



Royal Dutch Society  
for Physical Therapy

# ***KNGF Guideline***

## **for Physical Therapy in patients with Osteoporosis**

Supplement to the Dutch Journal of Physical Therapy  
Volume 121 • Issue 2 • 2011



In the context of international collaboration in guideline development, the Royal Dutch Society for Physical Therapy (Koninklijk Nederlands Genootschap voor Fysiotherapie, KNGF) has decided to translate its Clinical Practice Guidelines into English, to make the guidelines accessible to an international audience. International accessibility of clinical practice guidelines in physical therapy makes it possible for therapists to use such guidelines as a reference when treating their patients. In addition, it stimulates international collaboration in the process of developing and updating guidelines. At a national level, countries could endorse guidelines and adjust them to their local situation if necessary.

© 2011 Royal Dutch Society for Physical Therapy (Koninklijk Nederlands Genootschap voor Fysiotherapie, KNGF)

All rights reserved. No part of this publication may be reproduced, stored in an automatic retrieval system, or published in any form or by any means, electronic, mechanical, photocopying, microfilm or otherwise, without prior written permission by KNGF.

KNGF's objective is to create the right conditions to ensure that high quality physical therapy care is accessible to the whole of the Dutch population, and to promote recognition of the professional expertise of physical therapists. KNGF represents the professional, social, and economic interests of over 20,000 members.

The guideline is summarized on a flowchart; the Practice Guidelines as well as the flowchart can be downloaded from [www.fysionet.nl](http://www.fysionet.nl).

# Contents

## Practice Guideline 1

- A Introduction 1
  - A.1 Objectives 1
  - A.2 Problem definition and importance of the problem 1
  - A.3 Risk factors for the development of osteoporosis 2
    - A.3.1 Consequences of fractures 2
    - A.3.2 Risk factors for fractures 2
  - A.4 Role of physical therapy 2
    - A.4.1 Collaboration with other disciplines 3
  - A.5 Problem categories 3
  
- B Diagnostic process 3
  - B.1 Direct access to physical therapy 3
    - B.1.1 Identifying the presenting problem 4
    - B.1.2 Screening for pathology requiring medical attention 4
    - B.1.3 Information and advice 4
  - B.2 History-taking 4
  - B.3 Investigations 4
    - B.3.1 Inspection/observation and palpation 5
    - B.3.2 Physical examination 5
    - B.3.3 Additional investigations 5
  - B.4 Measurement instruments 5
  - B.5 Analysis 6
  - B.6 Treatment plan 6
  
- C Therapeutic process 6
  - C.1 Objectives 6
    - C.1.1 Information, advice and education 7
    - C.1.2 Practicing functions and activities 7
  - C.2 Evaluation 8
    - C.2.1 Aftercare and prevention 8
    - C.2.2 Concluding the treatment, record-keeping and reporting 8

Acknowledgments 9

## Supplements 10

- Supplement 1 Recommendations 10
- Supplement 2 Dutch national physical activity recommendations adapted to the evidence used for the osteoporosis guideline 12
- Supplement 3 Conversion formulas for the 1RM estimation test 14
- Supplement 4 Indicators of fragility 15

# Practice Guideline

B.C.M. Smits-Engelsman<sup>I</sup>, D. de Kam<sup>II</sup>, H.J.M. Hendriks<sup>III</sup>

## A Introduction

This revised edition of the *KNGF Guideline on Osteoporosis*, published by the Royal Dutch Society for Physical Therapy (KNGF), offers guidance for the treatment of people with osteoporosis-related health problems, and for the role of physical therapists in the management of these problems. The Guideline describes the diagnostic and therapeutic process based on the established methodical approach to physical therapy. The *Practice Guideline* offers guidance for physical therapy interventions, while the document called *Verantwoording & Toelichting* (review of the evidence) explains the choices that were made. This revised guideline can be regarded as a specification for physical therapists of the multidisciplinary guideline on osteoporosis and fracture prevention (*Osteoporose en Fractuurpreventie*) that was developed in 2011 by a multidisciplinary working party including specialists, family physicians and physical therapists, under the auspices of the Dutch Institute for Healthcare Improvement (CBO). The contents of the guideline are largely based on the recommendations made in the osteoporosis guideline published by the Dutch College of General Practitioners (NHG) and the above-mentioned multidisciplinary guideline.

Although osteoporosis as such does not require referral to a physical therapist, certain osteoporosis-related problems, such as pain, fear of movement, postural problems, reduced muscle strength or inadequate balance, may require physical therapy interventions. In addition, physical therapists may treat patients (for other health problems) who may also have or develop osteoporosis. This requires case-finding.

The present guideline replaces the original (2001) osteoporosis guideline and its 2005 update.

The guideline offers a comprehensive perspective on the role of the physical therapist. It is up to individual therapists to select the information that is relevant for each individual patient.

### A.1 Objectives

The guideline aims to offer physical therapists information about osteoporosis and osteoporosis-related complaints, as well as the way such complaints can be influenced, to enable therapists to design a treatment plan based on the available information.

The guideline is relevant for patients with either primary or secondary osteoporosis.

*Primary osteoporosis* is defined as loss of bone tissue associated with the normal process of aging, without any other identifiable cause. Primary osteoporosis may be due to an increased rate of bone resorption, rather than to a reduced bone formation rate, or to an abnormality in the mechanism linking bone formation and

bone resorption. Primary osteoporosis is subdivided into postmenopausal osteoporosis and age-related osteoporosis.

- Postmenopausal osteoporosis affects women aged 51–61 years, who show a clearly increased rate of loss of trabecular bone tissue. This loss of bone tissue can lead to vertebral fractures.
- Age-related osteoporosis affects both men and women over the age of 65 years. The disorder is characterized by the loss of trabecular as well as cortical bone tissue, which may lead to hip fractures and vertebral collapse.

*Secondary osteoporosis* is defined as loss of bone tissue with an identifiable cause. Examples of disorders that greatly increase the risk of osteoporosis include: inflammatory intestinal diseases, celiac disease, osteogenesis imperfecta, anorexia nervosa, hypogonadism, malabsorption syndrome, primary hyperparathyroidism, gastric resection, Cushing's syndrome and chronic rheumatoid arthritis. The use of corticosteroids also causes severe bone loss, especially in the first year. Other medicines that carry a risk of osteoporosis or osteopenia include antiepileptics, fenprocoumon (an anticoagulant) and goserelin (which inhibits hormone production in the hypothalamus).

The primary disorder in patients with secondary osteoporosis may impede the correct implementation of the present guideline, and may be a reason to deviate from the management described in the guideline.

### A.2 Problem definition and importance of the problem

Osteoporosis is a disorder of the skeleton characterized by low bone mineral density (BMD) and a lack of cohesion (microarchitecture) of the bone, resulting in brittleness and an increased risk of fracture. The World Health Organization (WHO) distinguishes several grades of osteoporosis, based on BMD measurements (dual energy X-ray absorptiometry or DEXA) and the presence or absence of osteoporotic fractures:

- *no osteoporosis*: BMD at or above the agreed lower limit, which is set at 1 standard deviation (SD) below the mean bone density (peak bone mass) for young adults (25–30 years);
- *osteopenia*: BMD reduced to 1–2.5 SD below the mean bone density (peak bone mass) for young adults, but osteoporosis has not yet set in;
- *osteoporosis*: BMD more than 2.5 SD below the mean bone density (peak bone mass) for young adults;
- *severe osteoporosis*: osteoporosis involving osteoporotic fractures.

I Prof. C.M. Bouwien Smits-Engelsman, PT, PhD, Scientific Advisor, Avans+ University for Professionals, Breda; Professor of Age-Related Changes in Motor Control, Faculty of Kinesiology and and Rehabilitation Sciences, Research Center for Movement Control and Neuroplasticity, KU Leuven, Belgium.

II Digna de Kam, PT, MSc, movement scientist / physical therapist, Sint Maartenskliniek; Radboud University Nijmegen Medical Centre, Department of Rehabilitation, Nijmegen.

III Erik J.M. Hendriks, PT, PhD, physical therapist and epidemiologist, program manager for KNGF Clinical Guidelines, Department of Epidemiology, Maastricht University, CAPHRI School for Public Health and Primary Care and Centre for Evidence Based Physiotherapy (CEBP), Maastricht, the Netherlands.

This WHO definition is extensively used in clinical practice. Different peak bone masses are used for men and women. The peak bone mass is largely determined by genetic factors, but also by nutrition and lifestyle (exercise). After the age of forty, bone resorption starts to exceed bone formation, resulting in a gradual loss of bone mass, by about 0.3–0.5% a year. Men then lose 20–30% of their bone mass in the course of the rest of their lives. Women go through a period of a few years of accelerated bone loss (3–5% a year) around the menopause. Some women may experience a total loss of bone mass of up to 40–50%. Only for postmenopausal women has the clinical significance of osteoporosis been validated by means of BMD measurements, and there is still a great deal of uncertainty about the reference values to be used, not only about the values for women, but especially about those for men. Based on data recorded by family physicians, the prevalence of osteoporosis in the Netherlands is estimated at 1.9 per 1000 men and 16.1 per 1000 women. The real prevalence is likely to be higher, as osteoporosis often remains undiagnosed. Typical locations for osteoporotic fractures include the (thoracic) spine, hips, and wrists. Each year, some 17,900 people in the Netherlands suffer a hip fracture, while 15,970 people aged 55 years or older break a vertebra and 12,114 a wrist. Hip fractures occur especially among women aged over 70, while wrist fractures are most common among women aged 40–60. The cause of fractures is nearly always a fall, although severe forms of osteoporosis may also lead to fractures that arise spontaneously or from a minor trauma. Each year, one in three Dutch persons aged over 65 suffer a fall; fractures occur in less than 10% of falls.

### A.3 Risk factors for the development of osteoporosis

Age and female sex are the main risk factors for the development of osteoporosis. In addition, there are many risk factors for low BMD, such as low body weight and a family history of osteoporosis. Lifestyle factors increasing the osteoporosis risk include smoking, lack of exercise and inadequate nutrition, particularly insufficient calcium intake, and lack of vitamin D in those elderly persons who rarely leave the house. Recent research suggests that a greatly elevated serum homocysteine level is also associated with an increased risk. It remains unclear whether the use of alcohol is also a risk factor.

#### A.3.1 Consequences of fractures

Fractures and their consequences have a major impact on a patient's quality of life. This is particularly true for elderly people, as it takes longer for them to recover and resume normal activities, and they may not fully recover.

A *vertebral fracture* need not result in complaints (about 2 out of 3 vertebral fractures are asymptomatic), although it may cause an episode of severe pain. This pain usually subsides after 1–3 months. Vertebral fractures may increase the thoracic kyphosis, which may in time lead to problems such as iliocostalis syndrome (iliocostal friction), compression of internal organs and chronic back pain. In addition, increased thoracic kyphosis changes the body posture, which may increase the risk of the patient losing their balance during activities of daily living. Chronic pain and limitations due to vertebral fractures are seen especially in patients with a severely deformed spine.

*Hip fractures* nearly always result in hospitalization. Hip fractures have more serious long-term consequences than other fractures (e.g. lower arm fractures), including restricted mobility and some-

times loss of independence and prolonged admission to a nursing home.

*Lower arm fractures* usually cause only temporary loss of function of the affected arm.

In the long term, the immobilization associated with fractures, whether temporary or permanent, leads to further decline of the BMD and deterioration of the patient's musculoskeletal system functions, including reduced muscle strength and coordination, which in turn increase the risk of falling and further fractures. In addition, loss of mobility, especially among older patients, increases the risk of social isolation. Patients with osteoporosis may also develop psychosocial problems due to their fear of new fractures and due to lack of mobility for fear of falling.

#### A.3.2 Risk factors for fractures

The risk of fractures is greater among women than among men. Elderly women have this increased risk even after correction for the difference in BMD between younger and older women. People who have suffered a previous fracture (especially after menopause) are at increased risk for new fractures. Other risk factors for fractures include low body weight and lack of physical activity. Older persons are also at increased risk for fractures due to their greater risk of falling. Other risk factors for falls relate to the patient's health status (including balance problems, reduced muscle strength or joint mobility in the lower extremities, poor vision or the consequences of CVA) and the use of medications with sedative effects (like antidepressants or analgesics). Environmental factors (like poorly fitting footwear, inadequate lighting, loose carpeting or staircases without handrails) can also increase the risk of falls and hence the risk of fractures. Factors reducing the risk of falling include regular exercise and putting sufficient mechanical load on the bones, insofar as these can be achieved in safe circumstances.

#### A.4 Role of physical therapy

Physical therapy has a three-fold role in the management of patients with osteoporosis:

1. reducing the risk of fractures by increasing the patient's BMD and reducing their risk of falling, concentrating on impairments (such as reduced muscle strength or inadequate balance) and limitations (like difficulties with walking or transfers);
2. secondary prevention of musculoskeletal system complaints associated with osteoporosis, such as pain, abnormal body posture (increased kyphosis), reduced muscle strength, inadequate balance, reduced joint mobility or fear of falling;
3. counseling patients, e.g. by providing them with information about osteoporosis and its consequences, advice and guidance on keeping or regaining an active lifestyle and instructions for the use of any suitable assistive devices (e.g. walking aids).

#### A.4.1 Collaboration with other disciplines

Collaboration between disciplines increases the efficiency and efficacy of care. It is important that the different care providers understand each other's expertise and methods and that they coordinate the information offered to patients.

Management of osteoporosis patients by doctors and physical therapists concentrates on preventing fractures, reducing fear of movement and stimulating participation. Management of older patients focuses on preserving mobility, stimulating an active lifestyle and preventing falls.

Reasons for patients to be referred (or present themselves directly) to a physical therapist include:

- impairments and limitations relating to the musculoskeletal system and mobility;
- a fracture in the subacute stage, if patients are insufficiently able to resolve their problems themselves with the help of the doctor's recommendations, and need more assistance.

An important component of the collaboration by various care providers is that they inform each other when they notice that a patient has a seriously increased risk of osteoporosis or fractures (risk of falling). The physical therapist should inform the other care providers or referring doctors about the patient's status, checking for signs of osteoporosis. The physical therapist should also assess whether it is no longer safe for a particular patient to walk or carry out transfers without assistance. If a physical therapist estimates that a different discipline should become involved in the treatment, they should contact a professional from this discipline. Patients with secondary osteoporosis should be treated in collaboration with the other specialists involved.

#### A.5 Problem categories

Depending on the patient's presenting problem and their functional status, various problem categories may be focused on (individually or in combination). The following problem categories can be distinguished:

- 1 *Actual or impending immobility.* In the long term, immobility causes BMD reduction, impairments and limitations, leading to an increased risk of fractures. Fear of falling or fear of movement can contribute to persistent immobility.
- 2 *Increased risk of falling.* The risk of falling can be increased by impairments and limitations, such as reduced muscle strength, decreased joint mobility or inadequate balance in general activities of daily living (ADL).
- 3 *Status after fracture.* Specific impairments, limitations, and participation restrictions may occur, depending on the location of the fracture. Key aspects after vertebral fractures include posture and balance problems, while those for hip fractures may include gait patterns and transfers. It is always important to teach patients to carry out the functions and activities required for daily living. The recommendations in the present guideline relate to the subacute stage after a fracture.

## B Diagnostic process

If a patient presents with osteoporosis or with complaints associated with osteoporosis, the physical therapist should identify the main problem categories (immobility, pain, increased fall risk and/or status after fracture). The point of departure is the patient's presenting problem.

If the patient has been referred by their family doctor or a medical specialist, the letter of referral should include the following details: patient's name (plus possibly their address and insurance details); social security number or similar (e.g. the Dutch national identification number called *burgerservicenummer*); the date of referral; the diagnosis (with diagnostic code if applicable); the indication for referral; the patient's presenting problem; relevant details about the patient's health status (including medication and relevant medical and psychosocial details, such as lifestyle); name of the referring doctor; signature of the referring doctor; name of the patient's family doctor (if the latter is not the referring doctor). In the Dutch situation, patients can present to a physical therapist without referral (Direct Access) or after referral by their family doctor or a medical specialist.

#### B.1 Direct access to physical therapy

In the Netherlands, direct access to physical therapy (i.e. without referral from a doctor) has been allowed by law since 1 January 2006. Therapists collaborate with other care providers through reciprocal referrals, after consultation with and consent from the patient. If some of the necessary medical data are missing, the physical therapist should contact the patient's family physician or specialist. If a patient presents directly to a physical therapist without referral, the therapist must apply a screening procedure, after identifying the patient's presenting problem. If the physical therapist suspects the presence of a different problem than the one for which the patient consulted him/her, it is important to refer the patient back to their family physician, so that medication can be prescribed and/or unidentified complaints can be excluded. This screening procedure was added to the established methodical approach when direct access became possible, and is intended to check whether physical therapy is indeed indicated. The screening procedure involves presentation, identifying the patient's presenting problem, screening for possible pathology requiring medical attention and informing and advising the patient based on the findings of the screening procedure. The physical therapist asks a number of specific questions, and uses tests or other diagnostics to decide, within a limited period of time, whether the patient's pattern of signs and symptoms is compatible with their area of competence. An important aspect of the screening for serious pathology is the identification of any red flags. The physical therapist has to develop a general idea of the patient's complaints and symptoms and the presence of any yellow or red flags. Yellow flags are indications of psychosocial and behavioral risk factors that could cause a patient's health problems to persist and/or worsen.

No screening procedure is needed if the patient was referred to the physical therapist, but throughout the diagnostic and therapeutic process, the therapist must remain on the alert for any signs and symptoms that might require contacting a doctor.

**B.1.1 Identifying the presenting problem**

The patient's presenting problem to be treated should be identified by assessing their main complaints, their development, and the patient's own objectives.

**B.1.2 Screening for pathology requiring medical attention**

The physical therapist should be able to decide whether the patient's signs and symptoms require medical attention, based on their age and sex, available incidence and prevalence data, the development of the problem and the current signs and symptoms, in order to decide whether to continue with further physical therapy examinations. The physical therapist must remain on the alert for unfamiliar patterns or familiar patterns with one or more unusual symptoms, or an abnormal or unfavorable progression, as well as for any red flags.

Any patient who presents to a physical therapist directly, i.e. without referral, will first have to undergo a screening procedure, which is intended to assess whether physical therapy treatment is indicated.

Red flags are patterns of signs or symptoms (warning signals) that may indicate more or less serious pathology, requiring further medical diagnostics. A physical therapist must be able to recognize the pattern of complaints that is characteristic of osteoporosis, in order to establish the presence of any red flags that deviate from this pattern.

**B.1.3 Information and advice**

At the end of the screening process, the therapist should inform the patient of the findings. If the pattern of signs and symptoms is unfamiliar, if one or more symptoms deviate from the pattern with which the physical therapist is familiar, if the pattern develops in an unusual or unfavorable way or if any red flags are present, the therapist must advise the patient to contact their family physician. If there are no unusual findings, the patient should be informed about the possibility of continuing the problem-solving process by the physical therapist.

**B.2 History-taking**

If pain is the osteoporosis patient's main complaint, the intake process should first focus on impairments of body functions and body structure. In addition, the intake process should always address limitations of activities and restrictions of participation, as well as the influence of personal and environmental factors.

**Focal points in history-taking**

- problem identification:
  - assessing the patient's expectations;
  - onset and nature of the symptoms.
- identifying the complaints:
  - severity of the impairments and the nature of the impairments, limitations and participation restrictions;
  - additional complaints, such as (chronic) joint complaints, respiratory problems, constipation, complaints occurring while bending or straightening the body, acute or chronic back pain;
  - factors relating to the onset and development of the complaints;

- previous diagnostics and treatments, and their outcome.
- assessing the patient's current status:
  - impairments, limitations, and participation restrictions associated with osteoporosis;
  - co-morbidity;
  - current use of medication and/or other treatment(s);
  - number of falls sustained during the past year, and circumstances of any falls;
  - current activity and participation level;
  - lifestyle and willingness to change;
  - activities the patient considers important and wants to continue or resume.
- identifying the risk of fractures:
  - increased risk of osteoporosis;
  - impaired muscle and joint function and gait and balance dysfunctions (see section B.3.2).

The FRAX Calculation Tool can be used to calculate the risk of fractures from the risk factors for osteoporosis. FRAX was developed by the WHO and is available from <http://www.sheffield.ac.uk/FRAX/>. However, FRAX does not include 'falling' as a risk factor, which may cause the fracture risk to be underestimated in patients who frequently suffer falls. The Garvan Fracture Risk Calculator (<http://www.garvan.org.au/bone-fracture-risk>) does include 'falling' as a risk factor.

The following checklist can be used to identify risk factors for fractures and falls.

**Checklist of risk factors for fractures and falls****Increased risk of fractures**

- age > 55 years;
- fracture after the age of 50 years (or presence of vertebral fracture);
- relatives: mother suffered hip fracture;
- low body weight (< 67 kg);
- use of corticosteroids (> 7.5 mg/day);
- poor vision;
- seriously impaired mobility.

**Increased risk of falls**

- use of medication: antidepressants, sedatives, etc.;
- cognitive dysfunction (score on Mini Mental State Examination [MMSE] < 24)

Patients at increased risk of osteoporosis have to be screened to identify these risk factors for fractures and falls.

**B.3 Investigations**

The investigations include: inspection/observation, palpation, physical examination and skills analysis. The scope and strategy of the investigations depend on the nature of the presenting problem and the patient's problem categories. The objective is to identify current impairments and limitations in relation to the participation problems.

**Prognostic factors for increased risk of falling\***

- Inability to rise from a chair without using hands.
- Impaired balance during rotation (360°).
- Impaired balance when standing on one leg and reaching upward.
- Interrupting walking when talking.
- Reduced step height (foot does not leave the floor completely).
- Reduced step length (foot does not go past the other foot).
- Lack of continuity of stepping (stopping between steps).
- Difficulty with turning while walking (no smooth turns).

\* These factors are tested using the Get-Up-and-Go test (GUGT). Generally speaking, the risk of falling is considered to be increased if the GUGT takes longer than 20 seconds.

**B.3.1 Inspection/observation and palpation**

- Are there any signs of vertebral compression? Vertebral compression is characterized by reduced body height and/or thoracic kyphosis. Percussion pain in the mid-thoracic vertebrae is also indicative of vertebral compression, though it can also be a symptom of a tumor or inflammation.
- Observing the patient's posture, if possible in their own home, while sitting (at table, watching TV or in bed) and while standing, to ascertain whether their posture could cause complaints.
- Observing the patient's gait and balance in ADL-related situations to get an impression of the risk of falling. ADL-related movements can easily be carried out during the diagnostic or therapeutic process. If any of these movements show prognostic characteristics associated with an increased risk of falling, the patient's gait and/or balance need to be examined in greater detail.

**B.3.2 Physical examination**

The physical therapist examines the muscle and joint functions of the spine and the functions/activities associated with the risk of

falling. The physical examination includes:

- measuring muscle function, in terms of strength and endurance of the core muscles;
- measuring joint function: spinal extension;
- identifying factors associated with risk of falling:
  - muscle function: strength and endurance of the muscles of the lower extremities (esp. the anterior tibial muscle);
  - joint function: joint mobility in the lower and upper extremities;
  - movement patterns: gait and balance;
  - transfers.

**B.3.3 Additional investigations**

If the physical therapist suspects an increased risk of falling due to reduced muscle strength or balance problems, he or she can do the following tests:

- for leg muscle power: Timed Chair Stand Test (TCST);
- for balance:
  - Performance Oriented Mobility Assessment (POMA);
  - Functional Reach (FR);
  - Timed-Up-and-Go test (TUGT) / Get-Up-and-Go test (GUGT);
  - Berg Balance Scale (BBS).

If required, the physical therapist can also use the following additional examinations:

- Situational analysis, including assessment of environmental factors and footwear. Patients can check the safety situation in and around their own house using a checklist.
- Quality of life. The QUALEFFO QoL questionnaire can be used to objectify findings and evaluate interventions.
- Relation between load and resilience. The physical therapist tests the patient's general physical condition using the 6-Minute Walk test (6-MWT), the Astrand Cycle test (AC) or a walking test with increasing speed.

**B.4 Measurement instruments**

Table 1 lists the measurement instruments that are recommended for use in the physical examination, if appropriate.

*Table 1. Measurement instruments for physical examination*

spinal mobility	• flexicurve ruler or kyphometer
overall muscle strength of lower extremity extensors	• Timed Chair Stand test (TCST)
muscle function	• Hand-Held Dynamometer (HHD)
joint mobility	• goniometer
gait and balance*	• Performance Oriented Mobility Assessment (POMA) • Functional Research (FR) • Get-Up-and-Go Test (GUGT) • Berg Balance Scale (BBS) • standing on one leg

\* Complete the full gait and balance tests if prognostic factors for increased risk of falling are present

### B.5 Analysis

The physical therapist must be able to answer the following questions:

- What is/are the major problem category/categories?
- What are the main impairments, limitations and restrictions of participation?
- Are there any factors that may favorably or unfavorably affect the chances of alleviating the patient's health problem? (psychosocial situation)
- What risk factors for falls and fractures are present (environmental factors, footwear, co-morbidity)?
- Is the patient sufficiently motivated to engage in exercise or other activities that involve mechanical loading of the bones? What activities appeal to them?
- What impairments and limitations can be modified by means of physical therapy?

The analysis should make it clear whether physical therapy is indicated for this particular patient and whether treatment in accordance with the guideline is possible. The physical therapist then designs the treatment plan, in consultation with the patient, stating the individual treatment goals and interventions. If necessary, the physical therapist contacts other care providers or the referring doctor to discuss whether it would be useful to involve other disciplines in the treatment of the patient's health problem. In addition to the problem categories that relate to the patient's presenting problem, there may also be other health problems, whether or not associated with osteoporosis (e.g. osteoarthritis, cardiopulmonary problems or acute pain). These problems are beyond the scope of the present guideline, but they might indicate the need for further physical therapy intervention(s) (in consultation with the patient and the referring doctor).

### B.6 Treatment plan

The treatment plan is formulated on the basis of the physical therapist's diagnosis and focuses on the patient's presenting problem. The treatment plan states the treatment goals and the priorities within these goals. The plan must be presented to the patient, who must agree with it.

In formulating the main and subsidiary treatment goals, the physical therapist must take account of the nature and severity of the disorder/complaints, whether the patient is sufficiently motivated for physical therapy, the presence of favorable or unfavorable factors and the expectations for recovery. The physical therapist should systematically evaluate the attainment of the treatment goals at all suitable moments, and adjust the treatment plan if necessary.

Note: In cases of secondary osteoporosis, the primary disorder may affect the treatment plan.

The main and subsidiary treatment goals should be formulated using the 'SMART' approach. SMART stands for 'specific', 'measurable', 'acceptable', 'realistic' and 'timely'. A SMART goal indicates what the patient would like to achieve and guides the behavior of patient and physical therapist.

Whether individual or group physical therapy is indicated is determined by the amount of personal attention required to meet the treatment goals.

## C Therapeutic process

### C.1 Objectives

The main objective of the treatment of patients with osteoporosis or osteoporosis-related complaints is to prevent fractures (or further fractures). To this end, the physical therapist will help the patient to resolve or ameliorate their loss of mobility, reduce their risk of falling, maintain or regain independence after a fracture, achieve a health-promoting lifestyle and engage in activities that involve mechanical loading on the bones.

#### Focal points for treatment and counseling

- Design the training program so as to be efficient and efficacious. Criteria for this include: correct stimulus level, low-risk, comfortable, promoting compliance, low-cost, and compatible with an overall lifestyle program.
- If the exercises are not continued after the treatment program ends, its effects will decline. Hence, the treatment aims to guide the patient toward continued independent exercising. If the patient requires long-term assistance to achieve this, the therapist can suggest existing exercise programs for osteoporosis patients.
- Avoid flexion exercises of the thoracic spine, in view of the risk of compression fractures. By contrast, stretching exercises appear to be useful.
- Behavioral strategies may help meet the treatment goals for patients with pain or fear of movement.
- Avoid adverse effects of exercise efforts. For instance: patients with a low body weight should not lose weight through exercising.

All patients may have risk factors for fractures. The physical therapist should discuss any modifiable risk factors for fractures with the patient as part of the education to promote a healthy lifestyle.

The treatment consists of information and advice and of practicing functions and activities.

Information and advice are given to provide assistance with and recommendations for achieving a healthy lifestyle, reducing fall risks, preventing falls and helping patients use assistive devices, such as zimmer frames. Where possible, the advice should also relate to the patient's home situation (paying attention to loose carpeting, handrails for stairs, etc.).

The focus of practicing functions and activities is on:

- carrying out osteogenic exercises;
- improving muscle functions;
- balance training;
- increasing endurance;
- improving gait patterns (such as step length, foot clearance [the distance between the foot and the floor or obstacles during the swing phase] and turns); and/or
- reducing the risk of falling.

The physical therapist should stimulate the patient to incorporate these functions and activities in their everyday routines, so that they will continue them independently after the treatment program ends.

The primary approach to alleviate pain is by means of education and by practicing functions and activities. This involves using a behavioral approach. If the patient experiences severe pain, a doctor should be contacted.

### C.1.1 Information, advice and education

The goal of the treatment is to inform the patient about the characteristics of osteoporosis as a disorder, the importance of sufficient mechanical loading of the bones, the dangers of immobility, risk factors for falls and ways to prevent falls. The physical therapist must provide information and advice about active lifestyles, medication, safe movements, risks in the home environment and coping with pain, as well as factors that increase the risk of fractures or falls and ways to eliminate them. Patients should also be made aware of their own possibilities and limitations. Other topics include how to put mechanical load on their spine and how much, how to lift objects and stoop, and how to use assistive devices.

A professional approach to education implies that the physical therapist must know about and understand the options for education – in terms of content as well as presentation – as well as the factors that may have a favorable or unfavorable effect on the achievement of the intended behavioral change. A commonly used theoretical framework to describe the behavioral change toward a more active lifestyle is the Integrated Model for Change (I-Change Model). Behavioral change can be achieved by tailoring education to the stage a patient is in.

- Someone who is in the precontemplation stage is insufficiently physically active, and has no intention to change their inactive lifestyle within the next 6 months. In this stage, the main intervention consists of offering information and knowledge about the importance of physical activity.
- Someone who is in the contemplation stage already has the intention to change their physical activity pattern within the foreseeable future (i.e. with 1 to 6 months). They are seriously contemplating changing their behavior. The focus in this stage is on turning intentions into abilities.
- Someone who is in the preparation stage is actively preparing to increase their physical activity level within 1 month. They are still inactive, but are searching for opportunities to take more exercise. The focus of interventions in this stage is on eliminating thresholds and barriers and getting the patient to start engaging in physical activities.
- Someone who is in the action stage is actually implementing favorable behavioral changes, meaning that they have engaged in significantly more physical activity in the past 6 months. This stage, however, also entails the greatest risk, as the person needs to maintain the altered behavior. This stage is unstable and there is a considerable risk of reverting to the old behavioral patterns. The focus is on ensuring that the patient enjoys the exercise, having them experience success and preventing them from dropping out.
- If someone's behavior is still favorably altered after 6 months, they are in the 'maintenance' stage, and the altered behavior has become permanent. The I-Change model explicitly

assumes that the patient is aware of their own behavior, in this case their level of physical activity, and makes deliberate choices regarding this behavior. It is unclear, however, to what extent they are actually aware; it might rather be a matter of habit. In addition to the current stage of behavioral change, the I-change model includes various other factors, such as motivational factors, predisposing factors, information factors, awareness-influencing factors, capacity factors and barriers.

### Behavioral approach

The treatment of patients with pain or fear of movement must include a behavioral approach. This approach concentrates on increasing healthy behaviors (like exercising and resuming hobbies and professional activities) and reducing pain behavior (like the use of unnecessary assistive devices and medication).

The treatment involves providing information and advice as well as a training program aimed at continuing (or if necessary learning to carry out) activities despite the pain. The training program builds up the activities step by step to the intended level. The information and advice to be provided include aspects of pain, pain behavior and ways of coping with pain. Patients should learn that movements and exercise cannot harm them, but in fact have favorable effects. If treatment in accordance with the guideline is insufficient to get the patient to adopt an active lifestyle, they may be offered an existing group exercise program for osteoporosis patients.

### C.1.2 Practicing functions and activities

A number of problem categories are distinguished as regards practicing functions and activities.

#### **Problem category 1: actual or imminent immobility**

The treatment goals include stimulating the patient to engage in physical activity (especially osteogenic activities) and inducing them to achieve an active lifestyle, to reduce or eliminate the impairments and limitations causing the immobility or causing it to persist.

The treatment of patients exhibiting fear of falling or fear of movement aims at increasing their sense of confidence as regards movements. This therapy goal is considered to have been achieved if the conditions for an active lifestyle have been met.

The aim is to achieve a level of physical activity that enables the patient to preserve or increase their BMD.

The intensity of the physical activity depends on the patient's individual basic level, and can range from walking, gardening, and cycling to various endurance sports and fitness programs. The aim is to incorporate the activities into regular ADL, leisure and sports activities.

Table 2. Examples of treatment goals and options for patients at increased risk of falling

<ul style="list-style-type: none"> <li>improving muscle function</li> </ul>	<ul style="list-style-type: none"> <li>Training three times a week, at 60–70% of maximal muscle strength.</li> <li>Aim for 3 sets of 10 repeats per session.</li> <li>Preferably train muscle function in a functional context.</li> </ul>
<ul style="list-style-type: none"> <li>improving joint function</li> </ul>	<ul style="list-style-type: none"> <li>Teaching patients functions/activities to enhance joint mobility and motivating them to continue using these at home.</li> </ul>
<ul style="list-style-type: none"> <li>improving balance/transfers</li> </ul>	<ul style="list-style-type: none"> <li>Teaching patients dynamic exercises, such as starting and stopping, changing direction and going from movement to standing on one leg, and motivating them to continue using these at home.</li> <li>Practicing various strategies for falling and stumbling.</li> </ul>
<ul style="list-style-type: none"> <li>improving gait pattern</li> </ul>	<ul style="list-style-type: none"> <li>Teaching patients dynamic exercises, such as changing direction while walking, avoiding and stepping over obstacles, and walking on different surfaces, and motivating them to continue using these at home.</li> </ul>
<ul style="list-style-type: none"> <li>improving posture</li> </ul>	<ul style="list-style-type: none"> <li>Including extension exercises in the exercise program and ADL, to prevent kyphosis from worsening.</li> </ul>

Focal points for exercises:

- The exercises should result in a relatively high mechanical load on the bones (high meaning about 50% higher than in the preceding period).
- Dynamic exercises utilizing the patient's own body weight and gravity (like walking or climbing stairs) result in high mechanical load on bones.
- The exercises should at least involve mechanical loading of the spine, hips and wrists (training effects are site-specific).
- Exercises to increase muscle strength also have an osteogenic effect at mechanical loads from about 70% of maximal muscle strength 2 to 3 times a week.
- The frequency and duration of the program depend on the training goal. Bone mass can only be modified by intensive daily mechanical loading, involving high mechanical loads with a limited number of repeats (e.g. 30–50 peak loading moments daily). To improve the patient's general endurance, they should aim at an exercise duration of at least 30 minutes, at low intensity (60–70% of their maximal heart rate 2 to 3 times a week).

#### **Problem category 2: Increased risk of falling**

The treatment goals include reducing the risk of falling by reducing or eliminating impairments and limitations (Table 2). The goal is considered to have been achieved when the impairments and limitations have been eliminated insofar as the individual patient's condition allows this. The main problems to be addressed are lack of muscle strength and balance problems.

#### **Problem category 3: status after fracture (including vertebral fracture)**

The treatment goals include maintaining or regaining independence by reducing impairments and limitations due to the fracture, and stimulating ADL activities.

The treatment aims to reduce the specific impairments and limitations that have caused the limitations and/or participation restrictions for the individual patient or are causing them to persist, to stimulate physical activity (see problem category 1) and to reduce the

risk of falling (see category 2). If the fracture is stable, the functions and/or activities are trained without applying mechanical load to the fracture.

#### **C.2 Evaluation**

Evaluation of the treatment outcome needs to take place after 3 and 6 weeks, and possibly also after 9 and 12 weeks, but in any case at the end of the treatment period. The measurements taken at the interim evaluations should show progress compared to the values found at the start of the treatment or at a previous evaluation. This progress may be subjective (patient-specific complaints [PSC], pain, ability to carry out ADL activities) and objective (strength, coordination, endurance, resilience).

Positive effects should be evident after a period of 6 weeks. These may include aspects like patient-reported improvements in terms of PSC and improved gait patterns in patients who make an effort to walk correctly. If no improvements are evident, the physical therapist should – in consultation with the patient – refer the patient to their family doctor.

#### **C.2.1 Aftercare and prevention**

After the treatment has ended, the patient will need to remain physically active to maintain the results achieved. The physical therapist should inform the patient about local or regional facilities that can allow them to keep up the kind and level of physical activity they are interested in, such as local sports clubs. Patients who find it difficult to keep up their physical activity level may be referred to special exercise programs for osteoporosis patients.

#### **C.2.2 Conclusion of treatment, record-keeping and reporting**

At the final evaluation, the physical therapist and the patient jointly evaluate both the therapeutic process and its final outcome. The physical therapist records the final evaluation in writing, in accordance with the KNGF guideline on record-keeping in physical therapy (*KNGF-richtlijn Fysiotherapeutische Verslaglegging*). The physical therapist must inform the referring doctor about the patient's individual treatment goals, the course of the therapeutic

process, the physical activity recommendations given and the treatment outcomes. This should be done at least at the conclusion of the treatment, but possibly also during the treatment period.

## **D Acknowledgments**

A special debt of gratitude for their share in the development of this KNGF Guideline is owed to the members of the external advisory group ('Tweede Kring'), whose contributions to the guideline have been highly valuable (in alphabetical order): Dr. L. de Boer, Osteoporose Stichting Nederland (Dutch osteoporosis patient association); H. Bult, Dutch Institute of Allied Health Care; Dr. J.H.W. Custers, Royal Dutch Society for Physical Therapy (now at tegenwoordig Hogeschool van Amsterdam University of Applied Sciences); Dr. F. van der Gies-

sen, Leiden University Medical Centre, Leiden; Dr. V.B. de Graaf-Peters, Royal Dutch Society for Physical Therapy; Dr. W. Hullegie, Nederlandse Vereniging voor Fysiotherapie in de Sportgezondheidszorg (Dutch society for physical therapy in sports healthcare); Dr. M.A.W. Jongert, Dutch Institute of Allied Health Care; Prof. H.C.G. Kemper, professor emeritus; Prof. C. Netelenbos, VU University Medical Centre; Mr. G. van der Poel, Infomotion; Dr. T. Takken, Utrecht University Medical Centre; Dr. C. van Uden, Vereniging Sport en Gemeenten (association for sports and municipalities), Maastricht University; Dr. V. Weerdesteyn and Dr. E. Smulders, Sint Maartenskliekie, *Radboud University Nijmegen Medical Centre*, Nijmegen.

The inclusion of the above persons as consultants does not imply that each of them agrees with every detail of the Guideline.

# Supplements

## Supplement 1 Recommendations

### Introduction

The level of evidence of the conclusions based on the literature has been categorized on the basis of Dutch national agreements (EBRO/CBO). A distinction is made between four levels, based on the quality of the articles from which the evidence was obtained:

- Level 1: a study at A1 level or at least two independent A2 level studies
- Level 2: one study at A2 level or at least two independent B level studies
- Level 3: one B or C level study
- Level 4: expert opinion

### Quality levels (intervention and prevention)

- A1 Systematic review of at least two independent A2 level studies
- A2 Randomized, double-blind, comparative clinical trial of good quality and sufficient sample size
- B Comparative study not meeting all criteria mentioned under A2 (including case-control studies and cohort studies)
- C Non-comparative study
- D Opinions of experts, for instance the members of the guideline development team

If a systematic review comprised RCTs of moderate quality, the quality of the literature was classified as B rather than A1. Depending on the number of moderate quality (B-level) studies, the conclusion was allocated an evidence level of 2 ( $\geq 2$  RCTs of moderate quality) or 3 (1 RCT of moderate quality).

If a comparative study failed to meet any of the criteria for A2 level research, it was allocated a C quality status.

### Summary of recommendations

#### Diagnostic process

##### 1 Red flags

The physical therapist must check each patient for the presence of red flags. If any red flags are identified, the physical therapist must inform the patient of them and advise them to contact their family doctor (if they had presented directly to the physical therapist) or the referring doctor (level 4).

Quality of the studies identified: D.

##### 2 History-taking

The physical therapist should identify the health problems of patients with osteoporosis by checking their health status using the health domains of the ICF model: body functions and body structures, activities, participation, environmental and personal factors (level 4).

Quality of the studies identified: D.

#### Therapeutic process

##### 3 Improving or preserving bone mineral density

Exercises to improve or preserve bone mineral density must be continued over a prolonged period; it takes about 1 year for the effect on BMD to become evident. Exercises to improve or preserve BMD should preferably be done on a daily basis.

Exercises to improve or preserve BMD should preferably involve weight-bearing, for instance weight-bearing exercises in the form of strength training or walking. The exercises should be of sufficient intensity:

- strength training exercises should have an intensity of 70–90% of the 1RM;
- patients should walk at speeds of over 6 km/h.

High-impact exercises, such as jumping, are to be preferred over low-impact exercises, provided the patient is able to carry these out safely.

The BMD of the wrists is best improved by means of arm strength exercises, as weight-bearing exercises are not expected to have beneficial effects on the wrists. The guideline development team recommends optimizing the effect of strength training on BMD by choosing exercises with a rapid, more explosive strength increase.

**4 Incidence of falls and fractures**

The guideline development team recommends functional strength and balance exercises to reduce the incidence of falls and fractures among people with osteoporosis.

**5 Muscle strength**

The guideline development team recommends improving muscle strength by training 2-3 times a week using 8-10 different exercises for the major muscle groups, at an intensity of at least 50% of 1RM. Low-intensity extension exercises for the back should be used to strengthen the back muscles.

**6 Balance**

The guideline development team recommends functional balance exercises, at a frequency of 3 times a week, to improve the patient's balance. Additional vibration exercises can be used to further improve the patient's balance.

**7 Endurance**

The guideline development team recommends improving the patient's endurance by means of aerobic exercise training, at a frequency of at least 3 times a week and an intensity corresponding to at least 50% of the  $\dot{V}O_2\text{max}$  or HRR or 12-13 on the BORG RPE scale.

**8 Walking speed**

The guideline development team recommends improving walking speed by including at least aerobic training in the form of walking in the program.

**9 ADL activities**

The guideline development team recommends improving ADL activities by including ADL-oriented exercises in the program.

## Supplement 2 Dutch national physical activity recommendations adapted to the evidence used for the osteoporosis guideline

These recommendations have been adapted to the findings reported in the *Trendrapport Bewegen en Gezondheid* [trends in physical activity and health] 2004/2005.<sup>1</sup>

### **Nederlandse Norm Gezond bewegen (NNGB; Dutch national recommendations for healthy physical activity)**

Activity levels are distinguished on the basis of age and recommended levels.

#### *Young people (below 18 years of age)*

One hour of physical activity of at least moderate intensity (5 MET [e.g. aerobic exercises or skateboarding] to 8 MET [e.g. running at 8 km/h]) every day (summer and winter), with activities focusing on improving or maintaining physical fitness (strength, agility, and coordination) at least twice a week.

#### *Adults (18–55 years)*

At least half an hour of physical activity of at least moderate intensity (between 4 and 6.5 MET) on at least five days a week. For adults, moderate intensity means activities like brisk walking (5 km/h) or cycling (16 km/h).

#### *Over-55s*

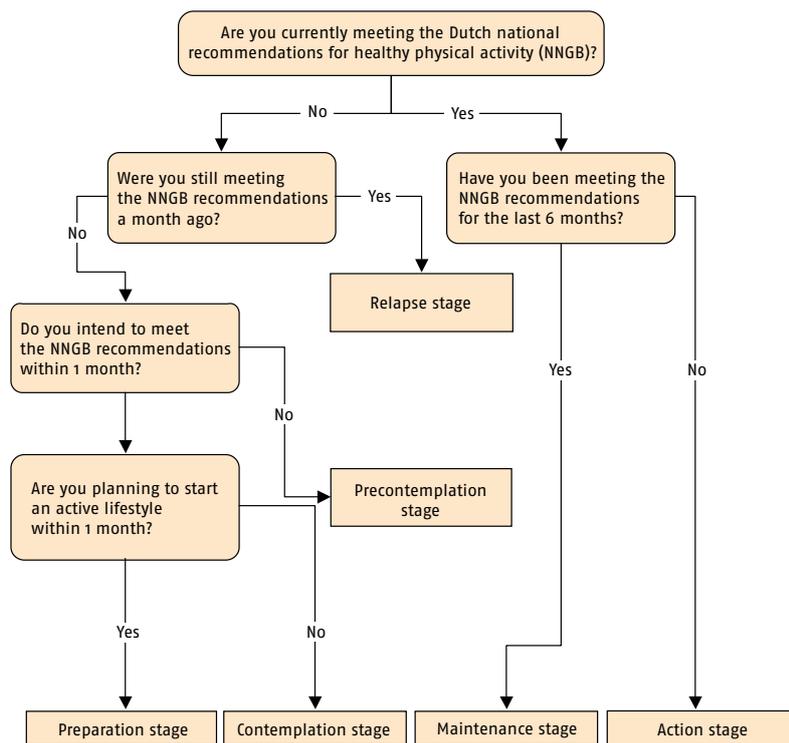
At least half an hour of physical activity of at least moderate intensity (between 3 and 5 MET) on 5 days a week, or preferably each day of the week (summer and winter). For this age category, moderate intensity means activities like walking at 4 km/h or cycling at 10 km/h. Any additional amount of physical activity, regardless of intensity, duration, frequency or type, is useful for people who are physically inactive, whether they have certain impairments or not.

*In the context of a physical activity program for people with osteoporosis, such activities should take the form of weight-bearing exercises.*

### **Questionnaire on the Dutch national recommendations for healthy physical activity (NNGB).**

1. What types of physical activities do you engage in?
  - running or cycling at competition level (extra high mechanical loading)
  - ball games at competition level (high loading)
  - recreational cycling, recreational sports, walking for exercise (moderate loading)
  - leisurely walking or cycling (low loading)
2. How long do you keep up these activities?
  - over 30 minutes
  - 20–30 minutes
  - 10–20 minutes
  - less than 10 minutes
3. How often do you engage in physical activities?
  - 5–7 times a week
  - 3–4 times a week
  - 1–2 times a week
  - once a month or less
4. Are you familiar with the Dutch national recommendations for healthy physical activity (*Nederlandse Norm Gezond Bewegen*)?
  - yes
  - no
5. How much physical activity do you think is required to promote health?
  - 10 minutes of moderate intensity activity, like brisk walking or cycling at 15 km/h, once a week
  - 10 minutes of moderate intensity activity, like brisk walking or cycling at 15 km/h, three times a week
  - 30 minutes of moderate intensity activity, such as brisk walking or cycling at 15 km/h, at least five times a week, but preferably every day
  - intensive physical activities, like running, for at least 20 to 30 minutes, at least three times a week

If the client already meets the national recommendations, or is in stage 5 of the behavioral change process, they only need advice.



Flow diagram for Dutch national recommendations for healthy physical activity (NNGB) .

### Recommendations for physical fitness ('Fitnorm')

Very intensive activity for at least 20 minutes, at least three times a week (summer and winter)

*In the context of a physical activity program for people with osteoporosis, this activity should involve functional strength training, including at least exercises for the lower extremities, at least twice a week.*

### Combined recommendations ('Combinorm')

These recommendations are met if the person meets the Dutch national recommendations (NNGB) *or* the above 'Fitnorm' recommendations for physical fitness.

### Combined recommendations adjusted for osteoporosis ('Osteo-Combinorm')

These recommendations combine the two recommendations described above. The combined recommendations adjusted for osteoporosis ('oste-combinorm') are met if the person meets the national recommendations (NNGB) as well as the recommendations for physical fitness ('Fitnorm') with the above osteoporosis-specific adjustments.

### Inactive

Not meeting the recommended 30 minutes of moderate intensity physical activity on any day.

### Reference

- Hildebrandt VH, Ooijendijk WTM, Hopman-Rock M. Trendrapport Bewegen en Gezondheid. Hoofddorp/Leiden: TNO Kwaliteit van Leven; 2005.

## Supplement 3 Conversion formulas for the 1RM estimation test

### Calculating 1RM from 4-6RM.<sup>1</sup>

exercise	calculating 1RM from 4-6RM
bench press	$1RM = -24.62 + (1.12 \times \text{kg}) + (5.09 \times \text{reps})$
inclined press	$1RM = -9.85 + (1.02 \times \text{kg}) + (5.70 \times \text{reps})$
triceps extension	$1RM = 6.74 + (0.99 \times \text{kg}) + (1.61 \times \text{reps})$
biceps curl	$1RM = 19.97 + (0.81 \times \text{kg}) + (2.31 \times \text{reps})$
leg extension	$1RM = 82.07 + (0.76 \times \text{kg}) + (5.66 \times \text{reps})$
<i>reps = repeats</i>	

### General formulas to calculate 1RM from 5RM.<sup>2</sup>

Bryzcki		Epley		O'Conner	
number of repeats	% 1RM	number of repeats	% 1RM	number of repeats	% 1RM
1	100	1	100	1	100
2	97.2	2	93.8	2	95.2
3	94.4	3	91	3	93
4	91.7	4	88.3	4	90.9
5	88.8	5	85.8	5	88.9

## Reference

- 1 Dohoney P, Chromiak JA, Lemire D, Abadie BR, Kovacs C. Prediction of one repetition maximum (1-RM) strength from a 4-6 RM and a 7-10 RM submaximal strength test in healthy young adult males. *Journal of exercise physiology online* 2002.
- 2 Reynolds JM, Gordon TJ, Robergs RA. Prediction of one repetition maximum strength from multiple repetition maximum testing and anthropometry. *J Strength Cond Res.* 2006 Aug;20(3):584-92.

## Supplement 4 Indicators of fragility

Unintentional weight loss: BMI less than 18.5 kg/m<sup>2</sup>

Weakness: a score of 75 or less on the 'physical functioning' scale of the SF-36.

Fatigue: a score of less than 55 on the 'vitality' scale of the SF-36.

Slowness: low walking speed.

Limited physical activity: less than 65 minutes a day spent on activities like cycling, walking or housekeeping.

*Normal values for walking speed, by gender and height*

Threshold values: the fragility criterion of slowness is met if the time needed to walk 4.5 meters (15 feet) exceeds the values listed below<sup>1</sup>

*Men*

Height ≤ 173 cm     ≥ 7 seconds

Height > 173 cm    ≥ 6 seconds

*Women*

Height ≤ 159 cm     ≥ 7 seconds

Height > 159 cm    ≥ 6 seconds

### Reference

- 1 Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol Biol Sci Med Sci.* 2001 Mar;56(3):M146-56.

**Postal address**

PO Box 248, NL-3800 AE Amersfoort  
The Netherlands

[www.kngf.nl](http://www.kngf.nl)  
[www.defysiotherapeut.com](http://www.defysiotherapeut.com)  
[info@kngf.nl](mailto:info@kngf.nl)