which must take into account the individual patient's needs and desires, are to guarantee optimal functional recovery and to prevent relapses and exacerbations. To achieve this goal, the patient has to learn to balance actual load-bearing with load-bearing capacity. The recovery of a normal dynamic gait and the return to active stability are also prime targets of therapy. The physical therapy interventions used to achieve these goals are the provision of advice, the provision of exercises for specific functions and skills, and the provision of support for the healing process through the administration of tape, braces and bandages.

The guidelines describe physical therapy interventions in patients with long-lasting or chronic ankle complaints. Usually, patients who suffer a first ankle sprain or a relapse should be treated in accordance with the guidelines on acute ankle sprain. The chronic ankle sprain guidelines should never be used to extend treatment beyond that recommended by the acute ankle sprain guidelines. The chronic ankle sprain guidelines are intended for a different

category of patients.

The treatment recommended by the chronic ankle sprain guidelines differs in a number of crucial ways from that recommended by the acute ankle sprain guidelines:

1. When the healing that took place after the initial acute ankle sprain did not lead to complete functional recovery, the chronic ankle sprain guidelines should be used. Analysis of the patient's health problem becomes more complex. It becomes necessary to investigate why the patient did not fully recover, and to determine which factors are hindering complete recovery and whether those factors can be influenced by physical therapy.

2. When a complaint is long-lasting, specific factors associated with chronic disease processes start to emerge. There may be a loss of strength, coordination and general endurance, which may have negative effects on the patient's levels of activity and social participation. The recovery process and the need for physical therapy will last longer.

The present guidelines take into account the intervention strategies used for treating ankle complaints occurring as residual complaints that were described in the KNGF guidelines on acute ankle sprain[5] and in the (Dutch) Collaborating Center for Quality Assurance in Healthcare (CBO) consensus document entitled "Diagnosis and treatment of acute ankle sprain".[6] They also link up with the Dutch College of General Practitioners (NHG) publication on standards entitled "Ankle distortion",[7] in which a referral for physical therapy is mentioned as a first line of treatment for residual complaints such as a feeling that the ankle is "giving way", a "(a feeling of) relapsed spraining" or a loss of muscle strength, or some combination of these complaints. Referral to a surgeon is considered a secondary option.

Clinical considerations
The chronic ankle sprain guidelines working group was interested in answering the following clinical questions:
Extent of the problem:
• How many patients suffer from residual

complaints after an acute ankle sprain?
• How many patients with these residual complaints also suffer from functional instability?
Diagnosis:
• Which elements of the physical therapy diagnostic approach are reliable, valid and useful in daily practice?
• Which data derived from the physical therapy diagnostic process are essential for defining treatment goals, for devising a treatment plan, and for making a prognosis?
Therapy:
• Which interventions and elements of advice are most useful, as indicated by evidence-based research or the views of the working group?

Working group composition and methodology
In August 2001, a multidisciplinary working group of experts was formed to answer the above clinical questions. The core members of the working group comprised physical therapists and researchers with the desired type of expertise who had been part of the core group working on the acute ankle sprain guidelines and who were willing to participate in developing these guidelines. In determining the composition of the chronic ankle sprain guidelines working group, an attempt was made to strike a balance between members with practical experience, subject experts, and individuals with a scientific background. All members of working group declared in advance that there were no conflicts of interest that would influence their involvement in the development of these guidelines. Development took place between August 2001 and February 2002.

These guidelines were developed in accordance with a published method for the development and implementation of physical therapy guidelines.[3] This publication gives practical information on finding appropriate literature, which details search terms, sources of information, and the time frame within which retrieved literature should have been published. In addition, inclusion and exclusion criteria applicable to retrieved material are specified, as is the level of scientific evidence necessary for making recommendations. In the absence of scientific evidence, recommendations can be formulated on the basis of consensus statements from

core members of the working group and external experts. The consensus reached should preferably be unanimous.

Administrative staff carried out scientific literature selection and the entire working group discussed critical appraisal and the results. The scientific evidence and its strength were summarized for each intervention. Evidence was summarized and graded systematically by an evidence-based guidelines discussion group (Evidence Based Richtlijnen Overleg list), which was formed under the auspices of the (Dutch) Collaborating Center for Quality Assurance in Healthcare (CBO). In addition to good scientific evidence, other factors were also considered important in establishing recommendations for the physical therapy of chronic ankle sprains: reaching a general consensus, cost-effectiveness, the availability of resources, the availability of the necessary expertise and educational facilities, organizational factors, and consistency with other monodisciplinary or multidisciplinary guidelines.

After a draft of the guidelines was drawn up, it was sent to a panel of experts and to professional organizations. The purpose was to reach a consensus, to achieve consistency with the views of other professional bodies and organizations, and to achieve consistency with other monodisciplinary or multidisciplinary guidelines, such as the Dutch College of General Practitioners (NHG) publication on standards entitled "Ankle distortion"[7] and the CBO consensus document entitled "Diagnosis and treatment of acute ankle sprain".[6]

Guideline appraisal by practicing physical therapists
Before the guidelines were published and implemented, they were systematically appraised by their intended users in a validation process. Consequently, the chronic ankle sprain guidelines have been evaluated by physical therapists working in different healthcare settings. Information on the guidelines was collected by questionnaire, which was structured using defined quality criteria for guidelines being developed by central bodies. Any comments or criticisms made by participating physical therapists were recorded and discussed by the guidelines

working group. Where necessary, the guidelines were adapted. The final recommendations on physical therapy practice were based on a combination of the scientific evidence available, the other important factors listed above, and the results of appraisal by intended users.

Composition and implementation of the guidelines
The guidelines comprise three parts: the practice guidelines themselves, a schematic summary of the most important points in the guidelines, and a review of the evidence. This division was chosen for practical and educational reasons. All three parts can be read separately. In addition to the guidelines, an expert guide has also been developed and published to promote implementation in clinical practice. Guideline implementation should be carried out in accordance with the recommendations of the published implementation strategy.[3,8]

A novel aspect of guideline use is access through the internet. There is a chronic ankle sprain guidelines internet site that enables physical therapists to consult the guidelines online, to update his or her knowledge about theoretical aspects of the guidelines, and to search for related topics on the internet. An important aspect of the internet site is that it provides the opportunity to 'chat' interactively with colleagues. In this way, physical therapists can discuss the guidelines and help each other implement and integrate them into their daily practice. This internet forum is moderated by the working group.

This review of the evidence explains how the recommendations made in the chronic ankle sprain guidelines were derived. Wherever possible, the guidelines are evidence-based. Where there is insufficient or no scientific evidence, the recommendations made are based on the experience and views of working group experts. Information on the epidemiology, etiology and diagnosis of chronic ankle sprain was obtained by a systematic search of the scientific literature. The following databases were searched: MEDLINE (from 1980–2001), CINAHL (from 1980–2001), the Cochrane Library rehabilitation and related therapies field database (from 1990–2001, accessed at Maastricht University in the Netherlands),

and the DocOnline database of the Documentation Center at the Dutch Paramedical Institute in Amersfoort, the Netherlands (from 1990–2001). The keywords used were: physiotherapy, physical therapy, ankle, inversion, chronic, instability, stability, diagnosis, prognosis, treatment, prevention, measurement instruments, guidelines, prevalence, incidence, randomized clinical trial, randomized controlled trial, meta-analysis, review, and systematic review. Reference tracking was used to obtain additional material. The articles used were written in English, German or Dutch.

Epidemiology

In the Netherlands, about 600,000 people sprain their ankles each year, half during sporting activities. About 300,000 visit a general practitioner or a hospital emergency department. Some 75% of sprained ankles are inversion injuries.[9] Irrespective of the severity of the initial trauma and of the treatment given, whether it involves an operation, use of a plaster cast or functional treatment, a considerable number of persons with acute lateral ankle sprains experience residual complaints.[10] The reported percentage varies between 10% and 60%.[11–15] The differences in prevalence rate can be attributed to variations in the nature of the residual complaints observed. In addition, differences in follow-up time also play a role in the reported prevalence rate variation.[10,11] The prevalence of functional instability is also variable: one year after the initial sprain, 10–40% of patients report a feeling that the ankle is "giving way", instability, or "inversion of the ankle".[11,12,15,16] Two to five years after the initial trauma, an increasing number (27–45%) mention "a feeling of giving way" and "inversion of the ankle".

Delineating the health problem

The flow chart in Figure 1 shows the decision diagram used in deciding whether an ankle complaint should be treated according to these guidelines.

Etiology

Factors responsible for the occurrence and maintenance of functional instability include mechanical instability, loss of muscle strength, delayed muscle reaction time, decreased mobility, peripheral nerve lesions, and inappropriate behavior in response to the complaint. These factors are strongly correlated. Probably, a combination of mechanical instability and reduced neuromuscular control due to abnormalities in proprioception are largely responsible for the failure of dynamic stability.[17–19]
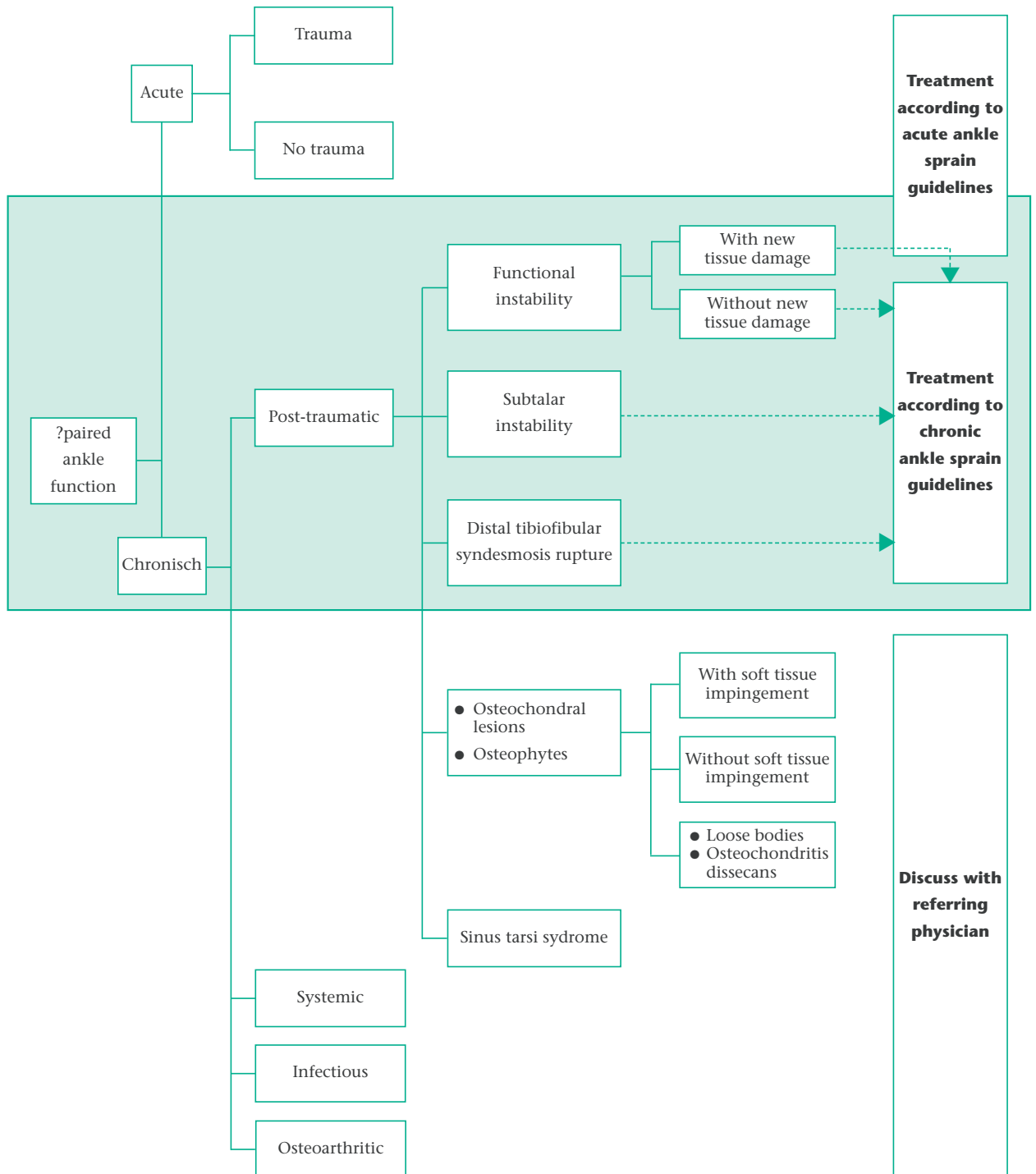
Mechanical instability

Movements that exceed the normal physiological range of motion of the joint most likely cause the mechanical instability that occurs after an inversion trauma involving straining of the lateral joint capsule. Ligament fiber endings separate and do not heal as a functional unit. The result is scar tissue formation and capsular thickening.[20,21] The resulting laxity limits the passive dampening of motion that normally occurs in minor sprains[16,22] and could be responsible for delayed sensory responses in the lateral ankle joint capsule.[13] Mechanical instability can be demonstrated by the presence of an anterior drawer sign (in the sagittal plane) or a positive talar tilt test (in the frontal plane), or both.[13,23] Most studies assessing factors related to functional instability demonstrate objective mechanical instability in only 2-4% of patients.[11,24–29]

Impaired proprioception

Proprioception is defined as "the ability to detect the position and motion of the body or body part relative to the surroundings by means of mechanosensory afferent information from joints, muscles, tendons and the skin".[30] Intact proprioception plays a key role in afferent-efferent neuromuscular reflex chains, thereby ensuring dynamic joint stability.

Impaired proprioception, as evaluated by asking the patient to stand on one leg or on a wobble board, has been demonstrated in patients with functional instability.[16,26,31–34] However, Tropp and other researchers[33,35,36] were unable to show this balance defect but did find that athletes who exhibited poorer balance when standing on one leg before the sport season had a greater chance of suffering ankle sprains. Positional sense and passive movement sense also seem to be disturbed in patients with chronically unstable ankles.[27,34,37–41]

Figure 1. Decision diagram used for deciding how to treat an ankle complaint.

Disturbed proprioception is thought to influence functional instability when damage and subsequent scar tissue formation occurs in the joint capsule and tendons during inversion injury. The lesion,[16] the resulting laxity[13,42] and the functional morphological adaptations that result from decreased use after the injury[43] may lead to a local loss of mechanosensory efferent (type-II) impulses and to decreased passive movement sense.[27] These articular mechanosensory impulses are thought to influence gamma motor neurons, thereby directly exciting the alpha motor neurons involved in musculoskeletal functioning.[13] However, there is no consensus about the extent to which decreased stability can be attributed to the loss of function of receptors in the joint. Recent experimental[26,44,45] and positional sense research[39] demonstrates that receptors in muscle-tendon bridges play a major role. Efferent muscle spindles, which react to muscle lengthening, and Golgi tendon receptors are thought to be responsible for triggering stabilizing reactions in muscles.

Central motor control
Lephart et al.[18] distinguish three subsystems through which the central nervous system receives information: the somatosensory system (see the definition of proprioception), the vestibular system, and the visual system. The integrated information flow from these systems is involved in motor control at three different levels: in the spine, via reflexes and central modulation (e.g., for unconscious joint stabilization); in the brainstem, for posture and balance; and in higher brain centers, which mediate conscious interactions between the individual, the action and the surroundings.

Recent literature acknowledges that different levels of the central nervous system play very active roles in local motor control, including active joint stabilization. The higher brain centers, which have central programs for motor control, are thought to be responsible for the bilateral effects that can be seen in unilateral disorders. For example, decreased conduction speed occurs in the nervi peronei after unilateral inversion trauma,[46] decreased balance in both legs is seen on the wobble board when there is only unilateral functional instability,[31,35] and training programs for proprioception[35] and muscle

strength[47] in one leg result in a general training effect in both legs. However, not all authors agree with this hypothesis. Laskowski and colleagues note: "since cortical routes are considered too lengthy to prevent injury, the shorter loops (i.e., spinal reflexes) are considered more important in preventive mechanisms".[48]

Delayed muscle reaction time
It has been demonstrated that peroneal muscles have a protective function because unstable ankles are less able to dampen sudden inversion movements than stable ankles.[49] Patients with chronic instability have been found to have delayed reactions in peroneal muscles.[13,32,50,51] Moreover, decreased conduction speed in nervi peronei following an ankle trauma could contribute to this phenomenon.[46,52] However, not all research demonstrates this mechanism.[49,53,54]

Decreased muscle strength
Studies of the relationship between muscle strength and functional instability have produced conflicting results. Nevertheless, adequate peroneal muscle activity and strength are considered essential for good balance.[55,56] A direct relationship has been found between loss of strength in the peroneal[41,57,58] and invertor muscles[59] and chronic ankle instability. In particular, peroneal muscle strength is considered important for quick movements.[41] However, other authors do not regard muscle strength as being primarily associated with functional instability.[17,24,26,27,60]

Altered mobility
Limited dorsal flexion in healthy individuals is thought to increase the risk of an inversion injury five fold.[61] In this hypothesis, decreased mobility leads to functional morphological adaptations in the number of mechanosensors. However, McKnight et al.[60] were unable to demonstrate any differences in joint mobility between individuals with functional instability, individuals without a history of ankle sprain, and individuals who took part in a proprioception rehabilitation program.

Inadequate way of coping with complaints
Behavioral factors, such as overloading the joint,

limiting weight-bearing because of fearfulness, and adopting an incorrect gait pattern, are strongly linked to the patient's character and to his or her social and cultural background.

Inadequate or insufficient treatment of acute ankle sprains

Renström and others[20,23] state that "inadequate rehabilitation is the primary cause of residual disability after ankle sprains". The treatment of acute ankle sprains described in the acute ankle sprain guidelines is intended to produce a complete cure, without any residual symptoms, and to prevent the development of chronic complaints and instability. In these guideline recommendations, building up adequate load-bearing capacity is a central feature of training. Adequate and sufficient rehabilitation of acute ankle sprains has been shown to be effective in limiting the risk of residual complaints, including functional instability.[6,23,25,62,63] Functional instability in itself is considered a risk factor for the development of a new ankle sprain.

Diagnosis

The diagnostic process should reveal which underlying disorder is responsible for the patient's condition. For example, it should be possible to determine why the patient has a residual complaint after the inversion trauma and why functional recovery has not occurred. It is important to differentiate between functional instability and other chronic complaints because of the implications for therapy. In order to distinguish between these different factors, the physical therapist has to be able to assess coordination, mobility, strength, load-bearing capacity, and the extent and cause of the patient's pain. Moreover, during history-taking, the patient's own goals and expectations should be ascertained. The following questions must be answered:

• What level of functioning does the patient want to achieve?
• Does the patient participate in any sports and what impact do sporting activities have on the patient's life?
• Which other activities does the patient consider to be important?
• What does the patient expect from therapy?

Answers to these questions are important because the patient's own preferences play a central role in devising treatment goals and the overall treatment plan. At the end of the diagnostic process, the physical therapist should be able to state clearly which treatment goals are attainable.

A previous inversion injury is a major risk factor for a relapse.[28,64,65] Therefore, the physical therapist should find out as much as possible about the initial trauma, recovery from the trauma, and any relapses. During history-taking, the patient should be asked whether he or she is afraid of the ankle 'giving way'. This fear could be assessed using a visual analogue scale, as described below in the discussion of measurement instruments.

Pain and swelling may occur because of new tissue damage. These phenomena are mainly useful for differential diagnosis. In particular, it is important to know if pain or swelling occurs while performing activities or resting, the location of the pain, and whether there is pressure pain. It should be remembered that the presence of pain and swelling can indicate overloading.

No relationship has been found between the anatomy of the foot and the occurrence of instability.[28]

The way in which a patient deals with his or her complaints depends on the patient's characteristics, his or her background, and interactions between the patient and his or her personal environment. The patient may be afraid of movement and, possibly, of "breaking something". In addition, he or she may also lack knowledge about the correct relationship between load and load-bearing capacity, thereby overloading the joint.

Investigations of active movement should take place with the joint under load. Dorsal flexion is the movement that is most likely to lead to pain and functional problems.[56] About 20 to 30 degrees of dorsal flexion[55] is needed for running.[67] Pain-free dorsal flexion is a vital determinant of walking speed and contralateral step length. If dorsal flexion is found to be limited or painful during history-taking, active movement investigation or observation of the

patient's walking pattern, ankle movement should be investigated passively.

Proprioception can be assessed by asking the patient to stand on one leg with eyes open and then with eyes closed. Differences in stance and pain behavior between left and right sides can be observed from the front.[31] It is important to be certain that this test is appropriate for the particular patient. By using this test, postural swaying and control over static balance can be evaluated to determine how neuromuscular control is influenced by the combined afferent input from peripheral, vestibular and visual systems.[26,30,31] Neuromuscular control itself also influences the test results as it is involved in ensuring that afferent stimuli are processed in such a way as to evoke an appropriate reaction.[68] Closing the eyes eliminates visual input and sensory feedback becomes more important. Subsequently, the patient can be asked to hop on one leg, including the injured leg. The therapist should check the patient's ability to balance on the affected leg after the exercise.

Patients can be asked to walk alternately on their toes or heels to assess proprioception and pain. Only a few steps on the heels are needed to demonstrate gait asymmetry. When assessing strength, the patient can be asked to walk for a longer period and the point at which fatigue starts can be recorded. In addition, the number of times the toe or heel is lifted (i.e., to a relative distance between toe and heel of more than 1 cm from the floor) while the patient stands on one leg for a minute can be noted. This can demonstrate differences between left and right sides.[69]

These tests can be repeated after a number of therapy sessions to evaluate the effects of therapy. When training for strength, it is necessary to carry out a strength assessment. When training for proprioception, proprioception assessment is called for.

If the patient has performed satisfactorily on the above-mentioned tests, the patient's quality of movement during heavy loading and during twin tasks can then be assessed. For instance, tasks involving activities the patient regards as being important or problematic can be practiced or balance

can be tested on an unstable surface such as an exercise mat, wobble board or trampoline. Ultimately, these activities could be made more complex by requiring the patient to throw or catch a ball at the same time.

Anterior drawer test
Use of the anterior drawer test has not been included in these guidelines because its prognostic value is limited and therapeutic management of the patient is not influenced by the test results. However, the test does give an impression of mechanical instability and could, therefore, be performed. The talofibular anterior ligament is the structure most likely to sustain damage during an inversion trauma. If this ligament is ruptured, exorotation (i.e., anterolateral rotation) instability is observable in the ankle joint. Under anesthesia, this can be demonstrated as a positive anterior drawer sign. Without local anesthesia, the test is less reliable[10] because of pain, reactive muscle spasms and swelling. Van Dijk et al.[10] assessed the validity of the anterior drawer test when carried out four to five days after the initial trauma and found a specificity of 74% and a sensitivity of 86%. Carrying out this clinical test without anesthesia is probably better tolerated in the subacute or chronic phase. The reliability of the anterior drawer test is probably better in these phases.[70]

The prerequisites for carrying out the anterior drawer test are that the patient is able to relax, that the test is not painful, and that the physical therapist has explained what will happen. The following sequence of events then occurs:
- the patient lies on his or her back or is seated while the upper leg is supported and the lower leg hangs free;
- the physical therapist takes hold of the heel, supports the sole of the foot using the forearm, and maintains plantar flexion in the foot (i.e., 10–15 degrees);
- the physical therapist holds the front of the lower leg with the other hand at a position 10 cm above the ankle joint; and
- the physical therapist moves the relaxed foot ventrally while the lower leg is held in position.

The test is regarded as giving a positive result when the foot slides ventrally relative to the lower leg by at

least 1 cm more than occurs in the healthy leg.

Recommended measurement instruments

The guidelines advise use of the following two measurement instruments to assist the physical examination: the visual analogue scale for patient-specific complaints and the Nijmegen gait analysis scale. These scales can be used to monitor the patient's progress during therapy. It is advisable to assess the patient's functional status and the severity of any problems performing normal daily activities at baseline, halfway through therapy, and at the end of therapy.

Patient-specific complaints instrument

The instrument for patient-specific complaints[71,72] is used to assess the patient's functional status. Firstly, the patient chooses the three activity-related complaints that he or she regards as being most important. The activities involved should be important to the patient, should hinder the performance of daily tasks, and should be performed regularly, at least once a week. The patient should estimate the amount of effort spent on carrying out these activities and score it on three visual analogue scales (VAS). This instrument is responsive in assessing patient-specific complaints in daily practice, and takes little time to apply.[71,73] Moreover, testing does not require specific knowledge.

The guideline working group regards the instrument for patient-specific complaints, as applied to the patient's three main complaints, as useful for assessing the severity of complaints in patients with functional instability of the ankle and for evaluating the effect of therapy.

Nijmegen gait analysis scale

The Nijmegen gait analysis scale can be used to assess and describe the patient's gait pattern. The working group regards a normal gait pattern as being essential for recovery. An abnormal walking pattern is thought to cause the complaint to persist. The Nijmegen gait analysis scale is a measurement instrument used by the St Radboud University Medical Center in Nijmegen, the Netherlands, to analyze gait patterns in patients with disorders affecting the lower extremities. It consists of 13 items, each of which

refers to an aspect of the patient's gait and involves the evaluation of different anatomical structures (e.g., the trunk, pelvis, knee and ankle). It indicates whether or not gait training for a particular item should be a primary goal of treatment.

Unpublished research[76] on the Nijmegen gait analysis scale shows that intra-rater reliability is fair to good for both experienced and inexperienced raters, with intra-rater correlation coefficients (ICCs) of 0.52 and 0.70, respectively, and good for expert raters, with an intra-rater correlation coefficient of 0.71. Inter-rater reliability is reasonable to fair for both experienced and inexperienced raters, with inter-rater correlation coefficients of 0.40 and 0.43, respectively, and reasonable for expert raters, with an inter-rater correlation coefficient of 0.54.

Use of the Nijmegen gait analysis scale can help guide physical therapy. Standard scores are available, enabling the comparison of individual patient data with reference values. However, as training in the use of this scale increases its reliability, additional training is necessary. The working group acknowledges that recommending use of the Nijmegen gait analysis scale is open to question as there is a lack of published data on its reliability and validity. Given that there are no better alternatives, however, the scale can be regarded as a useful tool for helping therapists to standardize their observations of gait patterns.

The guideline working group regards gait training as an important aspect of therapy in patients with chronic ankle sprains. Therefore, use of the Nijmegen gait analysis scale for diagnosis and therapy evaluation is recommended.

Differential diagnosis

The presence of residual complaints such as pain, a feeling that the ankle is 'giving way', or activity limitations can also be due to disorders other than chronic ankle sprain. It is important, therefore, that the disorders listed in Table 1 are identified if they are present as they may require a different approach to that advised in these guidelines.

Table 1. Other disorders that can cause chronic ankle complaints. Notes: Disorders 1 to 4 are all residual complaints associated with inversion trauma. Disorders 5 and 6 can also occur in the absence of preceding inversion trauma. All these disorders may be accompanied by functional instability.

Disorder	Description	Symptoms	Recommended actions
1. (Osteo)chondral lesions and osteophytes, with or without impingement	Compression fractures, cartilage damage and uncontrolled formation of talar or tibial bone, or both, with, as possible consequences, anteromedial or anterolateral impingement	Continued swelling (synovitis), pressure pain and activity-related pain that hinder the build up of load-bearing, stiffness, functional limitations, and limited and painful dorsal flexion resulting from ventral impingement[79]	Additional investigation by CT, magnetic resonance imaging or arthroscopy is indicated, and referral to a doctor required
1a. Soft tissue impingement, scar tissue[78]	The thickened capsule impinges, probably because of inflammation	Mostly anterior pain, swelling and limited dorsal flexion, plus limited synovitis	Additional investigation by arthroscopy is indicated, and referral to a doctor required
2. Loose bodies, osteochondritis dissecans	As for disorder 1 but with loose fragments	Intermittent pain, swelling and clicking, and limited synovitis	Additional investigation by arthroscopy is indicated, and referral to a doctor required
3. Subtalar (mechanical) instability	The estimated prevalence is 10% in patients with functional instability. However, there is no proven relationship between subtalar motion and the occurrence of symptoms[28]	Similar to those in functional instability, but with local pressure pain in the subtalar joint.[23] No reliable diagnosis is possible[42]	The same as for functional instability, as described in these guidelines
4. Sinus tarsi syndrome	Lesion of the talar calcaneal ligament that results in swelling in the sinus tarsi	Feeling of 'giving way' and pressure pain 2 cm anterior and distal to the tip of the lateral malleolus, on the sinus tarsi[23]	Rest and administration of non-steroidal anti-inflammatory drugs, in consultation with the referring physician
5. Distal tibiofibular syndesmosis rupture	The distal tibiofibular syndesmosis is stabilized by four ligaments. Of these, the anterior distal tibiofibular ligament is most affected. Increased mobility of the fibula is invoked. The incidence is estimated to about 1% in all ankle sprains. The result is a longer recovery period.[80,81] Possibly the result of an inversion or exorotation dorsal flexion trauma[23]	Initially, the disorder presents as a normal inversion injury with limited swelling. Persistent pressure pain in ventral syndesmoses, and an abnormal gait pattern because of pressure pain and dorsal flexion pain. The exorotation stress test and squeeze test give positive results	Early recognition is important. Building up of load-bearing capacity should be slower than for a normal inversion injury. Support with tape or a brace may be necessary for a longer period.[80] Exercise therapy should be given in accordance with the guidelines on acute or chronic ankle sprain
6. Arthrosis	The incidence is low compared to that in hip or knee arthrosis. Risk factors include the presence of incongruent joint planes that result in intra-articular trauma[6,10,79] and the presence of osteophytes	Starting pain and starting stiffness, activity-related pain, occasional instability, and dorsal flexion more (painfully) limited than plantar flexion	Improve range of dorsal flexion. Provide functional exercise therapy to improve gait pattern, proprioception and muscle strength. Provide frequent low-intensity training, involving, for example, cycling or the performance of normal daily activities. Give advice on regulating activity and alternating it with resting. Shoe adaptation.[81] If complaints persist, refer to a surgeon or to a general practitioner for non-steroidal anti-inflammatory drugs

Therapy

A systematic review of the scientific literature was carried out to substantiate the recommended therapeutic approach. Searches for systematic reviews and randomized clinical trials were conducted using the following databases: MEDLINE, CINAHL, the Cochrane rehabilitation and related therapies field database at Maastricht University in the Netherlands, the DocOnline database of the Dutch Institute for Allied Health Professionals, and EMBASE. The keywords used were: ankle, chronic, instability, relapse, prevention, and therapy. The reference lists in the articles found were evaluated for their relevance and additional articles were retrieved if appropriate. In addition, members of the working group also provided material.

The material found was included in the systematic review if: (a) the trials involved, for comparison, patients who received placebo or no treatment, or two interventions; (b) (sub)group analyses were reported; (c) the results of conservative treatment (e.g. no surgery or drug use) or preventative interventions were reported; (d) physical therapy interventions were used in either the experimental or control group; (e) clinically relevant and valid outcome measures were used; and (f) the publication language was Dutch, English or German. Abstracts, congress reports and unpublished material were excluded.

This search strategy yielded 21 randomized clinical trials and two systematic reviews. The reviews concerned the primary and secondary prevention of ankle sprains. The methodological quality of the trials was assessed using criteria laid down by the Evidence-Based Guidelines Meeting (EBRO platform) and specified in the CBO consensus document {Erik, v\can you add the appropriate reference to this?}.[82] The scientific weight of the material collected was evaluated according to the four levels of evidence described in Table 2.

Evidence

Literature findings indicate that conservative treatment – nonsurgical intervention – is preferred for chronic ankle complaints.[23,42,47,83–85] The treatment of relapses should start with a conservative approach

Table 2: Descriptions of the four levels of evidence used for evaluating the scientific weight of material collected.[82] The quality levels referred to are described in Table 3.

Level of evidence	Description
Level 1	One systematic review at quality level A1 or at least two independent trials at quality level A2
Level 2	At least two independent trials at quality level B
Level 3	One trial at quality level A2 or B, or research at quality level C
Level 4	Expert opinion, such as that of working group members

Table 3. Descriptions of the five quality levels used for evaluating the material collected on interventions.

Quality level	Description
A1	Systematic reviews, which include at least some trials at quality level A2, that show consistent results between studies
A2	Randomized clinical trials of a good methodological quality and with sufficient power and consistency
B	Randomized clinical trials of a moderate methodological quality or with insufficient power, or other non-randomized, cohort or patient-control group study designs that involve intergroup comparisons
C	Patient series
D	Expert opinion, such as that of working group members

lasting 8–12 weeks.[86] If complaints persist, surgery can be considered. The most important form of conservative therapy is reported to be exercise therapy augmented by taping or bracing.[23,42,65] However, the relative effectiveness of different conservative treatment options remains unclear. Most published articles are of limited methodological quality and contain inconsistent definitions of the interventions and outcome measures employed.[65,87,88]

Exercise therapy
To ensure that patients with chronic ankle complaints regain optimal functioning of the ankle, it appears advisable that treatment should be as varied and intense as possible.[42,86,89,92] Treatment should focus on training proprioception, increasing muscle strength, increasing mobility, normalizing the gait pattern, and training for sporting activities, if necessary.[23,42] Ideally, the patient's performance in these areas is assessed at the start of treatment and, depending on the findings, exercise therapy should focus on the weakest area or areas. The effects of therapy should be evaluated at regular intervals. The project group acknowledges that, at the moment, no valid instruments for the standardized assessment of proprioception, strength, mobility, gait pattern or functional instability in chronic ankle complaints are available for physical therapy practices. There is a need for appropriate clinical measurement techniques in physical therapy.

Conclusions
On the basis of the material collected, the project group concludes that the evidence on exercise therapy is at evidence level 2 and that the quality of the studies retrieved[89–92] is at quality level B.

It is likely, then, that the treatment of ankle complaints should consist of an exercise program that is as varied and intense as possible if optimal ankle functioning is to be achieved.

Training proprioception
The effect of training proprioception using a wobble board has been investigated in healthy individuals[93–95] and in patients with ankle sprains.[25,62,96,97] All studies show that coordination and balance exercises lead to increased functional stability of the ankle. In their review of prevention, Verhagen et al.[87] concluded that athletes who have had a previous ankle sprain and who receive proprioception training have the same risk of a new ankle sprain as individuals who have not had a previous ankle sprain. Vaes et al.[49] showed that, to train supination dampening in the standing position, the height of the wobble board should be sufficient to enable a tilt of more than 30 degrees.

Delayed reaction time in the peroneus longus muscle can be improved by rehabilitation therapy.[98] However, the impulse given to disturb balance should be sufficiently strong.[49] Nevertheless, there is an absence of data proving that proprioception training shortens the reaction time to such an extent that the ankle is better protected against trauma. In research into dynamic stability in the knees of healthy individuals, Wojtys et al.[99] concluded that muscle fatigue leads to a delayed muscular reaction to sudden joint translations. Matsusaka et al.[97] studied the additional effect of applying non-elastic tape around the lateral malleolus during wobble board training in 22 persons with functional instability of the ankle. The researchers hypothesized that taping may improve the afferent input from skin receptors, thereby improving the efficacy of proprioception training. On the basis of their primary outcome measure of 'maintaining position', they found that the experimental group reached their reference level two weeks earlier than the control group.

Conclusions
On the basis of the material collected, the working group concludes that the evidence on proprioception training is at evidence level 2 and that the quality of the studies retrieved[25,35,96,97,100] is at quality level B.

It is likely, then, that coordination exercises and balance training help patients with ankle complaints to regain functional stability of the ankle.

However, as other evidence on proprioception training is at evidence level 4, the working group postulates that training using a wobble board as stand-alone therapy does not fully provide proprioception training. It is advised, therefore, that

optimal use is made of the patient's normal daily activities and of exercises for specific sports. Proprioception should be trained using the full range of ankle motion in order to activate mechanoreceptors at all possible joint angles. In particular, this principle should be applied using the range of movement regained after mobilization.

Increasing muscle strength
There is little evidence available on the effect of strength training in patients with chronic ankle complaints. However, strength training is often an integral part of exercise programs.[23,33,42,85,86,89]
It seems likely that a particular strength level is associated with, and is a prerequisite for, a particular level of muscular stability. Moreover, active muscular contraction, by means of mechanisms in muscle spindles, influences proprioception.[101] Muscle training is thought to decrease the risk of relapse and to have a positive influence on proprioception.[25] Other research[93] suggests that muscle training is as effective as proprioception training in improving joint stability and balance. Uh et al.[102] and Kannus et al.[47] found that, in healthy individuals, strength training had a positive effect in not only the leg that had undergone training, but also in the contralateral leg that had not. This is the so-called cross-over effect. In addition, Wojtys et al.[99] found that muscle fatigue leads to decreased coordination and, thereby, to the deterioration of dynamic stability in the knees of healthy individuals.

Conclusions
On the basis of the material collected, the project group concludes that the evidence on strength training is at evidence level 3 and that the quality of the studies retrieved[47,93,99,102] is at quality level C.

It is possible, then, that strength training has a positive effect on the recovery of functional instability in the ankle.

Other evidence on strength training is at evidence level 4, and the working group believes that, in patients with chronic ankle complaints, the exercise program should involve enough repetitions and be of sufficient intensity to train muscle endurance.

Increasing mobility
There is no evidence available on the effectiveness of manipulative techniques in patients with functionally unstable ankles. In patients with acute ankle sprains, the use of anterior-posterior talocrural mobilization techniques in addition to RICE (i.e., rest, ice, compression, elevation) protocols has a positive effect in achieving earlier pain-free dorsal flexion and in improving walking speed.[67]

Conclusions
On the basis of the material collected, the working group concluded that the evidence on mobilization techniques is at evidence level 4.

The project group believes that, in patients with chronic ankle complaints, the range of motion of the ankle should be maximized by active exercises. Only when this is not sufficient, should passive techniques be employed.

Electrotherapy, laser therapy and ultrasound therapy
There is no evidence in the literature justifying the use of electrotherapy, laser therapy or ultrasound therapy in patients with chronic ankle complaints.[103]

Conclusions
On the basis of the material collected, the working group concluded that the evidence on electrotherapy, laser therapy and ultrasound therapy is at quality level A1.

The project group states that, in patients with chronic ankle complaints, use of electrotherapy, laser therapy or ultrasound therapy does not, in general, increase the effectiveness of exercise programs.

Table 4. The interventions for treating patients with chronic ankle strain reviewed in these guidelines ranked according to the level of evidence of their effectiveness.

Evidence level	Strength of evidence	Intervention
1	Strong	Bracing
		Taping
2	Intermediate	Proprioception training
3	Limited	Strength training
4	None or unclear	Electrotherapy, laser therapy and ultrasound therapy
		Manipulative therapies
		Special shoes
		Gait training

Relapse prevention

Tape and braces

Recent extensive reviews[87,88] show strong evidence, at evidence level 1, that the provision of external support prevents ankle sprain relapses. Other literature reviews confirm this finding.[104,105] The use of tape or a brace reduces the frequency of ankle sprains, especially in individuals who have had previous sprains. A reduction of 40–50% has been reported.[25,88,106,107] Taping and bracing also reduce ankle sprain severity.[87] The fit of the tape or brace must be optimal if maximum patient compliance is to be obtained.[108–111] Vaes et al.[104] distinguish between four types of support: wraps (i.e., non-adhesive bandages), straps (i.e., adhesive elastic bandages), tape (i.e., adhesive non-elastic bandages) and braces (i.e., a manufactured support that may be tailor-made to fit).

Braces

Extensive research has been carried out into the functioning of braces and into comparisons of the different types of brace. To date, no single type of brace has proved superior to the others. However, each has its own advantages and disadvantages with regard to fit and comfort. The more rigid the brace, the less comfortable it is to wear and the greater the restriction on joint movement. The task of deciding which type of brace is most appropriate is influenced by data from history-taking, the results of the physical examination, and the individual patient's wishes and needs. Literature reviews show that most studies have been performed on the usefulness of ankle braces for preventing ankle sprains during sporting activities.[28,88,109,112–116] Braces have been shown to be useful in preventing relapses in high-risk sports.

Tape

Taping has a minimal effect on sporting performance.[65,104,117] Moreover, it is claimed to be "useful for prevention, both in healthy and injured (chronically sprained) athletes".[87,88]

Taping has two functions.[118,119] Firstly, it exerts a mechanical or stabilizing effect by limiting plantar flexion and inversion movements. This is very important if there is weakness or secondary atrophy, or both, of the evertor muscles.[25] Lohrer et al.[120] noted that, in addition to movement being limited during inversion, movement speed is also reduced. However, Manfroy et al.[121] argued that these effects exist for only a short period after tape has been applied. After about 40 minutes of participation in a sport, no difference can be observed between the taped ankle and the normal ankle in terms of resistance to inversion.[121] Secondly, an influence on proprioceptive reflexes in ankle muscles has been reported. However, the effect of taping on proprioception is controversial. Refshauge et al.[122] and Konradsen and Bohsen-Ravn[32] concluded that there is no evidence that taping enhances proprioception. Nevertheless, both positive and negative effects on the reaction time and on the moment of contraction of the peroneal muscles have been reported. Karlsson et al.[13] showed that taping a mechanically stable ankle decreases the muscle reaction time. Matsusaka et al.[97] claim that

individuals with chronic ankle instability recover two weeks faster because taping has a positive influence on afferent input.

Different taping techniques have not been compared extensively in terms of the degree of mechanical restriction they exert on the ankle.[119] The basket-weave method, with 'stirrups' and a 'heel lock', has been described as the best way to apply tape.[124,125] In addition, Coumans' taping has also been reported to be effective.[15] On a theoretical basis, Riezebos et al.[126] postulate that applying tape limits exorotation of the lower leg and prevents exorotation and adduction of the talus relative to the calcaneus. It is assumed that inversion traumas occur primarily during rotation in the (mainly) horizontal plane.

Comparison of tape and braces
Braces are even more effective in preventing ankle sprain relapses than tape.[87] However, taping results in a 25% greater reduction in the range of joint motion before sporting activities than the use of a brace.[127] During sporting activities, however, there is a considerable loosening effect with tape, which leads to a reduction in efficacy of 40–50% within hours depending on the type of activity.[124,128] In contrast, braces show a loosening affect of only 4.5–12%.[127] Moreover, with braces, the initial rigidity can be easily regained by pulling on the straps or tightening the laces. Both taping and the use of braces have comparable effects on mechanical stability, as assessed after activities.[127,129]

Advantages and disadvantages of tape and braces
In addition to the considerable loosening effect, taping also has other disadvantages. The cost of the materials is high, there may be skin irritation due to the adhesive, and tape is hard to remove. One advantage of taping is that the fit is highly individual. In contrast, braces are less likely to irritate the skin and are easy to put on. The disadvantages are that it is difficult to find the right size (i.e., the optimal fit) and that patients cannot wear shoes with their braces, with the result that skin irritation may occur.[130] A good brace should balance comfort and support[112] and is, therefore, an individual choice.

Some authors think that the use of tape and braces is

beneficial until coordination training has ended[25,107,119] and in situations where there is a greater than average risk of injury[25], for example, when the patient is fatigued during a sporting activity, is involved in a high-risk sport, or has experienced a relapse.

The working group holds the opinion that the continuous use of taping or a brace is not supported by the literature. The effect of the continuous use of taping or bracing on proprioception is unknown. The intention of the treatment recommended by these guidelines is to optimize the recovery of neuromuscular function. The working group believes that the continuous use of taping or a brace could possibly have a negative influence on functional stability over the long term.

Conclusions
On the basis of the material collected, the working group concludes that the evidence on the use of taping and braces is at evidence level 1 and that the quality of the studies retrieved[87,88] is at quality level A1.

External support reduces the risk of ankle sprain in high-risk sports and, in general, prevents ankle sprain relapses and reduces sprain severity. Physical therapists should inform patients about these facts and advise accordingly.

Other evidence on the use of taping and braces is at evidence level 4, with the quality of the studies retrieved[87,88] being at quality level A1.

The project group believes that the routine use of external support during participation in sports or during heavy work could have a negative influence on functional stability over the long term. The project group holds the opinion that the recovery of functional stability should be the endpoint of treatment and advises the gradually diminishing use of external support.

Shoes
Evidence on the optimal use of footwear is contradictory. Some authors recommend high-top shoes[107,114] whereas others recommend low-top

shoes.[131] Barret et al.[132] found no strong relationship between shoe type and type of ankle injury. Verhagen et al.[87] concluded that the use of new shoes probably has a greater preventive effect than shoe height.

The project group holds the opinion that it is important that the patient's shoe type is appropriate for normal daily life activities, work and sporting activities, and for the type of surface encountered. The timely renewal of footwear is advisable.

Treatment frequency and duration

The frequency of treatment depends on the intervention being used and the stage of treatment. The project group recommends that more guidance should be given on complex processes, such as relearning a walking pattern or learning specific exercises, than on strength or proprioception training. The role of the physical therapist is both educational and correctional, thereby requiring frequent contact with the patient (i.e., two to three times a week). The patient should be able to perform strength and proprioception training at home if properly instructed. Here, the role of the physical therapist is similar to coaching, and contact with the patient need only occur once a week or fortnight.

There is no scientific evidence on how timing influences the effectiveness of interventions for chronic ankle sprain. The project group holds the opinion that an improvement should be noted in the patient, as assessed using the instrument for patient-specific complaints, by at least six weeks after the start of therapy. If this is not the case, the patient should be referred back to his or her doctor.

Updating these guidelines

These guidelines are based on currently available evidence. At the moment, there is a moderate amount of scientific evidence on the use of physical therapy in chronic ankle sprains. However, a significant part of the guideline recommendations is based on expert consensus. Therefore, the recommendations given in these guidelines might have to change as a result of new knowledge and scientific findings. The method of guideline development and implementation that was followed

in the production of these guidelines states that all guidelines should be revised within three to five years of the first publication.[3,133] The Royal Dutch Society for Physical Therapy (KNGF), together with members of the current working group, plans to update these guidelines in 2006. Nevertheless, if new scientific developments necessitate an earlier update, this would also be carried out.

The legal status of the guidelines

These guidelines are not legal documents. They detail knowledge and contain recommendations, which are based on the results of scientific research, that therapists should follow in order to provide appropriate healthcare. Since the recommendations made in the guidelines apply to the 'average' patient, therapists must use their professional judgement to decide when to deviate from the guidelines if that is required in a particular patient's situation. Any deviation from guideline recommendations must be justified and documented.[2,3]

Acknowledgements

References

1   Hendriks HJM, Reitsma E, van Ettekoven H. Centrale richtlijnen in de fysiotherapie. Ned Tijdschr Fysiother 1996;106:2-11.

2   Hendriks HJM, van Ettekoven H, Reitsma E, Verhoeven ALJ, van der Wees P. Methode voor centrale richtlijnontwikkeling en implementatie in de fysiotherapie. Amersfoort, the Netherlands: KNGF/NPi/CBO; 1998.

3. Hendriks HJM, Bekkering GE, van Ettekoven H, Brandsma JW, van der Wees P, de Bie RA. Development and implementation of national practice guidelines: a prospect for continuous quality improvement in physiotherapy. Introduction to the method of guideline development. Physiother 2000;86:547.

4   Roebroeck ME, Dekker J, Oostendorp RAB, Bosveld W. Physiotherapy for patients with lateral ankle sprains: a prospective survey of practice patterns in Dutch primary health care. Physiother 1998;84:421-32.

5   De Bie RA, Hendriks HJM, Lenssen AF, van Moorsel SR, Opraus KWF, Remkes WFA, et al. KNGF-richtlijn Acuut Enkelletsel. Amersfoort, the Netherlands: KNGF/NPi; 1998.

6   CBO consensus diagnostiek en behandeling van het acute enkelletsel. Utrecht, the Netherlands: CBO; 1998.

7   Goudsward AN, Thomas S, van den Bosch WJHM, Geijer RMM. NHG-Standaard Enkeldistorsie (eerste herziening). Huisarts Wet 2000;43:32-7.

8   Hendriks HJM, van Ettekoven H, Bekkering GE, Verhoeven ALJ. Implementatie van KNGF-richtlijnen. Fysiopraxis 2000;9:9-13.

9   Mulder S, Bloemhoff A, Harris S. Ongevallen in Nederland, opnieuw gemeten. Amsterdam, the Netherlands: Stichting Consument en Veiligheid; 1995.

10 Van Dijk CN. Review of the literature. In: Van Dijk CN. On diagnostic strategies in patients with severe ankle sprain (thesis). Amsterdam, the Netherlands: Universiteit van Amsterdam; 1994;5-51.

11 Zeegers AVCM. Het supinatieletsel van de enkel. Resultaten (thesis). Utrecht, the Netherlands: Universiteit Utrecht; 1995;83-131.

12 Møller-Larsen F, Wethelund JO, Jurik AG, de Carvalho A, Lucht U. Comparison of three different treatments for ruptured lateral ankle ligaments. Acta Orthop Scand 1988;59:564-6.

13 Karlsson J, Andreasson GO. The effect of external ankle support in chronic lateral ankle joint instability: an electromyographic study. Am J Sports Med 1992;20:257-61.

14 Povacz P, Unger F, Miller K, Tockner R, Resch H. A randomized, prospective study of operative and non-operative treatment of injuries of the fibular collateral ligaments of the ankle. J Bone Joint Surg 1998;80-A:345-51.

15 Van Moppes FI, van den Hoogenband CR. Diagnostic and therapeutic aspects of inversion trauma of the ankle joint (thesis). Maastricht, the Netherlands; 1982.

16 Freeman MAR, Dean MRE, Hanham IWF. The etiology and prevention of functional instability of the foot. J Bone Joint Surg 1965;47B:678-84.

17 Lentell GL, Katzman LL, Walters MR. The relationship between muscle function and ankle stability. J Orthop Sports Phys Ther 1990;11:605-11.

18 Lephart SM, Pincivero DM, Giraldo JL, Fu FH. The role of proprioception in the management and rehabilitation of athletic injuries. Am J Sports Med 1997;25:130-7.

19 Konradsen L, Olesen S, Hansen HM. Ankle sensorimotor control and eversion strength after acute ankle inversion injuries. Am J Sports Med 1998;26:72-7.

20 DeMaio M, Paine R, Drez D. Chronic lateral ankle instability inversion sprains: Part I. Orthopedics 1992;15:87-96.

21 DeMaio M, Paine R, Drez D. Chronic lateral ankle instability inversion sprains: Part II. Orthopedics 1992;15:241-8.

22 Staples OS. Result study of ruptures of lateral ligament of the ankle. Clin Orthop 1972;85:50-8.

23 Renström PAF, Konradsen L. Ankle ligament injuries. Br J Sports Med 1997;31:11-20.

24 Vaes PH, Duquet W, van den Broeck R. Enkeldistorsietrauma en enkelinstabiliteit. In: Jaarboek Fysiotherapie. 1997:1-45.

25 Tropp H, Askling C, Gillquist J. Prevention of ankle sprains. Am J Sports Med 1985;13:259-62.

26 Ryan L. Mechanical stability, muscle strength and proprioception in the functionally unstable ankle. Aust J Physiother 1994;40:41-7.

27 Lentell G, Baas B, Lopez D, McGuire L, Sarrels M, Snyder P. The contributions of proprioceptive deficits, muscle function, and anatomic laxity to functional instability of the ankle. J Orthop Sports Phys Ther 1995;21:206-15.

28 Louwerens JWK. The position of the rear foot at the moment of heel contact and chronic lateral instability: a video analysis (thesis). Rotterdam, the Netherlands: Erasmus Universiteit Rotterdam; 1996;61-8.

29 Birmingham TB, Chesworth BM, Hartsell HD, Stevenson AL, Lapenskie GL, Vandervoort AA. Peak passive resistive torque at maximum inversion range of motion in subjects with recurrent ankle inversion sprains. J Orthop Sports Phys Ther 1997;25:342-8.

30 Lephart SM, Pincivero DM, Rozzi SL. Proprioception of the ankle and knee. Sports Med 1998;25:149-55.

31 Fridén T, Zätterström R, Lindstrand A, Mortiz U. A stabilometric technique for evaluation of lower limb instabilities. Am J Sports Med 1989;17:118-22.

32 Konradsen L, Bohsen-Ravn J. Prolonged peroneal reaction time in ankle instability. Int J Sports Med 1991;12:290-2.

33 Leanderson J, Eriksson E, Nilsson C, Wykman A. Proprioception in classical ballet dancers: a prospective study of the influence of an ankle sprain on proprioception in the ankle joint. Am J Sports Med 1996;24:370-4.

34 Forkin DM, Koczur C, Battle R, Newton RA. Evaluation of kinesthetic deficits indicative of balance control in gymnasts with unilateral chronic ankle sprains. J Orthop Sports Phys Ther 1996;23:245-50.

35 Rozzi SL, Lephart SM, Sterner R, Kuligowski L. Balance training for persons with functionally unstable ankles. J Orthop Sports Phys Ther 1999;29:478-86.

36 Tropp H, Ekstrand J, Gillquist J. Factors affecting stabilometry recordings of single limb stance. Am J Sports Med 1984;12:185-8.

37 Garn SN, Newton A. Kinesthetic awareness in subjects with multiple ankle sprains. Phys Ther 1988;68:1667-71.

38 Glencross D, Thornton E. Position sense following joint injury. J Sports Med Phys Fitness 1981;21:23-7.

39 Konradsen L, Ravn JB, Sorenson AI. Proprioception at the ankle: the effect of anaesthetic blockade of ligament receptors. J Bone Joint Surg Br 1993;75:433-6.

40 Boyle J, Negus V. Joint position sense in the recurrently sprained ankle. Aust J Physiother 1998;44:159-63.

41   Hartsell HD. The effects of external bracing on joint position sense awareness for the chronically unstable ankle. J Sport Rehab 2000;9:279-89.

42   Karlsson J, Faxén E, Eriksson BI. Ankle joint ligament injuries: prevention, evaluation and treatment. Phys Rehab Med 1996;8:183-200.

43   Oostendorp RAB. Functionele instabiliteit na het inversietrauma van enkel en voet: een effectonderzoek pleisterbandage versus pleisterbandage gecombineerd met fysiotherapie. Geneesk Sport 1987;20:45-55.

44   Burke D, Gandevia SC, Macefield G. Responses to passive movement of receptors in joint, skin and muscle of the human hand. J Physiol 1988;Aug:347-61.

45   Clarke FJ, Grigg P, Chapin JW. The contribution of articular receptors to proprioception with the fingers in humans. J Neurophysiology 1989;61:186-93.

46   Kleinrensink GJ, Stoeckart R, Meulstee J, Kaulesar Sukul DMKS, Vleeming A, Snijders CJ, et al. Lowered motor conduction velocity of the peroneal nerve after inversion trauma. Med Sci Sports Exerc 1994;26:877-83.

47   Kannus P, Alosa D, Cook L, Johnson RJ, Renström P, Pope M, et al. Effect of one-legged exercise on the strength, power and endurance of the contralateral leg. Eur J Appl Physiol 1992;64:117-26.

48   Laskowski ER, Newcomer-Aney K, Smith J, van Deursen RW. [author - article title?] In: Laskowski. Proprioception. Sci Principals Sports Rehab 2000;11:323-40.

49   Vaes PH, van Gheluwe B, Duquet W. Control of acceleration during sudden ankle supination in people with unstable ankles. J Orthop Sports Phys Ther 2001;31:741-52.

50   Konradsen L, Bohsen-Ravn J. Ankle instability caused by prolonged peroneal reaction time. Acta Orthop Scand 1990;61:388-90.

51   Löfvenberg R, Karrholm J, Sundelin G, Ahlgren O. Prolonged reaction time in patients with chronic lateral instability of the ankle. Am J Sports Med 1995;23:414-7.

52   Brunt D, Andersen JC, Hunstman B, Reinhert LB, Thorell AC, Sterling JC. Postural responses to lateral perturbation in healthy subjects and ankle sprain patients. Med Sci Sports Exerc 1992;24:171-6.

53   Fernandes N, Allison GT, Hopper D. Peroneal latency in normal and injured ankles at varying angles of perturbation. Clin Orthop Rel Res 2000;375:193-201.

54   Beynnon BD, Renström PA, Alosa DM, Baumhauer JF, Vacek PM. Ankle ligament injury risk factors: a prospective study of college athletes. J Orthop Res 2001;19:213-20.

55   Louwerens JWK, van Linge B, de Klerk LWL, Mulder PGH, Snijders CJ. Peroneus longus and tibialis anterior muscle activity in the stance phase. Acta Orthop Scand 1995;66:517-23.

56   Balduini FC, Vegso JJ, Torg JS, Torg E. Management and rehabilitation of ligamentous injuries to the ankle. Ankle inversion injury and hypermobility: effect on hip and ankle muscle electromyography onset latency. Sports Med 1987;4:364-80.

57   Bosien WR, Staples OS, Russell S. Residual disability following acute ankle sprains. J Bone Joint Surg 1955;37A:1237-43.

58   Tropp H. Pronator muscle weakness in functional instability of the ankle joint. Int J Sports Med 1986;7:291-4.

59   Wilkerson GB, Pinerola JJ, Caturano RW. Invertor vs. evertor peak torque and power deficiencies associated with lateral ankle ligament injury. J Orthop Sports Phys Ther 1997;26:78-

86.

60   McKnight CM, Armstrong CW. The role of ankle strength in functional ankle instability. J Sport Rehab 1997;6:21-9.

61   Pope R, Herbert R, Kirwan J. Effects of ankle dorsiflexion range and pre-exercise calf muscle stretching on injury risk in army recruits. Aus Physiother 1998;44:165-72.

62   Wester JU, Jespersen SM, Nielsen KD. Wobble board training after partial sprains of the lateral ligaments of the ankle: a prospective randomized study. J Orthop Sports Phys Ther 1996;23:332-6.

63   Bahr R. Recent advances: sport medicine. BMJ 2001;323:328-31.

64   McKay GD, Goldie PA, Payne WR, Oakes BW. Ankle injuries in basketball: injury rate and risk factors. Br J Sports Med 2001;35:103-8.

65   Thacker SB, Stroup DF, Branche CM. The prevention of ankle sprains in sports: a systematic review of the literature. Am J Sports Med 1999;27:753-60.

66   Lankhorst GJ, Timmer M. Invaliditeits- en arbeids (on)geschiktheidsschattingen. Ned Tijdschr Geneesk 1990;3:215-7.

67   Green T, Refshauge K, Crosbie J, Adams R. A randomized controlled trial of a passive accessory joint mobilization on acute ankle inversion sprains. Phys Ther 2001;81:984-94.

68   Laskowski ER, Newcomer-Aney K, Smith J. Proprioception. Sci Principals Sports Rehab 2000;11:323-40.

69   Kaikkonen A, Kannus P, Järvinen M. A performance test protocol and scoring scale for the evaluation of ankle injuries. Am J Sports Med 1994;22:462-9.

70   Van Dijk CN. The relative merits of physical examination and arthrography after supination trauma of the ankle (thesis). Amsterdam, the Netherlands: Universiteit van Amsterdam; 1994;71-126.

71   Beurskens AJHM, de Vet HC, Koke AJ. Responsiveness of functional status in low back pain: a comparison of different instruments. Pain 1996;65:71-6.

72   Beurskens AJ, de Vet HC, Koke AJ. A patient-specific approach for measuring functional status in low back pain. J Manipul Physiol Ther 1999;22:144-8.

73   Huskisson EC. Measurement of pain. Lancet 1974;9:1127-31.

74   Miller MD, Daron G, Ferris MD. Measurement of subjective phenomena in primary care research: the visual analogue scale. Fam Pract Res J 1993;13:15-24.

75   Wevers ME, Lowe NK. A critical review of visual analogue scales in the measurement of clinical phenomena. Res Nurs Health 1990;13:227-36.

76   Brunnekreef JJ (namens de werkgroep). Betrouwbaarheid van de ganganalyse lijst Nijmegen. Jaarcongres Fysiotherapie. Den Haag, the Netherlands. 2-3 November 2001.

77   Van Dijk CN. On the cause of 'Medial ankle pain' after severe sprain (thesis). Amsterdam, the Netherlands: Universiteit van Amsterdam; 1994;139-62.

78   Van Dijk CN, Tol JL, Verheyen CCP. A prospective study of prognostic factors concerning the outcome of arthroscopic surgery for anterior ankle impingement. Am J Sports Med 1997;25:737-45.

79   Shea MP, Manoli A. Foot fellow's review: osteochondral lesions of the talar dome. Foot Ankle 1993;14:48-55.

80   Brosky T, Nyland J, Nitz AJ, Caborn DNM. The ankle ligaments: consideration of syndesmotic injury and implications for rehabilitation. J Orthop Sports Phys Ther 1995;21:197-205.

81 Hopkinson WJ, St Pierre P, Ryan JB, Wheeler JH. Syndesmosis sprains of the ankle. Foot Ankle 1990;10:325-30.

82 Richtlijnontwikkeling binnen het Kwaliteitsinstituut voor de Gezondheidszorg CBO: handleiding voor werkgroepleden. Utrecht, the Netherlands: Kwaliteitsinstituut voor de Gezondheidszorg CBO; 2000.

83 Munk B, Holm-Christensen K, Lind T. Long-term outcome after ruptured lateral ankle ligaments: a prospective study of three different treatments in 79 patients with 11-year follow-up. Acta Orthop Scand 1995;66:452-4.

84 Ogilvie-Harris DJ, Gilbart M. Treatment modalities for soft tissue injuries of the ankle: a critical review. Clin J Sport Med 1995;5:175-86.

85 Shrier I. Treatment of lateral collateral ligament sprains of the ankle: a critical appraisal of the literature. Clin J Sport Med 1995;5:187-95.

86 Safran MR, Benedetti RS, Bartolozzi III AR, Mandelbaum BR. Lateral ankle sprains: a comprehensive review. Part 1: etiology, pathoanatomy, histopathogenesis and diagnosis. Med Sci Sports Exerc 1999;31:S429-37

87 Verhagen EA, van Mechelen W, de Vente W. The effect of preventive measures on the incidence of ankle sprains. Clin J Sport Med 2000;10:291-6.

88 Handoll HHG, Rowe BH, Quinn KM, de Bie RA. Interventions for preventing ankle ligament injuries (Cochrane Review). The Cochrane Library. Oxford, UK: Update Software; 2001.

89 Heidt RS, Sweeterman LM, Carlonas RL, Traub JA, Tekulve FX. Avoidance of soccer injuries with preseason conditioning. Am J Orthop Soc Sports Med 2000;28:659-62.

90 Holme E, Magnusson SP, Becher K, Bieler T, Aagaard P, Kjær M. The effect of supervised rehabilitation on strength, postural sway, position sense and re-injury risk after acute ankle ligament sprain. Scand J Med Sci Sports 1999;9:104-9.

91 Söderman K, Werner S, Pietilä T, Engström B, Alfredson H. Balance board training: prevention of traumatic injuries of the lower extremities in female soccer players? Knee Surg Sports Traumatol Arthrosc 2000;8:356-63.

92 Bahr R, Lian Ø, Bahr IA. A two-fold reduction in the incidence of acute ankle sprains in volleyball after the introduction of an injury prevention program: a prospective cohort study. Scand J Med Sci Sports 1997;7:172-7.

93 Blackburn T, Guskiewicz KM, Petschauer MA, Prentice WE. Balance and joint stability: the relative contributions of proprioception and muscular strength. J Sport Rehab 2000;9:315-28.

94 Waddington G, Adams R, Jones A. Wobble board (ankle disc) training effects on the discrimination of inversion movements. Aus Physiother 1999;45:95-101.

95 Hoffman M, Payne VG. The effects of proprioceptive ankle disk training on healthy subjects. J Orthop Sports Phys Ther 1995;21:90-3.

96 Bernier JN, Perrin DH. Effect of coordination training on proprioception of the functionally unstable ankle. J Orthop Sports Phys Ther 1998;27:264-75.

97 Matsusaka N, Yokoyama S, Tsurusak T. Effect of ankle disk training combined with tactile stimulation to the leg and foot on functional instability of the ankle. Am J Sports Med 2001;29:25-30.

98 Sheth P, Yu B, Laskowski ER, An KN. Ankle disk training influences reaction times of selected muscles in a simulated ankle sprain. Am J Sports Med 1997;25(4):538-43.

99 Wojtys EM, Wylie BB, Huston LJ. The effects of muscle fatigue on neuromuscular function and anterior tibial translation in healthy knees. Am J Sports Med 1996;24:615-21.

100 Gauffin H, Tropp H, Odenrick P. Effect of ankle disk training on postural control in patients with functional instability of the ankle joint. Int J Sports Med 1988;9:141-4.

101 Gandevia SC, McCloskey DI, Burke D. Kinesthetic signals and muscle contraction. Trends Neuroscience 1992;15:62-5.

102 Uh BS, Beynnon BD, Helie BV, Alosa DM, Renström PA. The benefit of a single-leg strength training program for the muscles around the untrained ankle. Am J Sports Med 2000;28:568-73.

103 Gezondheidsraad. De effectiviteit van fysische therapie; electrotherapie, lasertherapie, ultrageluidbehandeling. Den Haag, the Netherlands: Gezondheidsraad; 1999.

104 Vaes PH, Duquet W, van Gheluwe B. Werkzaamheid van enkelbandages en enkelortheses. In: Jaarboek Fysiotherapie. 2000:49-66.

105 Sitler M, Ryan J, Wheeler B, McBride J, Arciero R, Anderson J, et al. The efficacy of a semi-rigid ankle stabilizer in reducing acute ankle injuries in basketball. A randomized clinical study at West Point. Am J Sports Med 1994;22:454-61.

106 Thorndike AJ. Athletic injuries: prevention, diagnosis and treatment. Philadelphia: Lea and Febiger; 1956.

107 Garrick JC, Requa RK. Role of external support in the prevention of ankle sprains. Med Sci Sports 1973;5:200-3.

108 Sitler MR, Ryan J, Wheeler B, McBride J, Arciero R, Anderson J, et al. The efficacy of a semi-rigid ankle stabilizer in reducing acute ankle injuries in basketball. Am Orthop Soc Sports Med 1994;22:454-61.

109 Gross MT, Everts JR, Roberson SE, Roskin DS, Young KD. Effect of Donjoy ankle ligament protector and Aircast Sport-Stirrup ortheses on functional performance. J Orthop Sports Phys Ther 1994;19:150-6.

110 Gross MT, Ballard CL, Mears HG, Watkins EJ. Comparison of Donjoy ankle ligaments protector and Aircast Sport-Stirrup orthoses in restricting foot and ankle motion before and after exercise. J Orthop Sports Phys Ther 1992;16:60-7.

111 Gross MT, Lapp AK, Davis M. Comparison of Swede-O-Universal ankle support and Aircast Sport-Stirrup orthoses and ankle tape in restricting eversion-inversion before and after exercise. J Orthop Sports Phys Ther 1991;13:11-9.

112 Alves JW, Alday RV, Ketcham DL, Lentell GL. A comparison of the passive support provided by various ankle braces. J Orthop Sports Phys Ther 1992;15:10-8.

113 Beynnon BD, Renström PA. The effect of bracing and taping in sports. Ann Chir Gynaecol 1991;80:230-8.

114 Shapiro MS, Kabo JM, Mitchell PW, Loren G, Tsenten M. Ankle sprain prophylaxis: an analysis of the stabilizing effects of braces and tape. Am J Sports Med 1994;22:78-82.

115 Johnson RE, Veale JR, McCarthy GJ. Comparative study of ankle support devices. J Am Podiatr Med Assoc 1994;84:107-14.

116 Stiggelbout M, van Mechelen W. De preventie waarde van de enkelbrace in vergelijking tot enkeltaping ter voorkoming van enkeldistorsies bij sporters. Geneesk Sport 1993;26: [author - page numbers please]

117 Hamer PW, Munt AM, Harris CD, James NC. The influence of ankle strapping on wobbleboard performance, before and after exercise. Aust Physiother 1992;38:85-92.

118 Firer P. Effectiveness of taping for the prevention of ankle ligaments sprains. Br J Sports Med 1990;24:47-50.

119 Karlsson J, Swärd L, Andréasson GO. The effect of taping on

ankle stability. Sports Med 1993;16:210-5.

120 Lohrer H, Alt W, Gollhofer A. Neuromuscular properties and functional aspects of taped ankles. Am J Sports Med 1999;27:69-75.

121 Manfroy PP, Ashton-Miller JA, Wojtys EM. The effect of exercise, prewrap, and athletic tape on the maximal active and passive ankle resistance to ankle inversion. Am J Sports Med 1997;25:156-63.

122 Refshauge KM, Kilbreath SL, Raymond J. The effect of recurrent ankle inversion sprain and taping on proprioception at the ankle. Med Sci Sports Exerc 2000;32:10-5.

123 Glick JM, Gorden RB, Nishimoto D. The prevention and treatment of ankle injuries. Am J Sports Med 1976;4:136-41.

124 Rarick GL, Bigley G, Karst R, Malina RM. The measurable support of the ankle joint by conventional methods of taping. J Bone Joint Surg 1962;44:1183-90.

125 Van Wingerden BAR. Tape en bandagetechnieken. Lochem, the Netherlands: Uitgeverij De Tijdstroom; 1982.

126 Riezebos C, Lagerberg A. Inversietrauma van de enkel, ontstaansmechanismen, risicofactoren en preventie. Tijdsch Fysiother 1998;16:16-47.

127 Brunch RP, Bednarski K, Holland D. Ankle joint support: a comparison of reusable lace-on braces with taping and wrapping. Phys Sport Med 1985;13:59-62.

128 Fumich RM, Ellison AE, Geurin GJ, Grace PD. The measured effect of taping on combined foot and ankle motion, before and after exercise. Am J Sports Med 1981;9:165-70.

129 Hughes LH, Stetts DM. A comparison of ankle taping and semi-rigid support. Phys Sports Med 1983;11:99-103.

130 Leemrijse C. Gaat bij chronische instabiliteit van de enkel de voorkeur uit naar bandageren/tapen of pushbraces? Respons 1990;1:1-2.

131 Rovere GD, Clarke TL, Yates CS. Retrospective comparison of taping and ankle stabilizers in preventing ankle injuries. Am J Sports Med 1988;16:228-33.

132 Barrett JR, Tanji JL, Drake C, Fuller D, Kawasaki RI, Fenton RM. High- versus low-top shoes for the prevention of ankle sprains in basketball players. Ankle inversion injury and hypermobility: effect on hip and ankle muscle electromyography onset latency. Am J Sports Med 1993;21:582-5.

133 Hendriks HJM, van Ettekoven H, van der Wees P. Eindverslag van het project Centrale richtlijnen in de fysiotherapie (Deel I): Achtergronden en evaluatie van het project. Amersfoort, the Netherlands: KNGF/NPi/CBO; 1998.

134 Van Mechelen W, Kemper HCG, Voorn WJ, de Jongh HR. Prevention of running injuries by warming-up, cool-down, and stretching exercises. Am J Sports Med 1993;21:711-9.

135 Pienkowski D, McMorrow M, Shapiro R, Caborn DNM, Stayton J. The effect of ankle stabilizers on athletic performance. Am J Sports Med 1995;23:757-62.