LOCOMOTOR DISABILITY IN THE ELDERLY

An epidemiological study of its occurrence and determinants
in a general population of 55 years and over

The Rotterdam Study

E. ODDING

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LOCOMOTORE BEPERKINGEN BIJ OUDEREN

Een epidemiologisch onderzoek naar de prevalentie en determinanten
in een algemene bevolking boven de 55 jaar

PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Erasmus Universiteit Rotterdam
op gezag van de rector magnificus
Prof. Dr. P.W.C. Akkermans M.A.
en volgens besluit van het College voor Promoties.

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ELSE ODDING

geboren te Eindhoven

PROMOTIE COMMISSIE

Promotores:	Prof. Dr. H.A. Valkenburg
	Prof. Dr. A. Hofman
Overige leden:	Prof. Dr. Sj. van der Linden
	Prof. Dr. B. van Linge

en te ervaren dat het verhaal van ons leven
den slag van het water gaat krijgen
dat wij rijpen bij wind en weer.
dan slaat ook de gloed niet zo licht meer
met snelle en vluchtige slagen naar buiten
in gelach en geween;

Uit 'Brief aan een vriend' H. Marsman
Verzamelde gedichten (1938)

In dankbare herinnering aan Geert, Elsje, Jan en Hendrikje.

Voor Karel

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Manuscripts based in the studies described in this thesis

Paragraph 4.1 Odding E, Valkenburg HA, Algra D, Vandenouweland FA, Grobbee DE, Hofman A. Disability in a Dutch general population of 55 years and over: the Rotterdam Study. Submitted.

Paragraph 4.2 Odding E, Valkenburg HA, Algra D, Vandenouweland FA, Grobbee DE, Hofman A. The association of locomotor complaints and disability in the Rotterdam Study. Submitted.

Paragraph 4.3 Odding E, Valkenburg HA, Algra D, Vandenouweland FA, Grobbee DE, Hofman A. Associations of osteoarthritis of the hip and knee with locomotor disability in the Rotterdam Study. To be submitted.

Paragraph 4.4 Odding E, Valkenburg HA, Algra D, Vandenouweland FA, Grobbee DE, Hofman A. Abnormalities on physical examination of the hip and knee and locomotor disability in the Rotterdam Study. To be submitted.

Chapter 5 Odding E, Valkenburg HA, Algra D, Vandenouweland FA, Grobbee DE, Hofman A. Self-reported and physician observed disability in elderly people - The Rotterdam Study. To be submitted.

CHAPTER 1

INTRODUCTION

Chapter 1

INTRODUCTION

Since the beginning of this century life-expectancy has increased by several decades. In 1990 newborn boys and girls in the Netherlands had a life-expectancy of 73 and 78 years respectively, compared to 51 years for boys and 53 years for girls born in 1910.[1] The consequences are twofold. Firstly, with stable birthrates the elderly become an ever-larger proportion of the population.[2] Secondly with the improvement of health care which can prevent premature death, the number of elderly people with chronic disease and disability steadily grows. Little is known about the burden of this on the health care system and on society as a whole. In a few countries some aspects of chronic disease and disability have been studied.[3-8]

From 1986 to 1988 the Netherlands Central Bureau of Statistics studied physical disability in the Dutch population. Disability was defined as difficulties in some activities of daily living as a result of some underlying impairment.[9] At present no data are available on disability in the population at large, regardless of its cause.

Disability can result from a wide array of organ impairments. A major organ of interest is the locomotor apparatus and more specifically the lower limbs. Locomotor disability is then defined as the amount of difficulty a person experiences when walking, climbing stairs, rising from a chair or bed or otherwise.

In 1990 the *Rotterdam Study* started as a population survey in people 55 years and older in one district of the city of Rotterdam. This study is primarily designed as a prospective follow-up study on the occurrence and risk factors of chronic disease and disability in a cohort of 10,275 people.[1] This thesis presents the prevalence of disability and the relation with putative risk factors in the first 5,034 participants to the study. Special attention is paid to the relationship between musculoskeletal signs and symptoms and locomotor disability.

In the second chapter a review is given on the concepts, the indices and the measurement of disability and its relation with osteoarthritis. The chapter is concluded with the hypotheses which underlie the study. The third chapter presents an extensive description of the *Rotterdam Study* population and the ascertainment of locomotor impairment and disability. The fourth chapter describes the prevalence estimates, the association of

disability with joint complaints, radiological osteoarthritis and the findings of physical examination of the hips and knees. In the fifth chapter the influence of non-response and other forms of cohort-reduction on prevalence estimates and associative measures are presented. The results of a comparison between self-assessed and physician-assessed disability is described.
Finally the thesis is concluded with a general discussion and suggestions for future research.

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CHAPTER 2

IMPAIRMENT AND DISABILITY

2.1 CONCEPTS AND THEIR MUTUAL INTERRELATION

2.1.1 International Classification of Impairments, Disabilities and Handicaps

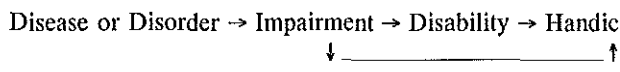
The classical medical model of disease is concerned with the etiology, pathology, manifestations and prognosis of disease. Most medical research focuses on one or more of these four subjects. The International Classification of Disease (ICD) is also based on the pathway: etiology → pathology → manifestation (= symptoms and signs).[1] In epidemiology research is concerned with the occurrence of disease, and with the determinants of its distribution, such as risk factors and prognostic factors.

The ultimate goal of most medical research is to prevent disease, or if this is not possible, to provide or develop optimal treatment once disease has developed. Much has been achieved in preventive medicine; in the developed countries infant and childhood mortality has decreased impressively since the beginning of this century, most major infectious diseases can be prevented or cured. As a result of improved health care premature death by cardiovascular disease can be prevented, and cancer-research made major progress in the knowledge of etiology and pathology and hence more and more oncologic diseases can be successfully treated.

A consequence of this vast improvement of medical knowledge is that life-expectancy has been increased by tenths of years since 1900. More people reach old or even very old age. However, this has its drawbacks as well: increasingly more people reach old age with chronic, incurable disease or with major disabilities.[2,3,4] The medical profession is becoming aware of its responsibility for the results of this improved health care. It no longer suffices to prevent premature death; future goals in medical research have to be concerned with the consequences of disease, especially of chronic disease, in addition to the classical themes of etiology, pathology, prognosis and therapy.

What are the consequences of disease? The principal events in the development of illness are as follows. Firstly, something abnormal occurs within the individual. The etiology gives rise to pathology, which manifests itself in symptoms and signs. Secondly, the person becomes aware of such an occurrence: the disease manifestations are referred to as clinical disease. The person's illness heralds recognition of *impairment*. Thirdly, the performance or behaviour of the individual may be altered as a result of this awareness. These experiences represent *disabilities*, which reflect the consequences of impairments in terms of functional performance and activity by the individual. And lastly, either the awareness of disease itself, or the altered behaviour or performance to which this gives rise, may place the individual at a disadvantage relative to others. This plane reflects the response of society to the individual's experience, and is called *handicap*, the disadvantages resulting from impairment and disability.

The International Classification of Impairments, Disabilities, and Handicaps (ICIDH) was developed in 1980 on initiative of the World Health Organisation.[5] The authors developed a classification system which contains three distinct and independent classifications, each relating to a different plane of experience consequent upon disease. The concepts can be linked in the following manner:



At any stage interruption can occur. Thus, one can be impaired without being disabled, and disabled without being handicapped. The definitions of the different planes are given below.

Impairment: any loss or abnormality of psychological, physiological, or anatomical structure or function. It is more inclusive than disorders in that it also covers losses. It is characterized by losses or abnormalities that may be temporary or permanent, and it includes the existence or occurrence of an anomaly, defect, a loss in a limb, organ, tissue, or other structure of the body, including the systems of mental function. Both ascribed and achieved status are included. Impairment does not necessarily indicate that disease is present or that the individual should be regarded as sick.

Disability: any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being. It is concerned with compound or integrated activities of the person or of the body as a whole. Disability is characterized by excesses or deficiencies of customarily expected behaviour or activity; these may be temporary or permanent, reversible or irreversible, and progressive or regressive. It takes form as the individual becomes aware of a change in his identity. By concentrating on activities, disability is concerned with what happens in a relatively neutral way; to say that someone has a disability is to preserve neutrality; to say that someone is disabled, as if this were an adequate description of that individual, is to risk being dismissive and invoking stigma.

The structure of these two classifications resemble that of the International Classification of Diseases (ICD) in that they are hierarchical and exhaustive. Impairments resemble disease terms in the ICD in that they are best conceived as threshold phenomena. Whereas, disabilities reflect failures in accomplishments so that a gradation in performance is to be anticipated.

Handicap: a disadvantage for a given individual, resulting from an impairment or a disability that limits or prevents the fulfilment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual. The important features of this concept are: first, some value is attached to departure from a structural, functional, or performance norm, either by the individual himself or by his peers; second, the valuation

is dependent on cultural norms; and last, the valuation is usually to the disadvantage of the affected individual.

The structure of the handicap classification is different from the ICD. The items are not classified according to individuals or their attributes but rather according to the circumstances in which disabled people are likely to find themselves. The scheme is not exhaustive and is restricted to key social roles.

2.1.2 Operationalisation of the concepts

It is the merit of Dr P.H.N. Wood that by developing the ICIDH the concepts of impairment and disability were clarified. The ICIDH offered the theoretical backbone for research on disability; it is however not suitable for use as a measurement-instrument. The operationalisation of the concepts introduced in this chapter has led to a large quantity of measurement-tools. Some are restricted to specific disease categories, others aim at covering aspects of disability, irrespective of its origin. Examples of the first are the Barthel index,[6,7] used in neurology, and the Steinbrocker Functional Index[8], used in rheumatology. An example of the second is the index used in the Framingham Disability Study.[9-12] Another distinction is that some indices only cover disabilities, while others incorporate handicaps as well. Examples of the latter are health-status measures like the Sickness Impact Profile and the Nottingham Health Profile.[13-16]

2.1.3 Ascertainment of disability in the Rotterdam Study

To describe the prevalence of disability as defined by the ICIDH several possibilities exist. The ICIDH disability classification consists of nine categories; they are listed in Appendix A. Each category consists of several subcategories and each subcategory is defined by several items. For example: the category of Locomotor disabilities is composed of three subcategories: ambulation disabilities, confining disabilities and other locomotor disabilities. Each subcategory consists of two to six items. By assessing the prevalence of disability in all 10 items of the locomotor category, and taking into account that a person can have a disability in several items it is possible to estimate three types of disability: i.e. first the prevalence of disability in an item (for example walking disability), second the prevalence of disability in the subcategory (for example ambulation disability) and third the prevalence of locomotor disability as a whole. Which measure is chosen depends on the goal and type of study.

In the *Rotterdam Study*[17] locomotor disability was defined as proposed by the ICIDH and composed of the relevant items from the ambulation subcategory, i.e. walking, climbing stairs, getting in and out of bed and a car, bending, and rising from a chair.

Apart from ambulation we assessed upper limb disability and disability defined as a compound index based on difficulties in lower and upper limb functions.

To assess disability in the *Rotterdam Study* the Stanford Health Assessment Questionnaire (HAQ)[18,19] was used. The HAQ measures disability in 8 components (dressing and grooming, rising, hygiene, reach, eating, walking, grip and activity), each of which consists of two to four questions beginning with: "are you able to ...". Each question is answered by one of four possible answers with score 0 = without difficulty, 1 = with difficulty, 2 = with much difficulty, and 3 = unable to do. The highest score on any question within a component is the score for that component. The six questions of the HAQ which refer to lower limb function are used as separate indices of disability; together they constitute the lower limb disability index in our study.

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2.2 REVIEW OF SOME DISABILITY-INDICES USED IN RHEUMATOLOGY

2.2.1 Introduction

In rheumatology many instruments to assess disability have been developed throughout the past 40 years. The tools fall into three categories. Firstly there are measures based on clinical judgement of the observer. Secondly there are measures based on observed performance and lastly there are self-reported assessments.

In addition to these broad categories of disability indices, a variety of health status measures have been developed. They include disability as one of a number of dimensions aimed at assessing the impact of arthritis on the patient's quality of live. The choice of a disability index should be based on the following considerations. Its measurement properties should be well described. The instrument should be valid (it must make biological sense), reproducible (has low variation between different observers), sensitive (it can detect the smallest clinically important change) and simple (it is easy to perform). These criteria implicitly require good precision and specification of datacollection. Apart from measurement properties, the choice of an instrument depends on the context in which it will be used.

In epidemiologic research in the general population one should use an instrument that, apart from its validity, reliability and sensitivity, is short and easy to use. Furthermore, as disease in the general population generally is less severe than in patients from hospital or outpatient clinics, the instrument should have high discriminative power: it should detect even the smallest difference in ability to perform various activities.

2.2.2 Measures based on clinical judgement of the observer

These measures are among the oldest indices that attempted to measure disability. The Steinbrocker functional index is an example of this category; its grades are also referred to as ARA-functional-classes.[1] It is a highly subjective measure with arbitrary grades (table 2.2.2.a.). Its advantage is that it is quick and easy to use. A major disadvantage is its very crude grading. In other words: it has very little precision. The Steinbrocker functional index is developed for use in patients with rheumatoid arthritis. It has been used in other rheumatologic disease like osteoarthritis, but as could be expected, a large proportion of patients with osteoarthritis were classified as either grade I or II.

Table 2.2.2.a. Disability measure based on clinical judgement of the observer: Steinbrocker Functional Index[1] (1949)

Grade	*Definition*	*Description*
I	Fit for all activities	Complete ability to carry out all usual duties without handicap
II	Moderate restriction	Adequate for normal activities, despite handicap or limited motion at one or more joints
III	Marked restriction	Limited only to self-care and little or none of the duties of normal occupation
IV	Confined to chair or bed	Incapacitated, largely or wholly bedridden or confined to wheelchair or no self-care

Some researchers have used the Katz' Index of ADL to assess disability in musculoskeletal disease.[2] This index was developed and based on observations of a large number of activities performed by a group of patients with fracture of the hip. It ranks patients according to adequacy of performance in six functions (table 2.2.2.b).

Table 2.2.2.b. Disability measure based on clinical judgement of the observer: Katz Index of ADL[2] (1963)

Function	*Description*	*(0 = independent, 1 = dependent)*
Bathing:	0 = assistance in 1 part	1 = assistance > 1 part
Dressing:	0 = assistance in tying shoes	1 = does not dress self or remains partly undressed
Toileting:	0 = independent toilet use	1 = uses bedpan or receives assistance in using toilet
Transfer:	0 = independently in/out bed/chair	1 = assistance or does not perform transfers
Continence:	0 = entirely self-controlled	1 = (partial)incontinence or control by enemas, catheters
Feeding:	0 = gets food to mouth	1 = assistance in feeding or parenteral feeding

A = independent in all
B = independent in all but one
C = dependent in bathing + one other
D = dependent in C + dressing
E = dependent in D + toilet
F = dependent in E + transfer
G = dependent in all
other = dependent in ≥ 2 functions but not classifiable in C, D, E, F.

Again this is an index which is easy to use. Its sensitivity however is low; there must be a rather high level of disability to reach a score on this index. Its usefulness in patients with osteoarthritis is very limited.

2.2.3 Measures based on observed performance

The Keitel functional test is an example of a measure based on observed performance (see table 2.2.3.a). The functional capacity of the extremities and the vertebral column is examined by 24 exactly prescribed exercises, which the patient has to perform and which are judged on well-defined rating scale categories.[3-5] Its disadvantage is that it is very time consuming.

Table 2.2.3.a Disability measures based on observed performance: Keitel-Index[3-5] (1971)

Test item	*Score*	*Test item*	*Score*
Lower limb:		Upper limb:	
rise from resting position	0 - 2,4,6	tip of thumb touches hypothenar	0 - 3
spreading legs in resting position	0 - 2	bending of 2nd - 5th finger	4 x 0 - 2
rising from chair	0 - 2,4,6	wrist volar flexion	1 - 3
stand on tiptoes	0 - 2	wrist dorsal flexion	1 - 3
stand on heels	0 - 2	forearm supination	0 - 2
knee flexion	0 - 2	forearm pronation	0 - 2
standing with heel on opposite knee	0 - 2	elbow flexion	0 - 2
standing on one leg	0 - 2	both hands behind the neck	0 - 3
standing with foot on close-by chair	0 - 2		
standing with heel on chair, knee extended	0 - 2		
walking 30 m in corridor	0 - 6		
walking 10 steps upstairs	0 - 3	Score 0 = test performed fully and without	
walking 10 steps downstairs	0 - 3	difficulty	

Another approach has been developed by Ekdahl et al in their "tests for muscle function".[6] This test measures three different types of lower extremity muscle function, i.e. muscle strength, endurance and balance/coordination (table 2.2.3.b). Again these tests take a lot of time to carry out, and are therefore not suitable for use in epidemiologic research in the general population.

Table 2.2.3.b Disability measures based on observed performance: Ekdahl muscle-function test[6] (1989)

Muscle function	*Test item*	*Score*
Muscle strength	rising from a chair (height 45 cm) without hand support	0 - 2
	stepping up 30 cm without hand support	0 - 2
	bending knees 90° with back against wall	0 - 2
Endurance	lying on back,knees bent,feet flat, lifting buttocks	0 - 2
	lying on back, lifting extended leg rapidly	0 - 2
	lying on side, lifting extended upper leg rapidly	0 - 2
Balance/coordination	standing on one leg, eyes open	0 - 2
	standing on one leg, eyes closed	0 - 2
	walking on a line	0 - 2
	flexing arm and opposite leg rapidly, alternating left/right	0 - 2

Score 0 = test performed at maximal level

2.2.4 Health status measures

In rheumatologic research the Stanford Health Assessment Questionnaire (HAQ) and the Arthritis Impact Measurement Scale (AIMS) are the most commonly used health status measures (tables 2.2.4.a and 2.2.4.b). Both measures were developed in the late 1970s and first published in 1980. Apart from functional disability, the HAQ measures pain, drug side effects and economic costs; the AIMS assesses psychological status, social activity and pain as well as physical function.[7]

Stanford Health Assessment Questionnaire

The Stanford Health Assessment Questionnaire (HAQ) is based on the fact that a patient with arthritis desires not only to be alive, but also to be free of pain, to function normally, to experience minimal treatment toxicity and to be financially solvent. On this basis a five-dimensional health status measure was developed, including death, discomfort, disability, drug side effects and dollar cost.[8,9]

In the first stage of its development 100 questions related to the above mentioned dimensions were presented to patients with arthritis by a nurse-assessor.[8] After evaluation of the results redundant questions were eliminated and a self-administered format with the 5 principal dimensions, broken into several components with an explicit hierarchy, was constructed.

Table 2.2.4.a. Health Status Measures: Stanford Health Assessment Questionnaire (HAQ)[8,9,13] (1980)

Disability Are you able to:

Dressing and grooming
- get clothes out of closet/drawers?
- dress yourself including closures?
- shampoo your hair?

Rising
- stand up from armless straight chair?
- get in and out of bed?

Hygiene
- wash and dry your entire body?
- use the bathtub or take a shower?
- turn taps on and off?
- get on and off the toilet?

Reach
- comb your hair?
- reach/get down 1 kg sugar above head?
- bend down/pick up clothing from floor?

Eating
- cut your meat?
- lift a full cup to your mouth?
- open a new milk carton?

Walking
- walk outdoors on flat ground?
- climb up stairs?

Activity
- run errands and shop?
- get in and out of a car?
- use public transport? (Dutch HAQ)
- do chores like vacuuming/gardening?

Grip
- open car doors?
- use pen or pencil?
- open jars which have been previously opened?

Question score: 0 = no difficulty, 1 = with little difficulty, 2 = with much difficulty, 3 = unable to do
dependency on equipment or physical assistance adjusts a lower score to 2

Component score: highest score for any question within a component

Disability index: sum of component scores divided by the total number of components answered

Discomfort Pain-severity: 0 - 3; 0 = none; 3 = severe
Pain-trend: 1 - 3; 1 = better, 2 = same, 3 = worse

Drug toxicity adverse effects from drugs and treatment: 0 - 3; 0 = none; 3 = severe

Dollar costs A. Medical and surgical costs for the year
B. Social cost: change in employment and income, need to hire domestic help, cost of transportation

Functional disability was measured by 9 components (dressing and grooming, rising, eating, walking, hygiene, reach, grip, outside activity and sexual activity), each of which consisted of one or more questions beginning with: "are you able to ...". Each question is answered by one of four possible answers with score 0 = without difficulty, 1 = with difficulty, 2 = with some help from another person or with a device (in later versions:

with much difficulty) and 3 = unable to do. The highest score on any question within a component is the score for that component. The disability index is calculated by adding the component-scores and dividing the sum by the total number of components answered. The component on sexual activity was dropped after the first validation study, because of low response. The latest version of the HAQ, which has been widely used since its final development stage in 1982, consists of 20 questions grouped in 8 components.[9]

The index of discomfort is a score for the severity of pain during the last week (0 = none, 1 = slight, 2 = moderate and 3 = severe pain) and the trend in pain with 1 = better, 2 = the same and 3 = worse. Drug toxicity is assessed by asking for the severity of side effects with 0 = none to 3 = severe side effects. The validity of the drug toxicity index was assessed in a separate validation study.[10]

In the cost section a distinction is made between medical and social costs. In the medical component the medical and surgical costs for the year are calculated; i.e. dollar costs for medication, X-rays, surgery, paramedical visits, devices, laboratory tests, physician visits and hospital admittance. In the social cost section the dollar costs of changes in employment, need to hire domestic help and transportation as well as income, are calculated.

A sample of patients with rheumatoid arthritis was given the questionnaire and was subsequently tested for the ability to perform the various tasks of the questionnaire.[8] The questionnaire and test agreed exactly on 59% of the responses and were within 1 point difference 93% of the time. Following the development of the HAQ several validation studies were carried out. The index proved to be valid and reliable for patients with rheumatoid arthritis as well as for patients with osteoarthritis.[9] As was anticipated, patients with osteoarthritis had a lower score (experienced less disability) and showed little change of function in a period of 2 years, compared to patients with rheumatoid arthritis. In a study among 400 rheumatoid arthritis patients the HAQ was associated with increasing age, female sex, unmarried status, family income and disease duration.[11] There was a strong association with joint count, grip strength, pain and erythrocyte sedimentation rate. The functional disability index was not influenced by the presence of one or more comorbid conditions. With a mean follow-up of 3.1 years the disability index explained changes in inpatient and outpatient charges as well as days hospitalised and outpatient physician visits (all variables increased stepwise as the disability index classification changed from 0 - 1 to > 2). The index explained more of the variance in utilization variables than joint count, erythrocyte sedimentation rate, pain or grip.

Patients needed less than 5 minutes to complete the disability index of the HAQ; experienced researchers needed 15 seconds and inexperienced ones 22 seconds to calculate the disability index.[11]

The HAQ was developed in the United States and has since been used in several countries. The British were the first to adapt the HAQ to their situation: they added questions concerning getting in and out of bed, climbing stairs, getting in and out of a car and doing chores such as vacuuming, housework or light gardening.[12] The Dutch version is roughly the same as the British version but added a question about the use of public transport, because this item was thought to be particularly relevant to the Dutch situation.[13] Valdidation of this Dutch version has been carried out in several studies with rheumatoid arthritis patients.[13-16] The Swedish only made textual adjustments to the British version.[17] Validated Spanish and Portuguese version of the HAQ are available as well.[18,19] The Dutch and Swedish validation studies investigated the relationship between the self-administered questionnaire and tests of the various tasks. In the Dutch study the questionnaire and test agreed exactly for 65% of the responses and coincided by a difference of one point in 95% of the items. A tendency was observed to under-reporting by rheumatoid arthritis patients. There was a strong positive correlation between the questionnaire and the test of 0.95 in the Dutch study and 0.71 in the Swedish study.[13,17]

In 1983 a modified version of the HAQ (MHAQ) was presented.[20] In this format one item from each component of the disability index was presented to the patient with three types of questions (see Appendix B). The patients were asked not only to rate the amount of difficulty in performing the tasks, but also how satisfied they were with their ability to perform the task, if there was a change in difficulty compared to 6 month ago and if they needed help to perform the task. Satisfaction proved to be most highly correlated with difficulty; but change and help were also highly significantly correlated with difficulty.

Arthritis Impact Measurement Scales

The Arthritis Impact Measurement Scales (AIMS) were constructed by building on two previously tested health status measures: Bush's Index of Well-Being[21] and the Rand Health Insurance Study batteries.[22] Items for the mobility, physical activity, and social activity scales were taken directly from the Rand batteries; social role activities were taken from the Index of Well-Being. A more specific activities of daily living scale was added. Dexterity items were added to assess upper extremity limitations. Modifications of the Rand anxiety and depression scales were included to measure psychological aspects. Finally pain items were added.[23] The 9 scales contain 4 - 7 questions each; every item has 2 - 6 possible responses. The item responses are summed by group to produce scale scores and then brought to a normal standard of 0 - 10. In the first validation study 55 health status items in 9 scale groups were presented to 104 patients from a rheumatology practice.[23] Patients needed about 20 minutes to complete the questionnaire and there were no major comprehension problems. In a scalogram analysis, using Guttman coefficients of reproducibility and scalability[24] 9 questions were dropped because of low scale-item

correlations. After these deletions all scales, except for social activity, met accepted criteria for Guttman-format scales. In an analysis of validity Pearson correlations of the scales with age, patients perception of general health and disease activity, as well as doctor's report of functional activity, disease activity and joint count, were assessed. The performance-oriented scales correlated with age; all 9 scales were correlated with patients estimate of general health and disease activity. When the psychological scales were excluded there was a 76% agreement between scale scores and physician's report of functional activity, disease activity and joint count.[23]

Table 2.2.4.b. Health Status Measures: Arthritis Impact Measurement Scales (AIMS)[23,25,26] (1980)

Physical Function

Mobility
- 4 most or all of the day in bed/chair
- 3 able to use public transportation
- 2 need assistance in travelling
- 1 stay indoors most or all of the day

Physical activity
- 5 unable to walk unless assisted
- 4 trouble climbing stairs
- 3 trouble walking long distance
- 2 trouble bending, lifting, stooping
- 1 limited in running, lifting heavy objects, strenuous sports

Activities of daily living
- 4 help to use toilet
- 3 able to move around
- 2 help to dress
- 1 help to take a bath

Dexterity
- 5 easily write with pen/pencil
- 4 easily turn a key in a lock
- 3 easily button articles of clothing
- 2 easily tie a pair of shoes
- 1 easily open a jar of food

Household Activities
- 7 able to take all own medicine
- 6 able to use telephone
- 5 able to handle own money
- 4 able to prepare own meals
- 3 able to do own laundry
- 2 able to shop for groceries/clothes
- 1 able to do own housework

Psychological status

Pain
- 4 how often severe pain from arthritis
- 3 description arthritis pain
- 2 how long morning stiffness
- 1 how often pain in $\geq$ 2 joints

Social activity
- 4 how often telephone with friends
- 3 how often friends to your home
- 2 how often get together socially with friends
- 1 how often visited friends at their homes

Depression
- 6 how often felt that others would be better off if you were dead
- 5 how often so down that nothing could cheer up
- 4 how often felt downhearted/blue
- 3 how often felt that nothing turned out right
- 2 how much of the time in low spirits
- 1 how much of the time enjoyed things you do

Anxiety
- 6 how much of the time felt tense
- 5 how much bothered by nervousness
- 4 how often difficulty in trying to calm down
- 3 how much of the time able to relax
- 2 how much of the time felt calm and peaceful
- 1 how much of the time felt relaxed and free of tension

Score: each item has 2-6 possible responses; item responses are summed by group and then brought to a normal standard of 0 to 10.

A larger validation study reported on the results of 336 patients with rheumatoid arthritis, 108 with osteoarthritis, 57 with systemic lupus erythematosus, 34 with seronegative variants and 61 other patients including soft-tissue rheumatism and crystal-associated arthropathy.[25] The questionnaire contained the same 45 items (9 were dropped in the first study, 1 question concerning sexual activity was dropped at this stage because of low response). The social role scale was renamed household activities. All 9 scales proved to be significantly correlated with ARA functional class and recent disease activity assessed by the subject's physician, although the correlation with functional class was higher. Analysis of subgroups of patients with rheumatoid arthritis and osteoarthritis showed similar results. The stability of the scales over a 6-month period was tested in 85 patients with rheumatoid arthritis: the average change was 0.14 on a scale from 0 to 10 with the physical scales showing the greatest tendency to decline over time.[25]

The AIMS was translated in Dutch in 1989 and proved to be valid and reliable for use in Dutch rheumatoid arthritis patients.[26]

In 1991 the AIMS was adapted for use in elderly respondents.[27] In this so-called GERI-AIMS 438 respondents 60 years of age and older, and not identified as having arthritis prior to enrolment, received the questions in a interview format. Each item of the first 5 scales (the physical function scales) received 2 scores: a generic question first asked to determine whether the respondent had any difficulty performing the particular activity; if the answer was affirmative the score was 1 and was followed by the question whether the disability was caused by arthritis; again a score of 1 was assigned to those who gave a positive answer. The method of constructing a scale score remained the same. Because respondents in a pilot study objected to the number and perceived repetitiveness of questions on the anxiety and depression scales these scales were reduced from 6 to 3 questions. In this population 90% of the respondents had a rheumatologist confirmed diagnosis of osteoarthritis, 36% had osteoporosis or hip fractures, 13% soft tissue rheumatism and 3% rheumatoid arthritis. Of those with osteoarthritis 60% were mildly impaired and 22% moderately; in contrast: 42% of the participants with rheumatoid arthritis were moderately impaired. There was an expected high prevalence of comorbidity in all participating patients: 68% had poor vision, 48% had cardiovascular problems (hypertension not included), 46% had hypertension and 29% suffered from chronic neuromuscular conditions. On average there were 3.4 chronic conditions per respondent. The relative prevalence of impairment by dimension was similar for the generic and arthritis-specific scores. More than half of the total amount of disability was related to arthritis. Correlations of functional class and joint count with the arthritis-specific scores were higher than with the generic scores. There was a strong relationship between functional class in respondents with osteoarthritis of the hip or knee and arthritis-specific scores on the mobility and physical activity scales.

In conclusion, the Stanford Health Assessment Questionnaire as well as the Arthritis Impact Measurement Scales are reproducible and yield similar results when repeated at different times under similar circumstances. Many validation studies of the AIMS and HAQ have been carried out and showed good validity, reproducibility and sensitivity. The HAQ performed somewhat better; possibly because it is much shorter and easier to administer.[9-10,13,14,23,25,28-37]

Ideally a new measurement tool is compared with a gold standard to determine criterion validity. Since no gold standard exists in rheumatologic disability research, comparisons are generally made between similar measures of the same concept. The dimensions of the HAQ and the AIMS were compared to each other; correlations of the same dimensions ranged between 0.64 and 0.91, indicating that the two questionnaires are measuring similar concepts. Interdimension correlations range between 0.19 and 0.43, suggesting that the other scales do provide separate information.[28] Both the HAQ and the AIMS are tested for their relationship with more traditional endpoints, like joint count, grip strength and morning stiffness. There were significant correlations of the HAQ as well as the AIMS with these endpoints[25].

Sensitivity to clinically meaningful change is an important criterion which ultimately determines the usefulness of any outcome measure. The AIMS[31,32] and HAQ[35-37] have both been used in randomized clinical trials where pain and function showed significant improvement in treatment groups over controls in a six to 24 month time period. Changes in disability and pain have been significantly correlated with changes in traditional measures.[33]

Apart from its use in rheumatology the HAQ has proved to be useful in other fields of medical research. In the context of this thesis it is noteworthy that the HAQ has been used in large population surveys like the National Health and Nutrition Examination Survey (NHANES-I) and National Health and Nutrition Examination Survey-I Epidemiologic Follow-up Study (NHEFS).[9,38] More recently the HAQ was successfully used in a survey among 1,694 men and women aged over 55 registered at a general practice in Bristol, Great Britain.[39,40] The HAQ proved to be useful in a questionnaire format in a study of patients with rheumatoid arthritis, osteoarthritis and gout from a general practice in the inner city of Glasgow, Scotland.[41]

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2.3 REVIEW OF THE LITERATURE ON THE RELATIONSHIP BETWEEN OSTEOARTHRITIS AND DISABILITY

2.3.1 Introduction

In this paragraph a review of the literature on disability studies in several western countries is given. Disability is studied in populations as well as in patients visiting hospitals or outpatient clinics. Furthermore some, studies focus on the *level* of disability in the population, while others investigate *relationships* between a certain disease or impairment and disability. As this thesis is concerned with disability in an ageing population and especially in the members of the general population with signs or symptoms of the hip or knee, this review is restricted to studies concerned with (osteo)arthritis in the elderly population. The results mentioned in the review are also depicted in the tables 2.3.2 and 2.3.3.

Most studies did not use the definition of disability as proposed by the International Classification of Impairments, Disabilities, Handicaps (ICIDH),[1] which was discussed in the previous paragraphs. Instead different aspects of disability, like difficulty in walking, and climbing stairs, are described. Sometimes disability is defined as some crude outcome measure like "activity restriction in general". Other studies use aggregate measures of disability in basic activities of daily living (ADL), like walking, bending and rising from a chair or instrumental activities of daily living (IADL), like shopping, doing household chores or gardening. Because of this wide variety of disability definitions it is not easy to compare different studies. This review focuses on disability in functions of the lower limbs, and restricts itself to studies which reported some measure of disability in these functions. The section starts with the studies in which crude measures are used, followed by the surveys on the different functions, like walking and climbing stairs.

The articles used for this review were selected with the support of MEDLINE from the literature published between 1981 and 1994. In addition, references from articles on disability in general were selected.

2.3.2 Disability as a general measure

Table 2.3.2. gives a summary of the data referred to in this paragraph. The National Health and Interview Survey (NHIS) is an ongoing population-survey of a large probability-sample of the United States population. Several diseases and disease-related factors are being studied. Osteoarthritis is defined as an ICD-code for osteoarthritis based on self reported arthritis symptoms. During the 1976 NHIS 18% of people, age 18 years and

older with osteoarthritis, were unable to perform their usual activities. This figure was 8% in the age-and-sex-matched control subjects. Of the osteoarthritis-patients 39% were limited in the amount or kind of their major activity (controls: 14%), and 14% of the respondents with osteoarthritis were limited in activities outside their major one (controls: 8%).[2]

In the 1984-1986 NHIS, limitation of any kind in general activities was found in 79% of persons with osteoarthritis, and complete limitation in the major activity was reported in 25% of the osteoarthritis group. Limitations of any kind in activities of daily living were present in 25% of people with osteoarthritis.[3] Unfortunately, the definitions of disability in these studies are not completely identical (see table 2.3.2), but it seems reasonable to conclude with the authors that in this 10 years timespan, disability caused by musculoskeletal diseases increased, suggesting a rising burden of disability due to osteoarthritis.

In the 1978 NHIS-study disability was defined as limitation in the kind or amount of work (or household) *resulting* from a chronic health condition or impairment for at least 3 months. Osteoarthritis was defined as physician diagnosed osteoarthritis and perceived pain or swelling in fewer than four joints and fewer than two symmetrical joint pairs. Disability was reported in 71.4% of the males with osteoarthritis. In men with osteoarthritis of one knee the prevalence of disability was 74.3% and in men with osteoarthritis of one hip 75.1%; 9.4% of the men without arthritis indicated disability. The percentage of men working outdoors was 66.7% for those with osteoarthritis, and 89.4% for men without arthritis.

Among women with osteoarthritis disability was reported in 66.9%. The prevalence of disability was 70.2% for women with one osteoarthritic knee, and 51.2% for women with one osteoarthritic hip; 9.9% of the women without arthritis reported disability. The percentage of women with osteoarthritis working outdoors was 35.5%, and of those without arthritis 61.6%.

In this study individuals with osteoarthritis were older, had lower formal education level, more comorbidity and were more likely to be divorced, widowed or separated than people without arthritis. Women with osteoarthritis annually earned only 30.2% of what the average women without arthritis earned. The earnings gap however, is only for 28.4% explained by arthritis; age accounts for 45.3%, education level for 11.8%, comorbidity for 8.3%, marital status differences for 5.1% and region of residence, a surrogate for the cost of living, for 1.1% of the earnings gap.[4]

Table 2.3.2 Disability as a general measure

Population	Disability					Comment
'76 NHIS		% restricted activity				
age: ≥ 18 yr		usual	major	outside major		OA = ICD-code for osteoarthritis
n = 113,000	OA	18	39	14		based on self-reported symptoms
Ref.2.	Contr	8	14	8		
		% restricted activity				
'84-'86 NHIS		general	major	ADL		
Ref.3.	OA	79	25	25		
'78 NHIS		% disabled		% not working		disabled = limited in kind/amount of
age: 18-65 yr		men	women	men	women	(house)work resulting from disease
n = 5,652	OA	71.4	66.9	33.3	64.5	lasting ≥ 3 months.
Ref.4.	Knee OA	74.3	70.2	41.4	58.9	OA = physician diagnosed OA and pain
	Hip OA	75.1	51.2	28.4	76.4	or swelling in < 4 joints, including
	Contr	9.4	9.9	10.6	38.4	< 2 symmetrical pairs.
						% OA: men: 2.5 women: 4.2
'83-85 Framingham		% disabled		OR		disabled = dependent on help in at
age: 63-93 yr	all ROA ≥ 2	37.5		1.3 (not significant)		least 1 of 7 ADL's.
n = 1,416	Symptoms	46.2		1.9		all ROA ≥ 2 = Kellgren ≥ 2 +/- pain
Ref.6.	Contr	29.8		1		Symptoms = pain in/around knee ≥
						1 month in past year.
'92 Bristol		% disabled				
age ≥ 55 yr		men		women		disabled = HAQ-score > 0.
n = 1,694	No pain	18		25		Pain = in/around knee most days ≥ 1
Ref.7.	Pain	46		67		month in past year.

In the 1983-1985 Framingham OA Study two lower extremity functions and five complex functional tasks were studied in 1,416 people 63 to 93 years of age. The lower extremity functions included walking a mile and stairclimbing; the functional tasks were housekeeping, heavy home chores, cooking, grocery shopping and carrying bundles. The tasks were recorded as able or unable to do without help.

Symptoms were defined as pain in or around the knee lasting for at least a month within the previous year. Osteoarthritis was defined as knee symptoms with osteophytes on X-rays or narrowing of joint space and osteophytes on X-rays with infrequent symptoms. After comorbidity adjustment osteoarthritis of the knee was as often associated with disability as heart disease, congestive heart failure and chronic obstructive pulmonary disease, i.e. in 4 tasks.[5]

When 'arthritis' was defined as all radiographic grades greater than or equal to two (i.e. at least osteophytes), regardless of the presence of symptoms, and dependence upon human assistance in one or more of the seven functional activities (ADL) combined into a single disability variable, 37.5% of the elders with 'arthritis' were dependent in one or more ADL compared to 29.8% of their peers without 'arthritis'. The odds ratio (OR) for dependence after controlling for age and sex were not significantly higher: OR = 1.25 (95% CI 0.97-1.60). A definition of osteoarthritis based only upon symptoms resulted in 46.2% of patients disabled in at least one ADL. The odds for dependency were significantly larger: OR = 1.85 (95% CI 1.30-2.65).[6]

In a recent study among 677 men and 1017 women aged 55 years and older registered at a general practice in North-West Bristol (GB) the participants were asked if they had had pain in or around a knee on most days for at least a month during the last year. Disability was defined as a score > 0 on the Stanford Health Assessment Questionnaire (HAQ). Knee pain was common: 20.1% of men and 27.6% of women had had knee pain for at least one month during the past year. The prevalence of disability was higher in women than in men, and in subjects with knee pain than those without. The frequency of reported disability rose in both sexes with age.[7]

2.3.3 Disability in various functions

In table 2.3.3. the data of the studies on disability in separate functions are summarized. In the United States the 1982-1984 National Health and Nutrition Examination Survey-I Epidemiologic Follow-up Study (NHEFS) of the 1971-1975 first National Health and Nutrition Examination Survey (NHANES-I) offered the possibility to study the relationship between radiological osteoarthritis of the knee at baseline and disability at follow-up.[9] Radiological osteoarthritis at baseline was defined as grade two or more on the Kellgren scale.[10] Disability at follow-up was measured using the HAQ, extended with questions concerning preparation of food, walking from one room to another, carrying bundles and doing heavy chores. Scores on the 26 questions ranged from 0 = no difficulty to 3 = unable to do. Disability in a task was defined as a score larger than 0. Of the participants who were 45-74 years of age and had radiological osteoarthritis of the knee at baseline men had more problems with 10 and women with 15 of the 26 activities at follow-up eight to ten years later.

The odds ratios for difficulty in walking with knee radiological osteoarthritis at baseline were 2.4 for men, and 2.8 for women. The odds for difficulty in climbing stairs were 3.1 for men and 4.8 for women (table 2.3.3). The odds for difficulty in rising from a chair were 3.2 in men and 4.7 in women.

Linear regression analysis to assess the association of radiographic severity and severity of difficulty was conducted for women only. Women with radiological osteoarthritis grade 3 and 4 had higher disability-scores than those with radiological osteoarthritis grade 2. Women with knee pain, regardless of whether they had radiological osteoarthritis, had higher scores than those without radiological osteoarthritis or pain. Women with symptomatic knee radiological osteoarthritis had higher scores than those with asymptomatic knee radiological osteoarthritis.[9]

In persons 55-74 years of age at baseline (1971-1975), the odds ratios for difficulty in walking, and rising from a chair at follow-up (1982-1984) in people with and without radiological osteoarthritis of the knee, and with or without pain were estimated. As can be seen in table 2.3.3 the odds for disability increases with the presence of radiological osteoarthritis and is especially higher for those with knee pain[11,12]. Unfortunately, the definition of radiological osteoarthritis in this analysis differed from the previous one, which is the most commonly used definition of radiological osteoarthritis. Radiological osteoarthritis in the latter study included the large proportion of people with radiological osteoarthritis grade one, i.e. doubtful radiological osteoarthritis.

Table 2.3.3 Disability in various functions

Population	Disability	Comment
'82-84 NHEFS age: 45-74('71-75) n = 2,844 Ref.9.	walking / climbing stairs men % OR / women % OR / men % OR / women % OR Knee-ROA 29.1 2.4 / 43.2 2.8 / 20.8 3.1 / 37.2 4.4 No Knee-ROA 14.6 1 / 21.2 1 / 8.0 1 / 10.9 1	ROA = Kellgren grade ≥ 2 % knee ROA men women 45-54 2.3 3.6 55-64 4.0 7.2 65-74 8.4 17.9
'82-'84 NHEFS age: 55-74('71-75) n = 2,385 Ref.11,12.	walking / rising from chair men % OR / women % OR / men % OR / women % OR ROA+/pain+ 35.7 3.3 / 66.7 8.6 / 39.3 3.4 / 60.8 5.9 ROA+/pain- 26.7 2.7 / 30.3 2.1 / 28.9 2.3 / 36.7 1.8 ROA-/pain+ 19.3 2.8 / 32.7 2.8 / 23.8 2.8 / 38.3 2.4 ROA-/pain- 14.2 1 / 18.8 1 / 16.5 1 / 22.2 1	ROA+ = Knee Kellgren grade 1-4 % ROA grade ≥1 men women / grade ≥2 men women 55-64 yr 8.3 10.8 / 4.1 7.3 65-74 yr 11.6 24.9 / 8.3 18.0 grade 0 / grade ≥2 % pain 9.9 19.0 / 47.0 40.1
'83-85 Framingham age: 63-69 yr n = 1,416 Ref.6.	OR: walking / climbing stairs / housekeeping all ROA ≥ 2: 1.7 / 2.7 / 1.1 (not significant) as ROA ≥ 3: 2.0 / 3.0 / 1.8 SROA ≥ 2: 2.9 / 3.8 / 1.9 symptoms: 2.6 / 3.7 / 1.8 (not significant)	Knee ROA-/symptoms-: 62.9% asymptomatic knee-ROA2: 15.1% all knee-ROA≥2: 32.5% asympt knee-ROA≥3: 10.7% symptomatic knee-ROA≥2: 7.3% knee-symptoms: 11.2% knee-ROA<2 + symptoms: 4.0%
'92 Bristol age ≥ 55 yr n = 159 Ref.8.	lower limb disability % men / % women / OR No knee pain 38.9 15.1 / Knee pain 1.7 Knee pain 44.1 38.9 / Muscle strength 0.84/kgf increase	disabled = HAQ-score > 0. pain = in/around knee most days ≥ 1 month in past year.

Elders with mild radiological osteoarthritis (Kellgren grade 2 = osteophytes) and infrequent knee pain in the 1983-1985 Framingham OA Study had no significantly elevated risk for dependence in any of seven functional activities. Elders with asymptomatic, moderate to marked osteoarthritis (Kellgren grade $\geq$ 3 = at least joint space narrowing) were at increased risk for dependence in four tasks. The odds ratios in persons with radiological osteoarthritis grade 3 and 4 were approximately 2 to 3 times higher for climbing stairs, walking a mile, housekeeping and carrying bundles. Elders with radiological osteoarthritis grade $\geq$ 2 accompanied by frequent pain had significantly increased odds of dependence in two tasks. These persons have odds ratios of approximately 3 and 4 for stairclimbing, and walking a mile. There were small nonsignificantly increased relative risks for cooking and shopping.[6,13] The odds ratios for dependence in three functional activities of the various arthritis definitions are shown in table 2.3.3.

To evaluate the influence of radiographic severity, quadriceps strength, knee pain, age and gender on functional ability respondents with knee pain and an equal number of controls were invited for further investigations. The HAQ-components rising, walking and activity were taken together as a 'lower limb score'. There was a significant independent association between lower limb disability and quadriceps strength (Odds Ratio = 0.84 per kgf increase), knee pain (Odds Ratio = 1.67) and age (Odds Ratio = 1.06 per year increase). Radiographic osteoarthritis of the knee was not independently associated with disability.[8]

2.3.4 Summary

Disability in the activities of daily living among people aged over 55 years in western societies are reported to vary between 8 and 61 percent, depending on the definition used and whether or not the subjects suffered from musculoskeletal signs and symptoms. Of the factors which could be associated with disability in the lower limb activities knee symptoms are the most frequently studied. Knee pain was found to be a strong predictor of present and future disability in all studies. The contribution of radiological osteoarthritis of the knee differed between the studies. A large part of the variation between the reviewed studies can be explained by the use of different definitions of osteoarthritis. The studies which used Kellgren-grade II as cutoff-point for osteoarthritis concluded that osteoarthritis alone did not increase the odds for disability substantially. If knee pain was added to the definition of osteoarthritis the odds are significantly increased. Data on the association of hip complaints with disability are lacking. Some researchers reported that they are currently studying this factor.

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2.4 PROBLEMS AND HYPOTHESES

2.4.1 Problems

The importance of studying disability in old age has been demonstrated. But, as has been pointed out in paragraph 2.3.1, there are definitional as well as classification issues to be considered.

Definition

The first issue in research of disability in old age is the definition of disability. In the past two decades many definitions based on several measurement tools have been used. It would be appropriate to reach consensus in this field of research, not only to avoid ongoing discussions on this topic, but also to allow for comparison between studies within and between countries. Unfortunately the International Classification of Impairments, Disabilities, and Handicaps (ICIDH) is by itself not suitable for use as a measuring instrument.[1] On the other hand it offers a thorough and systematical enumeration of possible disabilities.

The second definition issue is concerned with the meaning of the words 'old age'. When is a person considered to be old? Is there a clear cutoff? Of course not. "One is as old as one feels" is a beloved phrase of those who feel good. A valid cutoff-point seems to be retirement. The problem with this cutoff is that retirement-age has shifted to younger ages in the past decade, and is not the same for all countries. Furthermore, to evaluate the prognosis, incidence and risk factors of disability in a prospective follow-up study, people must not be to old at entry. Therefore the age of 55 seems to be a valid, although arbitrary, age to start studies on disease and disability in old age.

Classification

Classification in general is concerned with diagnosis. In epidemiologic research much attention is paid to describe the outcome and determinants as accurate as possible, as the effect of random and non-random misclassification of outcome and determinant status can be very large.[2] Misclassification can be characterized by the sensitivity and specificity of the classification criteria. Sensitivity is the proportion of the diseased subjects who fulfil the criteria while the complement of sensitivity is the proportion of false negative subjects. Specificity is the proportion of the non-diseased subjects who do not fulfil the criteria; its complement is the proportion of false positive subjects. Random or non-differential misclassification results if inaccuracies in the classification of subjects by outcome or determinant status occur in similar proportions in each of the study groups.[3,4] The effect of non-differential misclassification of the outcome is that it increases the

similarity between the groups with and without the determinant, so that any true association between the determinant and outcome will be diluted or underestimated. The relative risk will be changed towards the null value of one. Non-random or differential misclassification results when the errors in the classification of individuals by determinant or outcome are different for the study groups. Differential misclassification can result in an over- and underestimation of an effect.

In the study on disability in old age the classification of age is no issue. On the other hand the classification of disability can be a major problem. Many measurement tools, which all assess some kind of disability, exist. If however the definition as proposed by the ICIDH is used and the research is focused on disability in the general population logical restrictions towards the measurement tools are made. A disability index to be used in the general population should be short and easy to use as well as sensitive to measure even the smallest amount of disability, apart from the normal criteria of validity and reliability.

As far as the locomotor disabilities are concerned the Stanford Health Assessment Questionnaire as well as the Arthritis Impact Measurement Scales both comprise valid 'translations' of the locomotor disabilities category of the ICIDH.[5,6]

2.4.2 Hypotheses

The investigations on locomotor disability in the *Rotterdam Study* used the following definitions and classification criteria.

The outcome measure in this study is locomotor disability. Locomotor disability refers to an individual's ability to execute distinctive activities associated with moving, both himself and objects, from place to place. It covers ambulation disabilities (walking, traversing, climbing stairs, running), confining disabilities (transfer from lying, sitting, standing, reaching bed or chair and transport) and other locomotor disabilities (lifting). Subjects are classified according to the amount of difficulty they experience while executing the above mentioned activities. Disability assessment is done by means of the Disability Index of the Stanford Health Assessment Questionnaire (HAQ) as well as specific tests to evaluate the various activities. People are classified as either having a disability (at least some difficulty with the specific task) or not.

The determinants of interest in the study of locomotor disability are joint disease, and more specifically joint pain, morning stiffness, osteoarthritis and abnomalities on physical examiantion of the hip and knee. Osteoarthritis is defined according to the radiological criteria of Kellgren.[7] Classification is again dichotomous: osteoarthritic joints are those with grade two or more on the Kellgren scale. Subjects are classified according to their most affected hip and knee. Definition and classification of these determinants are

described extensively in chapter four.

The hypotheses of the study on locomotor disability are:

1. Locomotor disability is a major problem in the elderly general population.
2. The distribution of the prevalence of locomotor disability is influenced by educational level, income and living situation (living alone or not alone).
3. Locomotor disability can be largely explained by the presence of joint pain.
4. Radiological osteoarthritis of the hips or knees will have an additive effect on locomotor disability in the presence of joint pain.
5. Locomotor disability in the elderly with radiological osteoarthritis of the hips or knees can be largely explained by the effect of joint pain and abnormalities on physical examination of the hip and knee.

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CHAPTER 3

POPULATION AND METHODS

3.1 THE ROTTERDAM STUDY

3.1.1 Background

As a result of the increase in longevity during the second half of this century, the elderly form a substantial and growing proportion of the total population in Western society. Age-related illnesses with characteristics of chronicity, e.g. Alzheimer's disease, visual impairment, cardiovascular and locomotor diseases, affect large numbers of people and have a substantial impact on the quality of life.[1-3] A delay in the onset of chronic diseases or postponement of their sequelae will restrict the time spent with some form of disability and may limit the otherwise inevitable reduction in quality of life. However, before interventive action - to prevent chronic disease and subsequent disability - can be advocated with confidence more must be known about the etiology of geriatric diseases, especially with respect to potentially modifiable risk factors.

The *Rotterdam Study* focuses on the study of etiology by investigating the incidence and determinants of occurrence of important chronic diseases and disability. The investigation of potentially modifiable risk factors is one of the major objectives of the *Rotterdam Study*. The primary target is the improvement in quality of life by reducing morbidity in the elderly.

The *Rotterdam Study* is a prospective follow-up study carried out by the Departments of Epidemiology & Biostatistics and Ophthalmology of Erasmus University Rotterdam Medical School, the Netherlands. All participants are extensively examined at the time of enrolment. Three years later every respondent will be re-examined using identical procedures.[4]

3.1.2 Research questions

The *Rotterdam Study* was developed to investigate chronic diseases which occur particularly above the age of 55 years. The research questions were grouped in four disease categories: neurogeriatric diseases, cardiovascular diseases, ophthalmologic diseases and conditions of the musculoskeletal system: osteoporosis and osteoarthritis. The main research questions of each disease category are:

Neurogeriatric diseases

1. What is the incidence of dementia, specifically Alzheimer's disease, vascular dementia, mixed dementia and other dementia's?
2. What are risk factors for the various types of dementia?

3. What is the prevalence of Parkinson's disease among the elderly?

Cardiovascular diseases

1. What are the determinants of the occurrence and progression of atherosclerotic vessel disease and the development of cardiovascular disease, and what is the role of disturbances in haemostatic function?
2. Is progression of vascular atherosclerotic lesions in asymptomatic elderly patients a prelude to cardiovascular events?
2. What is the prevalence and incidence of aneurysms of the abdominal aorta and what are its determinants?
4. Are risk factors for cardiovascular disease, in particular high blood pressure, associated with cognitive impairment in the elderly and the occurrence of lesions of white brain matter?
5. What is the importance of raised insulin levels in the development of cardiovascular and cerebrovascular disease, and what are its determinants?
6. What are the determinants of deep venous thrombosis in the elderly, and what is the role of genetic or acquired changes in haemostatic function?
7. Is it possible to develop a risk function for vascular dementia that could be used to design subsequent intervention studies?
8. What is the association between social and economic status, social support and the development of cardiovascular disease in the elderly?

Musculoskeletal diseases

Osteoporosis

1. What is the incidence rate ratio and rate difference for vertebral and hip fractures in men and women with low versus high initial bone mineral parameters?
2. What are the determinants of vertebral and proximal femur fractures?
3. What are the determinants of bone mineral density in elderly men and women?
4. Is it possible to construct a risk function for vertebral and proximal femur fractures, which can be used as a guide for intervention?
5. What is the association between bone mineral density and vertebral crush fractures and a history of limb fractures?
6. What are the determinants of the rate of bone mineral loss at spinal and proximal femur sites in elderly men and women?
7. Is the rate of bone mineral loss at one location (vertebrae) associated with that at another (proximal femur)?
8. What is the clinical significance of discrepancies in the outcome of the different bone mineral density assessments?

Osteoarthritis

1. What are the demographic determinants of the occurrence or progression of disability?
2. What proportion of disability is associated with clinical symptoms and physical signs of joint complaints?
3. What is the contribution of radiographic osteoarthritis to disability?
4. What is the independent contribution of the signs and symptoms of the locomotor system to disability?

Ophthalmologic diseases

1. What is the prevalence and incidence of age-related macular degeneration (AMD) in the elderly?
2. What is the prevalence and incidence of glaucoma in the elderly?
3. What percentage of the aged population is visually handicapped or blind, according to the WHO criteria?
4. Are cardiovascular (atherosclerotic vessel disease, hypertension, abnormalities in lipid metabolism and haematological and coagulation disorders) and biochemical abnormalities or a positive family history associated with simple glaucoma, low-tension glaucoma or AMD?
5. Is cumulative lifetime light exposure or decreased iris or fundus pigmentation associated with AMD?

3.1.3 Population

All 3,950 men and 6,325 women aged 55 years and older and living in one district of the city of Rotterdam on January 1, 1988 were eligible to participate in the *Rotterdam Study*. The Ommoord district of Rotterdam consists of a great number of apartment-buildings, as well as one-family individual houses in which the majority of the participants live. Apart from these there are six homes for the elderly in this district, in which 890 females and 224 males reside. People in these homes are supposed to be independent of personal assistance in basic activities of daily living like eating, getting on and of the toilet and walking, but the residents are provided with meals, domestic services and are assisted, when needed, in taking a bath. The inhabitants are generally not bedridden, but nursing facilities are offered if necessary (table 3.1.3).

Table 3.1.3. Demographic data for the Ommoord district of Rotterdam by living accommodation.

	INDEPENDENTLY LIVING				*HOMES FOR THE ELDERLY*				*TOTAL*	
	MEN		WOMEN		MEN		WOMEN			
Age(yrs)	n	%	n	%	n	%	n	%	n	%
55-59	643	17.3	837	15.4	0	0.0	1	0.1	1,481	14.4
60-64	779	20.9	982	18.1	1	0.4	3	0.3	1,765	17.2
65-69	777	20.9	960	17.7	8	3.6	6	0.7	1,751	17.1
70-74	650	17.4	956	17.6	8	3.6	21	2.4	1,635	15.9
75-79	500	13.4	786	14.5	37	16.5	88	9.9	1,411	13.7
80-84	253	6.8	546	10.0	69	30.8	213	23.9	1,081	10.5
85-89	98	2.6	306	5.6	70	31.3	305	34.3	779	7.6
90 +	26	0.7	62	1.1	31	13.8	253	28.4	372	3.6
Total	3,726	100	5,435	100	224	100	890	100	10,275	100

Source: Municipal registry of Rotterdam, January 1, 1988.

The *Rotterdam Study* invited both types of residents to participate. The independently living participants were invited to visit the research centre, which is located in the Health Centre of the district. To circumvent low response in the homes for the elderly, measurements were done in the home itself. The study started in 1989 with a pilot-study of 500 male and female participants randomly chosen from the total population of 10,275 people. After evaluating the results of this pilot-study the main study started in april 1990. A flow sheet of the *Rotterdam Study* is given in figure 3.1.3.

3.1.4 Invitation and interview

People living in the district were eligible if they were at least 55 year of age or would reach the age of 55 in the year they were invited. Names, addresses and dates of birth were provided by the municipal registry. Every month a random sample of approximately 300 people was sent an invitation letter. Apart from a formal invitation to the study, a leaflet with information on the study was enclosed. People were advised to contact the research centre or their general physician when they doubted their eligibility. All fifteen general physicians, practising in the district, gave full cooperation to the study.

One to two weeks after receiving the letter the potential participant was contacted by telephone. One of nine interviewers introduced herself and asked if the person was willing to participate. If so she made an appointment to visit him or her at home.

Figure 3.1.3 Flow sheet *Rotterdam Study*

Most interviews were carried out in the four weeks following the invitation letter. A small minority chose to be interviewed at a later stage; reasons were recent or occurring illness, being away on holiday, etc.

The interview data were directly entered on a portable personal computer, and were sent to the main computer of the department on the same day the interview was carried out in order to be locally processed at the Department of Epidemiology & Biostatistics.

All but a small minority of the questions were of a closed format: only a few restricted answers were possible. At the end of the interview there was a possibility to enter additional information not asked for in the interview but considered to be important by the participant.

The interview consisted of eight chapters (table 3.1.4). Firstly demographic variables were checked and completed. The participants were asked to give written informed consent to obtain when needed information from their general physician or clinical specialist. They were offered to send the results of the study to their general physician. The second chapter of the interview consisted of questions related to difficulties in the activities of daily living.[5-8] A more detailed description of these questions will be presented in paragraph 3.3.1. To identify cardiovascular disease the interview contained a

modified Rose-questionnaire.[9] The questions concerning joint pain and treatment of possible joint complaints are described in paragraph 3.2.1. One chapter of the interview was devoted to ophthalmologic disease. The fifth chapter dealt with the medical history, including detailed information about surgeries and covering most organsystems. Depressive illness was assessed by means of 5 screening questions. Furthermore, there were questions about smoking habits, and health care consumption. An extensive list of questions to determine the social economic status of the participant was also part of the interview. The interview was completed by a set of observations; the interviewer scored the possible presence of cognitive impairment, visual or auditive impairment and depression. Finally, the interviewer assisted the participant to fill in a form with respect to the family history on cardiovascular, neurogeriatric, locomotor and ophthalmic diseases.

At the end of the interview an appointment was made for a visit to the research centre.

Table 3.1.4 Chapters of home interview

Chapter	*Content*	*Chapter*	*Content*
0	Demographic data	5a	Surgery
1	ADL and IADL	6	Depressive illness
2	Cardiovascular disease	7	Health care consumption
3	Joint complaints		Smoking
4	Ophthalmic disease	8	Social Economic Status
5	Medical history	9	Observations

3.1.5 The first visit to the research centre

The first visit to the research centre generally took place within two weeks of the interview and lasted approximately two hours. All participants underwent the same measurements.

The participant was asked to collect all urine between the time he/she went to bed the preceding night and the scheduled visit and bring this together with a self-administered questionnaire on nutritional habits[10] to the research centre.

The examination in the centre started with venous bloodsampling for routine screening. Glucose tolerance was measured by means of a non-fasting two hour glucose tolerance test.[11] Standing body height and body weight were measured with light indoor clothes and no shoes.

Radiological assessments included dorsopalmar X-rays of both hands and wrists, weightbearing anteroposterior X-rays of both hips and knees and 3 lateral X-rays of the vertebral column. A measurement of bonedensity of the lumbar vertebrae and right femoral neck by means of Dual Energy X-ray Absorptiometry (DEXA) completed the radiographic assessments. More detailed information on the X-rays of the hips and knees is given in paragraph 3.2.2.

A resting standard 12-lead electrocardiogram was made. An extensive ophthalmologic examination included measurement of ocular pressure, slit-lamp examination, visual acuity, assessment of visual fields, examination and photography of the retina. A short cognitive screening test (Mini Mental State Examination and Geriatric Mental Schedule) was carried out to allow for restricted referral for more extensive cognitive testing during the second visit to the research centre[12,13].

At the end of the first visit one of ten studyphysicians collected information concerning psychiatric history of the participant and his/her first degree family-members. Histories of transient ischaemic attacks, head trauma and joint complaints were taken. The current usage of drugs was checked. A short neurological examination was included to screen for Parkinson's disease. The carotid arteries as well as the abdominal aorta were checked for bruits; the distal tibiae were checked for pitting edema and ulcus cruris. Minimal waist circumference and maximal hip circumference were measured in tenth of centimetres. Four tests of locomotor disability and a physical examination of the joints completed the first visit. Detailed information about the joint examination and the disability tests is given in the paragraphs 3.3.2. and 3.2.3., respectively.

Participants were shown out by a research-assistant, who assessed the outdoor walking speed and the difficulty by which one flight of steps were taken. More detailed information on these tests is given in paragraph 3.3.2.

3.1.6 Second visit to the research centre

At the second visit to the research centre, two weeks after the first visit, blood pressure was measured with a random-zero sphygmomanometer. The presence of peripheral arterial atherosclerosis was evaluated by measuring the systolic blood pressure level of the posterior tibial artery at both the left and the right side using a 8 Mhz continuous wave probe and a random-zero sphygmomanometer.

Screening for aneurysms of the abdominal aorta was done by means of a 2-D echographic measurement of abdominal aorta dimensions. Carotid ultrasonography of both left and right carotid arteries was performed using a 7.5 Mhz linear array transducer to evaluate carotid artery atherosclerosis.[14,15]

An extensive cognitive screening test for dementia (Camdex) was carried out by a studyphysician if the screening at the first visit indicated possible cognitive impairment.[16,17] The Hamilton depression rating scale was used to assess depression.[18]

The questionnaire on nutritional habits was checked by a nutritional research-assistant.[10] She also asked some supplementary questions.

Finally, the participant visited a studyphysician; all available study results were presented to the participant. Whenever the studyresults were indicative of disease which was not diagnosed before, the participant was advised to contact his/her general physician. Possible questions of the participant were answered and he/she was informed about the follow-up study, which started in September 1993. The second visit lasted five quarters of an hour for those who did not receive the extensive cognitive screening and 2 hours for those who did.

Within four weeks of the second visit to the research centre, the participants received a letter to thank them for their cooperation and to inform them on the abnormal results, which were discussed at the end of the second visit. The abnormal results, which were also sent to the general physician, concerned glucose tolerance, cholesterol, haemoglobin, creatinine clearance, ECG-abnormalities, aneurysms of the abdominal aorta, never reported transient ischemic attacks, peripheral artery disease as assessed by the blood pressure on the tibial arteries, and cognitive impairment. In case of cognitive impairment the general physician gave consent to refer the participant to a neurologist at the Academic Hospital Dijkzigt of the Erasmus University. In case of aneurysm of the abdominal aorta automatic referral to a vascular surgeon of the same hospital was realized within days.

A detailed list of all assessments carried out during the two visits at the research centre is given in Appendix C.

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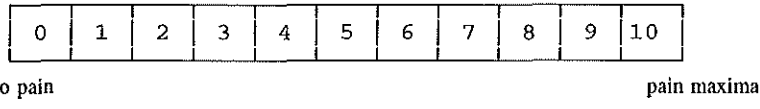
3.2 ASCERTAINMENT OF LOCOMOTOR IMPAIRMENTS

3.2.1 Symptoms and signs of hip and knee

During the home interview symptoms of the hips and knees were assessed for the first time. This chapter of the interview started with the question: "Did you have any pain or other complaints in or around your joints in the past month?" If the answer was affirmative, questions about site, duration and treatment followed. Subsequently the participants were asked whether they had had pain in their joints during the past 5 years. Again subsidiary questions followed when the answer was yes. Finally there was a question concerning pain ever. Appendix D gives the complete questionnaire.

At the first visit to the centre the studyphysician asked the participant about feelings of muscle-weakness in the legs. Date and frequency of hydrops of the knees in the past five years and type and frequency of trauma of the knees were registered. The questions about pain in or around the joints in the past month were repeated. If the painful joints included the hip or knee, type and frequency of pain were assessed. The participant was asked whether he/she suffered from pain in the hips or knees when standing up after a prolonged period of rest (starting pain), pain at rest, pain while walking a long distance or climbing stairs (pain on exercise), and whether he/she woke up at night because of joint pain (night pain). For each type of pain the frequency was assessed in terms of: less then once a month, more then once a month but not weekly, once a week, more then once a week but not daily, daily or always. At the end the participant was asked to indicate the level of pain he/she generally experienced on a horizontal 11-point Box Scale (figure 3.2.1).[1]

Figure 3.2.1. 11-point Box Scale for joint pain during the past month



In case of knee complaints the frequency of 'locking' and 'giving way' feelings in the knee was assessed. If there had been surgery in or around the hips or knees, more detailed information about the type of operation was collected. Appendix D contains the complete scoring-form used to assess joint pain.

3.2.2 Radiological osteoarthritis of the hip and knee

Weightbearing anteroposterior pelvic radiographs with both feet in 10° endorotation were obtained at 70 KV, a focus of 1.8, and a focus-film distance of 120 cm, applying a Fuji High Resolution G 35 x 43 cm film. Correspondingly weightbearing knee films were made with the patellae in central position. For practical reasons the participant did not undress. Only a minority of the pelvic radiographs could not be evaluated due to underexposure (abdominal obesity).

Radiographic osteoarthritis (ROA) was assessed by means of the Kellgren-grading system in 5 grades (0 - 4), (table 3.2.2.1).[2] Grade 1 denotes doubtful osteoarthritis and grades 2 to 4 are definite osteoarthritis with increasing severity. The scoring system is roughly the same for all joints, but small differences exist. In the hips the mere existence of osteophytes without joint space narrowing was considered doubtful ROA (grade 1). Hip ROA grade 2 is defined as the presence of definite osteophytes and definite joint space narrowing. The knees were classified grade two if definite osteophytes were present and there was possible joint space narrowing.

Table 3.2.2.1. Kellgren radiologic grading system[2]

Grade		*Description*
HIP		
0	No osteoarthritis	
1	Doubtful	possible narrowing of joint space medially and possible osteophytes around femoral head; or osteophytes alone
2	Mild	definite narrowing of joint space inferiorly, definite osteophytes and slight sclerosis
3	Moderate	marked narrowing of joint space, definite osteophytes, some sclerosis and cyst formation and deformity of femoral head and acetabulum
4	Severe	gross loss of joint space with sclerosis and cysts, marked deformity of femoral head and acetabulum and large osteophytes
KNEE		
0	No osteoarthritis	
1	Doubtful	doubtful narrowing of joint space or possible osteophytic lipping
2	Mild	definite osteophytes and possible narrowing of joint space
3	Moderate	multiple osteophytes, definite narrowing of joint space and some sclerosis and possible deformity of bone ends
4	Severe	large osteophytes, marked narrowing of joint space, severe sclerosis and definite deformity of bone ends

All features are scored left and right separately

Apart from the overall Kellgren-grades, separate scores were given to osteophytes, joint space narrowing, sclerosis, cysts and chondrocalcinosis. The pelvis was checked for abnormalities, obliquity and scoliosis of the lumbar vertebral column (table 3.2.2.2).

Table 3.2.2.2. Radiographic assessments

Feature	*Score*	*Feature*		*Score*
HIP		**KNEE**		
Kellgren-score	grade 0 - 4	Kellgren-score		grade 0 - 4
Osteophytes	no/yes	Osteophytes:	femur: medial/lateral	grade 0 - 3
			tibia: medial/lateral	grade 0 - 3
Joint space narrowing	grade 0 - 3	Joint space	medial/lateral	mm
Sclerosis	no/yes	Sclerosis	tibia medial/lateral	no/yes
Cysts: acetabulum/femur	no/yes	Cysts	tibia medial/lateral	no/yes
Chondrocalcinosis	grade 0 - 3	Chondrocalcinosis	medial/lateral	grade 0 - 3
Fractures	no/yes	Fractures		no/yes
Hip arthroplasty	no/yes	Knee arthroplasty	no/total/medial/lateral	
Hip fusion	no/yes	Knee fusion		no/yes
Porosis	no/yes	Porosis		no/yes
PELVIS AND LUMBAL VERTEBRAE				
Sacroiliitis	grade 0 - 3			
M Paget	no/yes			
Dysplasia	no/yes			
Scoliosis right	no/yes			
left	no/yes			
Pelvic obliquity	no/right/left higher			

All features are scored left and right separately

The radiographs were scored by two independent observers (Odding and Valkenburg), who were blinded to all data of the participant. There was no indication of sex or age on the X-rays. After each set of 150 radiographs the scores of the two readers were evaluated. Whenever the Kellgren-score differed more than 1, or was 0 or 1 for one reader and 2 or more for the other, the two readers met to read the X-ray together to reach consensus. The final score for the film, was either the consensus-score or the highest score of the two readers. A subject was considered to have ROA of the hips if the Kellgren-score of one or both joints was larger than or equal to 2. Likewise ROA of the knees was defined as Kellgren-score $\geq$ 2 of one or both joints. Severe ROA was defined as Kellgren-score $\geq$ 3.

3.2.3 Physical examination of the lower limbs

At the research centre the joints were examined by one of the studyphysicians (table 3.2.3). In supine position internal and external rotation of the hips, flexion of the hips and knees, and the ligamental apparatus of the knees were tested. Restriction in range of motion (ROM) was expressed in five grades, in which 0 means no restriction, 1 = doubtful, 2 = mild restriction (less than 20% of the normal range of motion), 3 = moderate restriction (20-60% restriction), 4 = severe restriction (more than 60% restriction). The reason for this is twofold. Firstly accurate measurement of range of motion by means of a goniometer is subject to a considerable inter-observer error and secondly in large scale epidemiological studies of essentially normal people a limited amount of time is available for each of the assessments and measurements. From earlier studies we knew that by grading ROM in rather broad categories inter-observer variation could be minimized and reproducibility was enhanced. For practical purposes ten physicians participated off and on in the *Rotterdam Study*, and they could not be kept completely standardized over the three years time period the survey lasted. However, much effort was put in instruction and training the physicians who for purposes of physical examination were all initially coached and standardized by an experienced orthopaedic surgeon. If the maximal range of motion caused pain, this was also noted.

The cruciate and collateral ligaments of the knees were tested for instability. In case of a positive anterior drawer test, special attention was given to left and right comparison. The same procedure was followed with a positive lateral or medial stress test.

While sitting on the couch with the legs over the edge the participant was asked to put the lateral ankle of one leg on top of the knee of the opposite leg, which rested on the couch. The standard for a normal test was the healthy adult, i.e. the thigh of the upper leg in a horizontal position. Again restrictions in motion were scored as percentages abnormality. With the participant standing upright, barefoot and without trousers or dress, valgus- and varus-deformity was assessed. The physicians were instructed to draw an imaginary line down from midway the groin through the centre of the patella towards the floor; if the medial malleolus was lateral of this line the participant was classified as having a valgus-deformity (knock-knee); if the lateral malleolus was medial of the line the knee was considered to be in a varus-position (bow-leg). Pelvic obliquity, regardless of its cause, was tested by placing the thumps on the spinae iliacae anteriores superiores and deciding whether the line between the thumps was in a horizontal plane. This is by no means considered to prove a difference in length of the legs, but a rather crude way to assess possible problems with stature. As a proxy for muscle strength and balance the participant was asked to squat and rise again. This is also a test for hip and knee function. Appendix D presents the complete scoring form.

Table 3.2.3. Physical examination

Measurements	*Score*
HIP	
Endo- and Exorotation	normal, doubtful, <20%, 20-60%, >60% restriction
Flexion	pain on maximal range of motion
Extension	normal, restricted
Foot-on-knee-test	normal (= flexed upper leg in horizontal plane), doubtful, <20%, 20-60%, >60% restriction, not possible. pain on maximal range of motion
KNEE	
Flexion	normal, doubtful, <20%, 20-60%, >60% restriction pain on maximal range of motion
Extension	normal, restricted
Collateral/Cruciate ligaments	normal, instable left = right, left > right, right > left
Valgus/Varus-deformity	no, valgus, varus
LOWER LIMB	
Pelvic obliquity	no, right higher, left higher
Muscle strength	normal, diminished
Other	hydrops knee, posterior instability, paralysis, amputation, Heberden's nodules, rheumatoid arthritis

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3.3 ASCERTAINMENT OF LOCOMOTOR DISABILITY

3.3.1 Questionnaire

During the home interview disability was assessed by means of the Disability Index of the Stanford Health Assessment Questionnaire (HAQ).[1,2] The properties of this questionnaire are described extensively in paragraph 2.2.4. The HAQ covers the full range of disabilities in spine, upper and lower limb functions. It is composed of twentyfour questions in eight categories; nine questions are concerned with activities of the upper limbs, six with lower limb activities and nine with complex activities (table 3.3.1).[3-7]

Table 3.3.1. Stanford Health Assessment Questionnaire (HAQ) [1,2].

Are you able to:	
Dressing and grooming	*Eating*
get your clothes out of closet and drawers?	cut your meat?
dress yourself including handling of closures?	lift a full cup to your mouth?(*)
shampoo your hair?(*)	open a new milk carton?(*)
Rising	*Walking*
stand up from an armless straight chair?(#)	walk outdoors on flat ground?(#)
get in and out of bed?(#)	climb up stairs?(#)
Reach	*Grip*
comb your hair?(*)	open car doors?(*)
reach and get down 1 kg bag of sugar which	use pen or pencil?(*)
is just above your head?(*)	open jars which have been previously
bend down and pick up clothing from floor?(#)	opened?(*)
Hygiene	*Activity*
wash and dry your entire body?	run errands and shop?
use the bathtub or take a shower?	get in and out of a car? (#)
turn taps on and off? (*)	use public transport? (Dutch HAQ)
get on and off the toilet?	do chores like vacuuming/gardening?

(#) Questions used for the Locomotor Disability Index (LDI)
(*) Questions used for the Upper Limb Disability Index (ULDI)

Scores:

Question:	0 = without difficulty 1 = with little difficulty 2 = with much difficulty 3 = unable to do without help
Component:	highest score for any question within a component
Disability Index:	mean of component scores
Locomotor Disability Index:	mean of question scores on lower limb functions (#)
Upper Limb Disability Index:	mean of question scores on upper limb functions (*)

Appendix D for definitions of score 0 - 3

All questions start with: "Are you able to", followed by the specific activity. Answers are restricted to four alternatives: with no difficulty, with little difficulty, with much difficulty or not able to do without personal assistance. The interviewers were instructed not to interpret activities, but to register the answers as given by the participants. If, for example, the participant said to have no difficulty in walking, but the interviewer did notice some difficulty, the answer of the participant was entered. At the end of the interview the interviewer could indicate her doubts with respect to the answers. All interviewers were standardized on a regular basis using written scoring instructions. The scoring instructions for lower limb activities of the HAQ are presented in Appendix D.

The score on a question ranges from zero to three and the score for a component is defined as the highest score on a question within that component. The Disability Index (DI) was calculated as proposed by the authors of the HAQ; it is the mean of the eight component scores. The Locomotor Disability Index (LDI) was defined by us as the mean of the scores on the six questions related to activities of the lower limbs. Likewise an Upper Limb Disability Index (ULDI) was calculated as the mean of the nine questions about upper limb function. Moderate disability was defined as a score larger than zero on a single question or a component or a score larger than 0.50 on the indices. The rationale for this cutoff is that it indicates at least some difficulty in the particular activity or component and in four out of the eight components which constitute the DI. Moderate disability is present whenever there is at least some difficulty with three out of six functions in the LDI and five out of nine functions in the ULDI. Severe disability was defined as a score larger than 1 on the questions and components and larger than 1.00 on the indices.

3.3.2 Tests of Locomotor Disability

At the research centre disability was assessed by the studyphysician who judged the amount of difficulty in four lower limb activities. The participant was asked to sit down on and stand up from a high armless chair (sitting hight: 45 cm). While standing the physician put down a paper towel on the floor and the participant was asked to pick it up. Next the participant was told to sit down on a low chair with arm-rests (sitting hight: 37 cm, arm rests at 58 cm), and asked to touch with the left hand the right toes and vice versa and finally to stand up from the chair without using the arm-rests. The scores on these activities are identical to the HAQ-scores in the interview: ranging from 0 to 3. All participating physicians were extensively instructed on assessment and scoring methods; standardization procedures were carried out regularly.

At the end of the first visit to the research centre the participant was shown out by one of the researchassistants. They took a flight of stairs of which the steps were 19 cm high.

First the participant was asked to step on as high a step as possible, using the handrail when needed. Next the researchassistant walked up and down the 8 steps with the participant and assessed the amount of difficulty this caused. Again the same scoring-system (from 0 for no difficulty to 3 for unable to do) was used. Finally the 30-metres-comfortable-walking-speed was assessed outdoors. The research-assistant walked with the participant and assessed with a stopwatch in tenth of seconds the time needed to walk this distance. When possible the participant was asked to walk the same distance again, but now as fast as he/she could. All possible walking-aids (including the arm of the research-assistant) were registered. Appendix D presents the scoring forms of the disability-tests.

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3.4 PARTICIPATION IN THE *ROTTERDAM STUDY*

3.4.1. Response rates

In total 3,950 men and 6,325 women were invited to participate during the period between September 1989 and July 1993. Of these, 3,726 men and 5,435 women lived independently and 224 men and 890 women resided in the six homes for the elderly in the study-district. Of the eligible persons 807 men (21.7%) and 1,268 women (23.3%) living independently and 38 men (17.0%) and 179 women (20.1%) living in homes for the elderly refused to participate. Consequently of the independently living persons 2,919 men (78.4%) and 4,167 women (76.7%) took part in the study. Of the residents of the homes for the elderly 186 men (83.0%) and 711 women (79.9%) participated in the first phase of the study (table 3.4.1).

Table 3.4.1. Response (*) at interview by living-accommodation

	INDEPENDENTLY LIVING				*LIVING IN HOMES FOR THE ELDERLY*			
	MEN		WOMEN		MEN		WOMEN	
Age(yrs)	n	%	n	%	n	%	n	%
55-59	513	79.8	717	85.7	-	-	1	100
60-64	648	83.2	835	85.0	1	100	3	100
65-69	647	83.3	759	79.0	7	87.5	6	100
70-74	515	79.2	751	78.6	6	75.0	15	71.4
75-79	360	72.0	572	72.8	28	75.7	72	81.8
80-84	172	68.0	341	62.5	57	82.6	177	83.1
85-90	51	52.0	159	52.0	61	87.1	244	80.0
90 +	13	50.0	33	53.2	26	83.9	193	76.3
Total	2,919	78.4	4,167	76.7	186	83.0	711	79.9

(*): with percentage (%) of eligible people

Response at the interview was better for women in the youngest age-groups and for men between the ages of 60 and 70 years. A possible explanation for the lower response of the youngest men is that they are more often employed outside the house and could not find time to be interviewed. Response decreased substantially above the age of 84 years. The main reason for not responding to our invitation in this age-group was serious illness or

'having had too many medical examinations in the recent past'.

The response to the interview in the homes for the elderly was remarkably good. This could have been the result of the better social contact between the residents of these homes, as opposed to the contact between the independently living people. This was substantiated by the better response of the independently living people residing in an apartment-building compared to that of those living in one-family houses. This emphasizes the effect of mouth to mouth information. Another important determinant of the high response-rates in the homes for the elderly was the active policy of the managing staff and auxiliary personnel to encourage the inhabitants to take part in the study.

Of the interviewed participants 2,702 men (92.6%) and 3,792 women (91.0%) visited the research centre and 151 men (81.2%) and 484 women (68.1%) were examined in their home for the elderly (table 3.4.2).

Table 3.4.2. Response (*) at research-centre by living accommodation

	INDEPENDENTLY LIVING				*LIVING IN HOMES FOR THE ELDERLY*			
	MEN		WOMEN		MEN		WOMEN	
Age(yrs)	n	%	n	%	n	%	n	%
55-59	488	95.1	684	95.4	-	-	1	100
60-64	622	96.0	799	95.7	1	100	2	66.7
65-69	611	94.4	716	94.3	7	100	5	83.3
70-74	475	92.2	682	90.8	5	83.3	15	100
75-79	327	90.8	507	88.6	21	75.0	51	70.8
80-84	135	78.5	282	82.7	52	91.2	129	72.9
85-90	36	70.6	105	66.0	46	75.4	169	69.3
90 +	8	61.5	17	51.5	19	73.1	112	58.0
Total	2,702	92.6	3,792	91.0	151	81.2	484	68.1

(*): with percentage (%) of interviewed participants

As was expected the response to the invitation to visit the research centre was good, once the person agreed to take part in the interview. Again non-response was mainly due to serious illness.

3.4.2. Strategies to diminish non-response

As in all epidemiologic population surveys we realized that a high response-rate would be important, in particular for the prevalence phase of the study. Although the design of the *Rotterdam Study* primarily was based on research-questions related to incidence and risk factors of disease and disability and hence was meant as a prospective follow-up study, reliable prevalence-data of the cross-sectional first phase of the study were considered to be indispensable as there were no valid estimates on the prevalence of, for instance, Alzheimer's disease or disability in the Dutch general population of 55 years and over. In order to avoid unnecessary non-response, several strategies were followed.

Training

First of all the interviewers were trained and standardized on a regular basis. Methods to address potential participants were introduced to them by experienced researchers. They learned to cope with negative responses and to anticipate on common questions.

Information

The 15 general physicians of the district were already informed at the development phase of the study. They all gave full cooperation to the study, and encouraged their patients to participate in the study. Meetings between the physicians and the management team of the *Rotterdam Study* were organized on a regular basis.

Some of the apartment-buildings in the study district were specially designed for elderly people. These houses offered the possibility to organize introductory meetings in the first days after the formal letters of invitation for the study came in. During these meetings the study coordinator informed the potential participants of the study. For these occasions a special slide-show was developed.

As was stated before all inhabitants of the homes for the elderly were visited at their homes, not only for the interview, but for the medical examinations as well. The study was extensively discussed with the managing directors and nursing staff who cooperated fully. Furthermore at each floor of the home, which occupied between 20 to 30 inhabitants, an introductory meeting was assembled by the study coordinator.

Service

Our interviewers offered people the possibility to be interviewed in the evening. This would enable persons still employed outside the house to take part in the study without having to take a morning or afternoon off.

Furthermore the elderly could use a district-bus to travel free of charge whenever they were not able to come to the research centre under their own power.

Potential participants who refused to participate when addressed the first time, were again contacted after one year, in case they might have changed their mind.

Publicity

At the beginning of the survey the local television and radio broadcasting companies payed attention to the study. The research centre was formally opened by the Dutch Queen-mother, Princes Juliana. Whenever appropriate, publicity was actively sought. Articles about the study were published in the local newspapers as well as in the information leaflet of the districts Health Centre.

Results of the strategies to diminish non-response

The effect of the information meetings was large. Among the independently living people in the apartment-buildings for the elderly the response was higher than among the people, in the corresponding age-groups, living elsewhere. This effect is undoubtedly also present in the homes for the elderly, although their inhabitants were, as was stated in paragraph 3.4.1 even more encouraged to participate than the independently living people.

The services of the district-bus were put to a good use. This enabled particularly the disabled and eldest participants to visit the centre.

The response to the reminder one year later was 25%.

Nevertheless 22% of the eligible people refused to participate. About 5% of the total eligible population refused without reason ("not interested"), but the majority of refusals were because of illness.

CHAPTER 4

DISABILITY

4.1 PREVALENCE ESTIMATES OF DISABILITY

ABSTRACT

The *Rotterdam Study* is a prospective follow-up study on the occurrence and risk factors of chronic disease and disability in a Dutch general population of 55 years and over. The prevalence of disability in 1819 men and 2817 women living independently and 82 male and 315 female residents of homes for the elderly was assessed by the Disability Index (DI) of the Health Assessment Questionnaire (HAQ). For the independently living participants overall disability was 21.9% for men and 36.0% for women; the prevalence of locomotor disability (LLD) was 21.9% for men and 34.8% for women; prevalence of upper limb disability (ULD) was 4.1% in men and 10.6% in women. The corresponding percentages for people living in homes for the elderly are DI: 84.0% in men, 96.5% in women; LLD: 81.5% in men and 91.1% in women; ULD: 45.7% in men and 75.9% in women. Locomotor disability was associated with female sex, increasing age, living in a nursing home, low education and low income.

INTRODUCTION

Since in the developed countries the elderly form an increasing proportion of the population, the ever-swelling numbers of people suffering from chronic disease and concomitant disability are a major problem to the health service system and a financial constraint to the society [1-3]. To enhance the knowledge on possible intervention strategies the *Rotterdam Study* was designed to investigate occurrence and risk factors of chronic disease and disability in the elderly[4].

The *Rotterdam Study* offers the possibility to investigate locomotor disability, as defined by the International Classification of Impairments, Disabilities, and Handicaps (ICIDH),[5] in the general population aged 55 years and over. According to the ICIDH locomotor disability is any restriction or lack of ability to perform an activity, in this case related to lower limb function, in the manner or within the range considered normal for a human being. The ICIDH can be considered the theoretical framework for the development of instruments to measure disability. The most widely used instrument to assess locomotor disability (in a general population) is the Stanford Health Assessment Questionnaire (HAQ)[6-9].

In the study presented here the HAQ was inventoried by interview in over 5,000 people seen in the *Rotterdam Study*. Estimates of the prevalence of disability as measured by the eight components of the HAQ are presented, as well as the prevalences of overall

disability in upper and in lower limb function. Differences in prevalence according to living accommodation (living independently or in a home for the elderly), marital status, living situation (alone or not alone), educational level and net income were assessed.

POPULATION AND METHODS

Population

The *Rotterdam Study* is a prospective follow-up study of the incidence and risk factors of chronic neurological, cardiovascular, ophthalmologic and locomotor disease, in persons aged 55 years and over in the general population. The source population of the study is defined by all residents aged 55 years and over of the Ommoord district of Rotterdam on January 1, 1988. Eligible subjects lived either independently or in one of the six homes for the elderly.[4] The study population comprised 10,275 people who were invited to participate in the study between April 1990 and July 1993.

The present study is concerned with those participants who were examined between April 1990 and July 1992. Of the people living independently 2,247 men and 3,433 women were invited and 1,830 men (81.4%) and 2,834 women (82.6%) took part in the study. Because of incomplete interview-data, 11 men and 17 women had to be excluded from the analysis. Complete data were therefore available of 1,819 men (81.0%) and 2,817 women (82.1%).

Of the six homes for the elderly three were part of the present study. Of the 151 male and 648 female residents, 107 men (70.9%) and 421 women (65.0%) participated. Of this subgroup, data were not complete for 25 men and 106 women; the analysis was therefore restricted to 82 male (54.3%) and 315 female (48.6%) residents.

Methods

The *Rotterdam Study* investigates various aspects of disability. In the present analysis the prevalence of locomotor disability is estimated. Locomotor disability is defined according to the International Classification of Impairments, Disabilities, and Handicaps (ICIDH) and composed of the relevant items from the ambulation subcategory, i.e. walking, climbing stairs, getting in and out of bed and a car, bending, and rising from a chair.[5]

To assess disability the Stanford Health Assessment Questionnaire (HAQ) was used. The HAQ was part of an one-hour home interview carried out by one of nine intensively trained interview-assistants. The HAQ measures disability in eight components (dressing and grooming, rising, reach, hygiene, eating, walking, grip and activity), each of which consists of two to four questions starting with: "Are you able to ...". Each question is answered by one of four possible answers with score 0 = without difficulty, 1 = with

difficulty, 2 = with much difficulty, and 3 = unable to do. Special attention was paid to standardization of the scoring-system of the HAQ. The interviewers were instructed to score the answers given by the participant and not their own assessment of the participants ability to carry out the various tasks. The highest score on any question within a component constitutes the score for that component.[6-9]

The Disability Index (DI) was calculated by adding the component-scores and dividing the sum by the total number of components answered. Apart from the overall disability index, the prevalence of disability in the various components and separate questions was assessed. The Locomotor Disability Index (LDI) was constructed from the six questions most related to lower limb function. Likewise the Upper Limb Disability Index (ULDI) consisted of the nine questions about upper limb function.

The cutoff for moderate disability was 1 for the individual questions and 0.50 for the DI, LDI and ULDI. The rationale of these cutoff-points is as follows: a score of at least 1 on one question indicates at least some difficulty in that activity; a score of at least 1 on a component indicates at least some difficulty in at least one of the activities of the component. A score of 0.50 on the DI indicates at least some difficulties in four out of eight components. A score of 0.50 on the LDI refers to at least some difficulties in three out of six functions, for the ULDI there are difficulties in at least five out of nine functions. The cutoff for severe disability was 2 for the individual questions, and 1.00 for the DI, LDI and ULDI.

Data analysis

We first estimated the prevalence of disability in the eight components of the HAQ and of the separate questions relating to upper and lower limb function. Next the overall disability index (DI), the locomotor disability index (LDI) and the upper limb disability index (ULDI) were assessed. As the overall disability index was largely determined by the LDI and the prevalence of upper limb disability was low we restricted our further analyses to the lower limb functions.

For the various measures of disability the distribution according to several demographic characteristics was studied. Education was assessed at seven levels and subsequently categorized in three levels (i.e. primary education (10 years of schooling or less), secondary education (11 - 15 years of schooling) and college/university education (16 years of schooling or more). Income was initially categorized in thirteen levels of net annual income and subsequently analyzed according to an income below or above the median. Income could not be accurately assessed in the homes for the elderly, because the residents did not always know their income, as it is based on a combination of private income and social security. Marital status was classified in four groups: married, widowed, divorced or unmarried (i.e never married). Living situation was assessed in

five categories and subsequently reduced to two groups: living alone or not alone.

The data were analyzed for men and women separately. Prevalence was estimated in ten-years age categories. Separate analyses were done for independently living people and those living in homes for the elderly.

To assess the significance of the differences in disability between subgroups of the population age-adjusted Mantel Haenszel χ^2 statistics were calculated. Although demographic variables can not be considered to be risk factors of disability in the literally sense of the word for reasons of presentation we calculated age-adjusted prevalence odds ratios for locomotor disability of the various demographic variables using a multiple logistic regression model.

RESULTS

Demographic data

Some baseline characteristics of the participants of the *Rotterdam Study* are given in table 4.1.1. Of all participants 62.2% were female. The mean age for men was lower than for women (69.5 and 71.4 years respectively). Relatively more women lived in homes for the elderly (10.1% versus 4.3% of the male participants) and of the participants living in homes for the elderly 79.3% were women. More detailed demographic data are presented in table 4.1.2. Of the independently living participants most men (83.8%) shared their house with someone (i.e. partner or child). Significantly more women lived alone (43.4%). Most men were married (78.5%), but only 43.3% of the women. Of all male participants 59.4% had at least secondary school as did 39.8% of the females. The median net annual income was higher for men than for women.

Table 4.1.1. Some baseline characteristics of the participants of the *Rotterdam Study*

	Men		Women	
Number	1901	(37.8%)	3132	(62.2%)
Age				
range	55.0 - 94.6 yr		55.0 - 99.2 yr	
mean age	69.5 (± 0.2) yr		71.4 (± 0.2) yr	
Living accommodation				
independent	1819	(95.7%)	2817	(89.9%)
homes for the elderly	82	(4.3%)	315	(10.1%)

Table 4.1.2. Demographic data of the participants of the *Rotterdam Study*

	INDEPENDENTLY LIVING		*LIVING IN HOMES FOR THE ELDERLY*	
	Men	**Women**	**Men**	**Women**
Number	1819 (39.2%)	2817 (60.8%)	82 (20.7%)	315 (79.3%)
Age				
range	55.0 - 94.3 yr	55.0 - 95.6 yr	65.7 - 94.6 yr	60.0 - 99.2 yr
mean age	68.9 (± 0.2) yr	69.7 (± 0.2) yr	83.2(± 0.7) yr	86.3 0.3) yr
Marital status				
married	1466 (80.6%)	1341 (47.6%)	26 (31.7%)	19 (6.0%)
widowed	202 (11.1%)	1018 (36.1%)	43 (52.4%)	236 (74.9%)
divorced	89 (4.9%)	205 (7.3%)	7 (8.5%)	13 (4.1%)
unmarried	62 (3.4%)	253 (9.0%)	6 (7.3%)	47 (14.9%)
Living situation				
alone	236 (16.2%)	1215 (43.4%)	n.a.	n.a.
not alone	1571 (83.8%)	1586 (56.6%)	n.a.	n.a.
missing	12	16	n.a.	n.a.
Educational level				
primary	700 (39.9%)	1586 (58.5%)	39 (60.0%)	211 (77.9%)
secondary	877 (49.9%)	1002 (36.9%)	20 (30.8%)	49 (18.1%)
college/university	179 (10.2%)	125 (4.6%)	6 (9.2%)	11 (4.0%)
missing	63	104	17	44
Income (*)				
median	16,092.44	12,620.84	n.a.	n.a.

(*) net annual income in US $
n.a. = not applicable (see text)

Independently living people

The prevalence of moderate and severe disability for the eight components of the HAQ in independently living people is given in tables 4.1.3.a for men and 4.1.3.b. for women. For the different components total moderate disability varied from 7.5% to 37.7% in men and from 16.6% to 48.8% in women. Severe disability occurred in 3.2% to 20.6% in men and in 7.1% to 21.7% in women. The most affected components involved the lower limb functions (walking and (outdoor) activities): they were two to five times as often affected as upper limb functions (grip and eating). In both men and women moderate disability rose steeply with age in all components, and except for eating reached figures of well over 50% in women 85 years and older and over 45% in men of the corresponding age.

Table 4.1.3.a. Prevalence(%) of moderate and severe disability(*) in the components and the disability indices of the HAQ in *independently living* men by age.

Age group (years)	55-64		65-74		75-84		85 +		Total	
Number	635		756		385		43		1819	
	% m	% s	% m	% s	% m	% s	% m	% s	% m (95% CI)	% s (95% CI)
Components										
Grip	2.5	0.6	7.3	2.8	11.7	5.7	46.5	27.9	7.5 (6.3- 8.7)	3.2 (2.4- 4.0)
Eating	3.6	1.7	7.3	3.7	14.8	7.0	32.6	16.3	8.2 (6.9- 9.5)	4.0 (3.1- 4.9)
Hygiene	3.1	1.1	8.7	3.0	14.5	7.8	55.8	30.2	9.1 (8.4- 9.8)	4.0 (3.1- 4.9)
Dressing	6.5	2.0	12.3	4.8	15.3	6.5	46.5	23.3	11.7 (10.2- 13.2)	4.6 (3.6- 5.6)
Reach	14.6	5.4	17.3	6.6	27.8	11.7	55.8	41.9	19.5 (17.7- 21.3)	8.1 (6.8- 9.4)
Rising	14.0	2.0	25.8	4.2	38.7	8.8	62.8	27.9	25.3 (23.3- 27.3)	5.0 (4.0- 6.0)
Walking	14.8	3.5	30.6	8.2	48.3	17.1	86.0	58.1	30.2 (28.1- 32.3)	9.6 (8.2- 11.0)
Activities	25.7	15.6	36.0	18.0	55.3	28.3	86.0	69.8	37.7 (35.5- 39.9)	20.6 (18.7- 22.5)
Indices										
DI	11.2	3.8	20.0	7.3	36.9	15.3	79.1	55.8	21.9 (20.0- 23.8)	8.9 (7.6- 10.2)
LDI	10.1	3.9	21.0	7.1	37.1	17.9	74.4	58.1	21.9 (20.0- 23.8)	9.5 (8.2- 10.8)
ULDI	1.3	0.5	4.0	2.0	5.7	2.9	32.6	18.6	4.1 (3.2- 5.0)	2.0 (1.4- 2.6)

DI = Disability Index
LDI = Locomotor Disability Index
ULDI = Upper Limb Disability Index

(*) m = moderate disability: score component: ≥ 1; index: ≥ 0.50
s = severe disability: score component: ≥ 2; index: ≥ 1.00

Table 4.1.3.b. Prevalence(%) of moderate and severe disability(*) in the components and the disability indices of the HAQ in *independently living* **women** by age.

Age group (years)	55-64		65-74		75-84		85 +		Total	
Number	947		1083		665		122		2817	
	% m	% s	% m	% s	% m	% s	% m	% s	% m (95% CI)	% s (95% CI)
Components										
Grip	8.8	2.6	13.6	6.0	26.2	14.7	53.3	33.6	16.6 (15.2- 18.0)	8.1 (7.1- 9.1)
Eating	12.6	4.1	16.7	7.6	22.4	9.8	38.5	12.3	17.6 (16.2- 19.0)	7.1 (6.2- 8.0)
Hygiene	9.6	2.9	17.0	6.6	28.9	10.8	54.1	32.8	18.9 (17.5- 20.3)	7.5 (6.5- 8.5)
Dressing	11.9	3.0	21.4	8.6	34.7	17.7	64.8	43.4	23.3 (21.7- 24.9)	10.4 (9.3- 11.5)
Reach	22.0	7.1	31.2	11.7	48.3	22.1	68.0	39.3	33.7 (32.0- 35.4)	13.8 (12.5- 15.1)
Rising	22.7	2.5	36.7	6.7	53.2	13.4	72.1	28.7	37.4 (35.6- 39.2)	7.8 (6.8- 8.8)
Walking	29.4	5.8	47.4	14.1	66.3	29.5	88.5	57.4	47.6 (45.8- 49.4)	16.8 (15.4- 18.2)
Activities	30.4	8.3	46.1	18.1	71.1	37.4	93.4	71.3	48.8 (47.0- 50.6)	21.7 (20.2- 23.2)
Indices										
DI	17.7	6.0	33.4	14.6	56.8	32.0	86.9	58.2	36.0 (34.2- 37.8)	17.7 (16.3- 19.1)
LDI	17.3	6.5	33.4	15.4	53.7	31.0	79.5	57.4	34.8 (33.0- 36.6)	17.9 (16.5- 19.3)
UlDI	3.9	1.9	8.8	3.4	17.4	6.9	42.6	21.3	10.6 (9.5- 11.7)	4.5 (3.7- 5.3)

DI = Disability Index
LDI = Locomotor Disability Index
ULDI = Upper Limb Disability Index

(*) m = moderate disability: score component: ≥ 1; index: ≥ 0.50
s = severe disability: score component: ≥ 2; index: ≥ 1.00

The prevalence of disability as expressed by the DI, derived from the 8 components of the HAQ, is also presented in table 4.1.3 together with the Locomotor Disability Index (LDI) and the Upper Limb Disability Index (ULDI). Although the DI was developed to describe 'overall' disability as computed from difficulties in the back, the lower and the upper limb functions in about equal amount, disability in the elderly general population is almost completely explained by locomotor disability. The prevalence of upper limb disability as expressed by the ULDI is three to five times lower than the LDI.

Locomotor disability was associated with below median annual income in both men and women ($p = 0.0008$ and $p = 0.0312$ respectively). Men with only primary education were significantly more disabled than men with secondary education ($p = 0.0014$). Women who were widowed were almost significantly more disabled than married women ($p = 0.0532$). Living alone was not associated with disability (men: $p = 0.7455$, women: $p = 0.2413$).

The age-adjusted odds ratios for LLD of demographic variables, presented in table 4.1.4, illustrate the differences in the prevalence of LLD in another way. In men and women the odds for disability rose with age and decreased with increasing net annual income. Men with only primary education were significantly more often disabled than men with at least secondary education. Neither marital status nor living alone were significantly associated with LLD.

Table 4.1.4. Age-adjusted odds ratios (OR) and 95% confidence intervals (between brackets) for moderate locomotor disability of demographic variables in *independently living* men and women.

	Men		Women	
	OR	(95% CI)	OR	(95% CI)
Age (continuous)	1.11	(1.10- 1.12)	1.10	(1.09- 1.12)
Marital Status				
Married	1.0		1.0	
Widowed	0.9	(0.6- 1.2)	1.1	(0.9- 1.4)
Divorced	0.8	(0.4- 1.5)	1.3	(0.9- 1.8)
Unmarried	1.2	(0.6- 2.2)	1.0	(0.7- 1.3)
Educational level				
Primary	1.5	(1.2- 1.9)	1.1	(0.9- 1.3)
Secondary	1.0		1.0	
High	1.1	(0.7- 1.7)	0.8	(0.5- 1.2)
Living alone	1.0	(0.7- 1.5)	1.0	(0.9- 1.3)
Income				
< median	2.0	(1.5- 2.7)	1.2	(1.0- 1.5)
continuous	0.90	(0.86- 0.95)	0.96	(0.93- 0.99)

People in homes for the elderly

As the number of people living in homes for the elderly was small (82 men and 315 women) the results of the prevalence estimates are presented for the total group only (table 4.1.5.).

Table 4.1.5. Prevalence(%) of moderate and severe disability(*) in the components and the disability indices of the HAQ in men and women living in *homes for the elderly.*

	Men		Women	
Number	82		315	
	% m	% s	% m	% s
Components				
Grip	58.0	42.0	73.7	59.0
Eating	44.4	24.7	54.1	30.6
Hygiene	69.1	53.1	85.1	74.0
Dressing	64.2	34.6	86.0	80.6
Reach	66.7	40.7	82.5	59.0
Rising	75.3	35.8	84.4	53.0
Walking	84.0	65.4	91.3	77.2
Activities	95.1	82.7	99.7	95.2
Indices				
DI	84.0	70.4	96.5	90.5
LDI	81.5	61.7	91.1	78.1
ULDI	45.7	27.2	75.9	51.1

DI = Disability Index (*) m = moderate disability: score component: ≥ 1; index: ≥ 0.50
LDI = Locomotor Disability Index s = severe disability: score component: ≥ 2; index: ≥ 1.00
ULDI = Upper Limb Disability Index

For both sexes the age standardized prevalence of disability was significantly higher among people living in homes for the elderly compared to independently living people (for men: Mantel Haenszel $\chi^2 = 34.90$, $p < 0.000$; for women Mantel Haenszel $\chi^2 = 64.03$, $p < 0.000$). Lower educational level was not significantly associated with LD ($p = 0.07$ in men and 0.55 in women), but widowed men were more disabled than married men ($p = 0.05$). Net annual income could not be analyzed (see methods).

Table 4.1.6. presents the age-adjusted odds ratios for LLD of demographic variables in these homes. In men only being widowed was significantly associated with disability. In women the only significant predictor of LLD was age. Living in a home for the elderly as opposed to living independently was strongly associated with LLD; the age-adjusted odds ratios were 5.0 (95% CI: 2.7-9.2) for men and 4.8 (95% CI: 3.1-7.4) for women.

Table 4.1.6. Age-adjusted odds ratios (OR) and 95% confidence interval (between brackets) for moderate locomotor disability of demographic variables in men and women living in *homes for the elderly*.

	Men		Women	
	OR	(95% CI)	OR	(95% CI)
Age (continuous)	0.98	(0.89- 1.07)	1.07	(1.00- 1.13)
Marital Status				
Married	1.0		1.0	
Widowed	5.2	(1.4- 19.6)	2.4	(0.6- 9.2)
Divorced	1.3	(0.2- 8.9)	0.6	(0.1- 4.0)
Unmarried	7.1	(0.4-139.4)	1.6	(0.3- 7.6)
Educational level				
Primary	0.2	(0.03- 2.2)	0.4	(0.08- 1.6)
Secondary	1.0		1.0	
High	0.3	(0.01- 5.8)	1.2	(0.05- 26.7)

DISCUSSION

The *Rotterdam Study* estimated that a fifth of all men and a third of all women living independently have at least some difficulty in at least three out of six lower limb functions. In the homes for the elderly more than 80% of men and more than 90% of women experience this amount of difficulty in lower limb functions. Female sex, living in a home for the elderly, increasing age, low educational level and low income are the most important demographic determinants of locomotor disability.

With regard to the interpretation of our results some points have to be discussed. The Ommoord district of Rotterdam is a geographically defined area harbouring relatively many elderly people, mainly because of its convenient living accommodations. The elderly inhabitants of Ommoord comprise a stable population; people either move to one of the homes for the elderly or the nursing home within the district or die. The response of the independently living people to our study is high (81.4% in men and 82.6% in women). People who refused to participate were generally older (especially above the age

of 80) and more often seriously ill or bedridden. If we take into account that non-response was largely due to illness it can be expected that our prevalence estimates are biased towards lower levels. Response in the homes for the elderly was generally lower; 70.9% of the male and 65.0% of the female residents participated. The main reasons for non-response were again very old age and serious illness. The results of the study on disability are however even more biased than by this non-response alone; 23.4% of the male and 25.2% of the female participants were not able to answer to the questions of the HAQ mostly because of the presence of some cognitive impairment. The results of the study on disability are therefore biased towards lower rates of disability. The fact that the prevalence of locomotor disability in the residents of the homes for the elderly is much higher than in independently living people (even at an age-adjusted basis) could not be explained by locomotor complaints; the prevalence of concurrent pain in the hips, knees and/or feet was even lower in the homes for the elderly. A possible explanation for this difference could be that the prevalence of other disabling impairments like cardiovascular and ophthalmologic diseases is much higher in these homes. In that respect the homes for the elderly represent a natural selection of living accommodation amongst the very old: they contain the more impaired and disabled people.

As to the question whether our results are applicable to the total Dutch population of 55 years and over we compared our demographic data with the total Dutch population. The marital status of the male participants is comparable with that of all Dutch males above the age of 55: 11.1% versus 9.6% widowed; 4.9% versus 4.8% divorced. The marital status of the female participants of the *Rotterdam Study* differed more from all Dutch women: 36.1% widowed, compared to 34.9% of the total female population; 7.3% were divorced versus 5.1% of all Dutch women[33]. Therefore the prevalence of disability in women might be biased towards somewhat higher values, because of the over-representation of widowed women in our study. The educational level of our participants was generally higher than in the 1993 Dutch Central Bureau of Statistics continuous Health Interview Survey (CBS-HIS)-sample of 55-64-year-olds: among the male participants in this age group 35.1% had primary education only (CBS-HIS 42.2%) and 50.9% had secondary education (CBS-HIS 40.6%). Of the female participants of our study in this age group 51.2% had primary education only (CBS-HIS 59.8%) and 43.3% had secondary education (CBS-HIS 32.5%)[11]. Because of the observed association between primary education and disability our prevalence estimates for men could be biased towards lower levels.

Our data on the prevalence of disability applying the HAQ in a large general population of people aged 55 years and over in the Netherlands compare well with those obtained by the CBS-HIS in a representative sample of people aged 55 years and over[11]. Disability in the CBS-HIS was defined as the ability to perform 10 activities of daily living 'with great

difficulty' or 'only with help'. The prevalence estimates of disability of the CBS-HIS are shown in table 4.1.7.; our prevalence estimates of severe disability as assessed by the DI are within the 95% confidence intervals of the CBS-HIS results. Other disability-related studies in the Netherlands are based on patients or measure disability after assessing some form of impairment[12].

Table 4.1.7. summarizes some data on disability of four other studies apart from the *Rotterdam Study*. The follow-up study of the National Health and Nutrition Examination Survey-I (the NHEFS) assessed disability in persons with arthritis related symptoms; their definition of disability is identical to ours; in that they assessed disability by means of the HAQ and used the same cutoff point.[13-15] The prevalence of arthritis related disability is generally higher in men especially in the younger age group. Women of 65-74 years of age with arthritis more often experience difficulties in the selected activities of daily living than women in an unselected population.

Table 4.1.7. Prevalence (%) of 'overall' disability and of disability in three separate functions in five studies

	Disability		Walking			Rising			Climbing stairs		
Age group (years)	55-64	65+	55-64	65-74	75-84	55-64	65-74	75-84	55-64	65-74	75-84
Men											
[1]Rotterdam (n=1819)	3.8	11.7	9.0	20.8	35.6	9.3	17.5	30.4	11.2	23.9	39.7
[2]CBS-HIS (n=1324)	4.1-7.7	8.2-12.4									
[3]NHEFS (n=742)			12.9	21.5		15.3	23.9				
[4]Framingham (n=1066)			3	5	13				2	3	7
[5]Göteborg (n=38)								11			26
Women											
[1]Rotterdam (n=2817)	6.0	23.6	15.4	27.7	47.7	14.5	26.1	43.9	24.0	42.7	61.3
[2]CBS-HIS (n=1715)	5.7-9.6	19.4-24.0									
[3]NHEFS (n=919)			16.4	35.7		20.7	37.0				
[4]Framingham (n=1550)			4	10	28				4	5	20
[5]Göteborg (n=46)								9			22

[1] *Rotterdam Study*; Disability : % severe disability HAQ(DI) ≥ 1.00. Functions: % moderate disability HAQ(question) ≥ 1.

[2] Netherlands Central Bureau of Statistics, continuous Health Interview Survey; Disability = 95 % confidence interval of 'with great difficulty' or 'only with help' in 10 ADL-functions[11].

[3] '82-'84 follow-up of '71-'75 NHANES I; Functions : % moderate disability HAQ(question) ≥ 1 in persons with arthritis related symptoms[13].

[4] '76-'78 Framingham Disability Study; Functions: % dependency on personal assistance[16].

[5] Göteborg-study among 79-year-olds; Functions: % difficulty or inability[23].

In the Framingham Disability Study[16-19] disability was assessed by a compound index constructed form the already existing measurement instruments of Katz, Rosow and Nagi.[20-22] Disability was defined as the need for personal assistance in performing the activities. The prevalence of disability in walking half a mile is much higher than in our study where the prevalence of inability to walk without help varies in men from 0.3% and 1.8% between the ages of 55 and 85 and in women between 0.4% and 3.0% respectively. However the prevalence of severe walking disability (i.e. score $\geq$ 2) in our study was found to be between 2.2% and 12.0% in men and between 3.2% and 17.8% in women. As the rates for score $\geq$ 2 on the HAQ compare well with the findings in the Framing ham Disability Study, the discrepant findings might be due to the definition of the need for personal assistance.

The Swedish study among the elderly in Göteborg was mainly concerned with testing various aspects of functional disability[23]. There is only one published result of interview data concerning difficulties in mobility functions. As the number of people participating in this study are small it is difficult to draw firm conclusions.

A study among 9,571 households in the Wellington Hospital Board Area in New Zealand resulted in a prevalence estimate of 38.9% disabled men and 45.0% disabled women above the age of 65[24]. Disablement was defined as either being impaired or handicapped in 9 selfcare activities and/or ability to work and/or dependency on walking aids and/or minor sensory difficulties and are therefore difficult to compare with other studies.

The prevalence of disability in walking half a mile was 25% in the Branch's 1976 Massachusetts Elders survey of non-institutionalized persons of 65 years and older[25], somewhat lower than the 34% of our participants of the corresponding age. Difficulties in rising from an armchair were more often seen in women, 28% versus 20% in men and rose with age[26]. We didn't assess rising from an armchair, but asked for difficulties in rising from an armless straight chair; the prevalences of disability for this function in men and women aged 65 years and over were 23.0% and 35.2% respectively and also rose with age. Provided that the composition of the population of the Massachusetts study does not differ very much from ours, the differences in prevalence estimates might be explained by the fact that rising from an armless straight chair causes more difficulties than rising from an armchair.

Our finding that disability is associated with gender, age and educational level are in concordance with the Framingham data[17]. The researchers of the NHANES-I study come to the same conclusion regarding the associates of disability; there was a tendency for widowed and divorced people to report more 'activity restriction', but this did not reach significance[14].

The major characteristics contributing to greater disability in the NHEFS were older age, less nonrecreational activity, arthritis history, less education, female sex and greater body mass index at baseline[27]. Also the 1984 Supplement on Aging of the National Health Interview Survey (NHIS) confirmed the association of gender, age and low educational level with disability in persons aged 80 or older[28]. In the Finnish part of the Seven Countries Study higher age and lower education were strong predictors for disability in men[29]. Pincus proposed a hypothesis that low formal educational level is a compo site/surrogate variable which identifies behavioral risk factors predisposing to the etiology and poor outcomes in most chronic diseases and health status[30,31].

The association of disability with below median income can not be compared with other studies. The Massachusetts study among the non-institutionalized aged concluded that active life expectancy (i.e. remaining years of independent ADL) was longer for the nonpoor than for the poor. People were considered poor when they received their income from Old Age Assistance or Supplemental Security Income, or had medical expenses covered by Medicaid or other public-assistance programs[32].

The HAQ has been validated in patients with rheumatologic disease as well as in the general population[8]. The HAQ was used in other population studies prior to the *Rotterdam Study*; e.g. the NHEFS in the United States[13] and more recently in a survey among 1,694 men and women aged over 55 registered at a general practice in Bristol, Great Britain[34,35]. There has been questions about a liability of the instrument to female bias[36]; however, the items of the HAQ likely to be responsible for this bias (handfunctions) do not lie in the sections relating to lower limb function. Our data as well as the data of the Bristol study suggest a genuine excess of locomotor disability in women.

The conclusions of our study are that locomotor disability is a major problem for people aged 55 years and over and even more so for people living in homes for the elderly. Of the demographic variables age, female sex, living in a home for the elderly, low educational level and low income were the most important determinants of locomotor disability.

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4.2 THE ASSOCIATION BETWEEN LOCOMOTOR DISABILITY AND JOINT COMPLAINTS

ABSTRACT

In the *Rotterdam Study* the association between locomotor disability and joint complaints among 1,901 men and 3,135 women aged 55 years and over was investigated. The prevalence of locomotor disability (LD) as assessed by 6 questions of the Health Assessment Questionnaire (HAQ) was 24.5% for men and 40.5% for women. The prevalence of joint pain in men ranged from 0.7% for pain in the hips, knees and feet simultaneously, 3.7% for pain at two joint-sites, 16.0% for pain at one joint-site to 20.4% for pain in the hips and/or knees and/or feet; the corresponding estimates for women were 1.9%, 9.0%, 23.7% and 34.5%, respectively. The prevalence of morning stiffness which lasted at least half an hour was 4.9% for men and 10.4% for women. There was a strong association between locomotor disability and joint complaints: the age-adjusted odds ratios for disability in men ranged from 2.4 of pain at one joint-site to 8.8 of pain at all three joints simultaneously; for women the odds ratios varied between 2.5 and 5.7, respectively. The age-adjusted odds ratios of morning stiffness were 7.3 for men and 8.0 for women.

INTRODUCTION

In the previous paragraph we reported on the prevalence of disability as evaluated by the Stanford Health Assessment Questionnaire in an open population of 55 years and older in a district of Rotterdam, the Netherlands (the *Rotterdam Study*).[1,2] Disability as assessed by the Disability Index (DI) of the HAQ in 1,819 men and 2,817 women living independently occurred in 21.9% of the men and 36.0% of the women. The prevalence of locomotor disability (LD) as expressed by the Locomotor Disability Index was 21.9% for men and 34.8% for women. Locomotor disability therefore explained most if not all of the disability in the general population of 55 years and over. For the 82 men and 315 women living in homes for the elderly, but still independent in most activities of daily living, the corresponding rates were for DI: 84.0% and 96.5%, and for LD: 81.5% and 91.1% respectively. Locomotor disability was associated with female sex, increasing age, living in a home for the elderly, low education and low income.

The present study analyzed in the same study group of 5,033 people the association of selfreported pain and morning stiffness in the joints of the lower limb and locomotor disability.

POPULATION AND METHODS

Population

The present study is concerned with those participants who took part in the study between April 1990 and July 1992. At this stage of the study 2,398 men and 4,081 women were invited to participate; 1,937 men (80.8%) and 3,255 women (79.8%) took part in the study. Because of incomplete interview-data 36 men and 120 women had to be excluded from the analysis. Complete data were therefore available of 1,901 men (79.3%) and 3,135 women (76.8%). Some baseline characteristics of the participants are given in table 4.2.1.

Table 4.2.1. Selected baseline characteristics of the participants of the *Rotterdam Study*.

	Men		Women	
Number	1901	(37.7%)	3135	(62.23)
Age				
range	55.0 - 94.6 yr		55.0 - 99.2 yr	
mean age	69.5 yr		71.4 yr	
Living accommodation				
independent	1819	(95.7%)	2819	(89.9%)
homes for the elderly	82	(4.3%)	316	(10.1%)

Methods

The analysis is focused on the association of locomotor disability with lower limb joint pain and morning stiffness. Locomotor disability (LD) was defined according to the ambulation subcategory of the International Classification of Impairments, Disabilities and Handicaps (ICIDH)[3] and assessed with the questions about walking, climbing stairs, getting in and out of bed and a car, bending, and rising from a chair from the Stanford Health Assessment Questionnaire (HAQ).[4-7] An extensive description of the HAQ and the way it was assessed has been presented in paragraph 4.1. The cutoff for moderate disability was 1 for the separate functions and 0.5 for the Locomotor Disability Index (LDI); the cutoff for severe disability was 2 for the separate functions and 1.0 for the LDI.

Locomotor factors assessed in the interview which could possibly be associated with locomotor disability were joint pain and morning stiffness. Pain was assessed by asking the participants if they suffered from pain or other complaints in their joints during the past month and if so which joints bothered them most. For the current analyses we used the data on pain in the joints of the lower limbs. Pain at a joint-site was defined as pain in

the left and/or right joint. Several levels of joint pain could be distinguished, i.e. people with pain in their hips and/or knees and/or feet (any joint-site), with pain at all three joint-sites simultaneously (in hips, knees and feet), with pain at two joint-sites (in hips and knees, in hips and feet, or in knees and feet), and finally pain at one joint-site (in hips only, knees only, or feet only). Duration of morning stiffness was assessed at three levels (less than ½ hour, ½ - 1 hour, more than 1 hour) and subsequently dichotomized to no morning stiffness or ½ hour or more.

Data analysis

Data were analyzed for men and women separately. Because the inhabitants of the homes for the elderly are considered to be independent in the activities of daily living as assessed by means of the Locomotor Disability Index we included them in the current analyses.

As the frequency for severe disability was low, the analyses of associations with locomotor disability were restricted to moderate disability. Adjusted prevalence odds ratios for locomotor disability were estimated using a multiple logistic regression model. The odds ratios of joint pain were adjusted for age and morning stiffness, while the odds ratios of morning stiffness were adjusted for age and the four categories of joint pain.

Age, joint pain, morning stiffness and selected demographic variables were entered together in a multiple logistic regression model of locomotor disability to estimate adjusted odds ratios and etiologic fractions for all independent variables. The etiologic fraction (EF) is defined as the proportion of disabled persons which is attributable to the determinant of interest.[8] The EF was calculated using the formula:

$$EF = p(aOR-1)/\{p(aOR-1) + 1\}$$

where p is the prevalence of the determinant in the population and aOR is the odds ratio adjusted for age, joint complaints and demographic variables. In this analysis locomotor disability was dichotomized at the cutoff-point of 0.50, joint pain and morning stiffness were dichotomous variables. The reference categories for living accommodation was independently living, for marital status: being married, for living situation: living not alone, for education: primary education and for income: below median income.

RESULTS

In table 4.2.2. the prevalence of disability in the six activities most related to lower limb function, as well as the Locomotor Disability Index (LDI) is given by sex and age. The prevalence of moderate disability in the separate functions as well as the LDI was 1.5 to 1.8 times higher in women as compared to men, and the figures for severe disability were 1.7 to 2.2 times higher in women than in men. In each gender the prevalences of disability in the separate functions were about the same.

Table 4.2.2. Prevalence (%) of moderate and severe disability (*) in separate lower limb functions by single questions and Locomotor Disability Index (LDI) in men and women by age.

Age group (years)	55-64		65-74		75-84		85 +		Total	
	% m	% s	% m	% s	% m	% s	% m	% s	% m (95% CI)	% s (95% CI)
Men Number	635		762		426		78		1901	
Getting in/out bed	9.8	1.3	18.6	2.5	30.8	5.9	55.1	19.2	19.9 (18.1- 21.7)	3.5 (2.7- 4.3)
Rising from chair	9.3	1.6	17.9	3.5	34.7	9.9	60.3	29.5	20.5 (18.7- 22.3)	5.4 (4.4- 6.4)
Bending	12.6	4.7	16.4	6.4	28.6	12.7	56.6	36.8	19.5 (17.7- 21.3)	8.5 (7.2- 9.8)
Getting in/out of car	8.8	2.2	17.3	4.7	38.4	14.8	72.7	46.8	21.4 (19.6- 23.2)	7.8 (6.6- 9.0)
Walking	9.0	2.2	21.4	6.4	40.7	17.5	67.1	44.7	23.4 (21.5- 25.3)	9.0 (7.7- 10.3)
Climbing stairs	11.2	2.5	24.5	7.0	44.1	19.2	79.2	50.6	26.7 (24.7- 28.7)	10.0 (8.7- 11.3)
LDI	10.1	3.9	21.7	7.5	41.8	23.0	74.4	55.1	24.5 (22.6- 26.4)	11.7 (10.3- 13.1)
Women Number	950		1090		773		322		3135	
Getting in/out bed	17.1	1.8	27.5	3.8	42.4	8.7	68.0	24.2	32.2 (30.6- 33.8)	6.5 (5.6- 7.4)
Rising from chair	14.7	2.2	26.5	6.3	48.0	16.2	80.1	44.7	33.7 (32.0- 35.4)	11.4 (10.3- 12.5)
Bending	17.8	6.0	27.5	9.6	44.8	19.8	71.7	40.8	33.3 (31.7- 34.9)	14.2 (13.0- 15.4)
Getting in/out of car	17.1	4.1	32.0	10.1	57.0	25.8	88.2	59.6	39.3 (37.6- 41.0)	17.1 (15.8- 18.4)
Walking	15.7	3.5	28.0	9.0	51.6	22.8	85.2	59.9	35.9 (34.2- 37.6)	15.9 (14.6- 17.2)
Climbing stairs	24.3	5.1	43.0	11.6	64.5	30.0	88.0	65.0	47.2 (45.5- 48.9)	19.6 (18.2- 21.0)
LDI	17.6	6.8	33.8	15.8	57.8	36.0	89.1	73.9	40.5 (38.8- 42.2)	24.0 (22.5- 25.5)

(*) m = moderate disability: score question: ≥ 1; index: ≥ 0.50.
s = severe disability: score question: ≥ 2; index: ≥ 1.00.

95% CI = 95% Confidence Interval

The prevalences of pain in the joints of the lower limbs and morning stiffness are given in table 4.2.3. Pain in at least one joint of the lower limbs (any joint-site) was present in one fifth of the men and in a third of the women. Of the men 16.0% had pain at one joint-site only (most often the knee (8.6%)), 3.7% at two joint-sites (most often the hip and knee (2.2%)) and 0.7% at all three joint-sites. Among women 23.7% suffered from pain at one joint-site (most often the knee (12.8%)), 9.0% had pain at two joint-sites (most often the hip and knee (5.1%)) and 1.9% at all three joint-sites. Tests for linear trend showed no significant increase with age of the prevalence of pain in any pain-category for women; for men there was a borderline significant increase with age of the prevalence for joint pain anywhere ($p = 0.062$) and a significant increase with age for men with pain at one joint-site ($p = 0.020$). Morning stiffness occurred in nearly 5% of the men and more than 10% of the women. In women morning stiffness increased significantly with age ($p = 0.0001$) from 8.7% in the age group 55-64 years to 16.8% in women of 85 years and older. In men it increased slightly with age up to 84 years and decreased there after (not significant).

Table 4.2.3. Prevalence (%) of locomotor complaints in men and women by age.

Age group (years)	55-64 %	65-74 %	75-84 %	85 + %	Total % (95% CI)
Men Number	635	762	426	78	1901
Joint pain					
Any joint-site	18.7	20.1	22.5	25.6	20.4 (18.6-22.2)
One joint-site	14.2	15.6	18.1	23.1	16.0 (14.4-17.6)
Two joint-sites	3.8	3.8	4.0	1.3	3.7 (2.9- 4.5)
Three joint-sites	0.8	0.7	0.5	1.3	0.7 (0.3- 1.1)
Morning stiffness	4.1	4.9	6.1	5.1	4.9 (3.9- 5.9)
Women Number	950	1090	773	322	3135
Joint pain					
Any joint-site	32.5	37.1	33.9	33.5	34.5 (32.8-36.2)
One joint-site	22.4	25.2	23.4	22.7	23.7 (22.2-25.2)
Two joint-sites	8.2	9.4	9.1	9.3	9.0 (8.0-10.0)
Three joint-sites	1.9	2.4	1.4	1.6	1.9 (1.4- 2.4)
Morning stiffness	8.7	9.2	11.6	16.8	10.4 (9.3-11.5)

Any joint-site = pain in hips and/or knees and/or feet.
One joint-site = pain in hips or knees or feet.
Two joint-sites = pain in hips and knees, or hips and feet, or knees and feet
Three joint-sites = pain in hips and knees and feet.

95% CI = 95% Confidence Interval

The prevalence of locomotor disability according to whether or not the participants had joint complaints is shown in table 4.2.4. The prevalence of locomotor disability increased with the number of painful joint-sites. The figures for locomotor disability were highest in people suffering from morning stiffness. Although the prevalences of morning stiffness in all men and women were of the same order as those for pain at two joint-sites, there was more disability in relation with morning stiffness than with pain at two joint-sites.

Table 4.2.4. Prevalence (%) of locomotor disability in men and women according to joint complaints

	Men		Women	
Joint pain	n	%	n	%
Nowhere	1513	19.8	2052	31.2
Any joint-site	388	42.8	1083	58.1
One joint-site	304	39.5	742	53.2
Two joint-sites	71	53.5	281	68.0
Three joint-sites	13	61.5	60	71.7
Morning stiffness				
No	1808	22.4	2808	36.2
Yes	93	64.5	327	77.1

Note that the sum of the numbers in the various strata of joint pain is higher than the total number of men and women present in the study; the stratum 'any joint-site' comprises people who are also present in one of the other categories of pain.

Table 4.2.5. shows the age-adjusted odds ratios for locomotor disability of joint pain. The odds ratios for disability increased with the number of affected joints in both sexes, and were somewhat higher for men than for women, albeit that both locomotor disability and joint pain occurred significantly more often in women than in men. The odds ratios adjusted for age and morning stiffness are of the same magnitude.

Table 4.2.5. Odds ratios with 95% confidence intervals (between brackets) for locomotor disability of joint pain adjusted for age and morning stiffness.

Odds Ratios	adjusted for age	adjusted for age and morning stiffness
Men		
Any joint-site	3.4 (2.6- 4.4)	3.1 (2.3- 4.0)
One joint-site	2.4 (1.8- 3.2)	2.3 (1.7- 3.0)
Two joint-sites	4.9 (2.9- 8.3)	4.3 (2.5- 7.4)
Three joint-sites	8.8 (2.6- 29.3)	6.7 (1.8- 24.4)
Women		
Any joint-site	4.5 (3.8- 5.4)	4.0 (3.4- 4.9)
One joint-site	2.5 (2.0- 3.0)	2.4 (2.0- 3.0)
Two joint-sites	4.7 (3.5- 6.3)	4.0 (3.0- 5.4)
Three joint-sites	5.7 (3.1- 10.4)	5.2 (2.8- 9.9)

Table 4.2.6. gives the age-adjusted odds ratios for locomotor disability of morning stiffness. Locomotor disability was strongly associated with morning stiffness and the associations are stronger for men than for women. Adjustment for joint-pain did not significantly change these odds ratios. Analysis of the six separate functions which constitute the LDI showed that the odds ratios of joint pain and morning stiffness for disability in these functions are of the same magnitude as those presented in tables 4.2.5. and 4.2.6. (table 4.2.1.a. in Appendix E).

Table 4.2.6. Odds ratios with 95% confidence interval (between brackets) for locomotor disability of morning stiffness adjusted for age and joint pain.

	Men	Women
Odds ratios adjusted for		
Age	8.0 (4.9- 13.0)	7.3 (5.4- 9.8)
Age + Any joint-site	6.7 (4.0- 11.0)	6.0 (4.4- 8.2)
Age + One joint-site	7.6 (4.7- 12.4)	7.2 (5.3- 9.7)
Age + Two joint-sites	7.4 (4.5- 12.1)	6.5 (4.8- 8.8)
Age + Three joint-sites	7.7 (4.7- 12.5)	7.2 (5.3- 9.7)

In table 4.2.7. the results of a multiple logistic regression model are presented. Significantly increased odds for locomotor disability were observed in both men and women suffering from joint pain and morning stiffness and living in a home for the elderly. In women there were almost significantly increased odds ratios for locomotor disability of being widowed or divorced. Men with a net annual income above the median were significantly less often disabled, while in women this determinant just not reached significance. The last column for each gender shows that the proportion of disability in the total population attributable to joint pain ranks first, followed by morning stiffness and living in a home for the elderly. The various demographic variables attribute either very little or not at all to the occurrence of locomotor disability.

Table 4.2.7. Adjusted odds ratios and etiologic fractions for locomotor disability adjusted for age, joint complaints and demographic variables.

	Men			Women		
	aOR	95% CI	EF	aOR	95% CI	EF
Pain any joint-site	2.8	(2.0- 3.8)	26.8	4.2	(3.4- 5.2)	53.2
Morning stiffness	4.9	(2.7- 9.0)	14.8	6.6	(4.6- 9.6)	35.8
Home for the elderly	5.8	(2.5- 13.6)	14.2	5.8	(5.2- 3.0)	24.9
Widowed	0.7	(0.4- 1.2)	-*	1.3	(0.9- 1.8)	(10.5)#
Divorced	0.6	(0.3- 1.4)	-*	1.5	(0.9- 2.4)	(3.7)#
Unmarried	0.8	(0.4- 1.9)	-*	1.1	(0.7- 1.7)	(1.0)#
Living alone	1.3	(0.8- 2.3)	(4.7)#	0.8	(0.6- 1.1)	-*
Secondary education	0.8	(0.6- 1.1)	-*	0.9	(0.8- 1.2)	-*
High education	0.8	(0.5- 1.4)	-*	0.8	(0.5- 1.3)	-*
Above median income	0.6	(0.4- 0.8)	-*	0.9	(0.7- 1.2)	-*

aOR = Odds ratio adjusted for all variables in the model.
95% CI = 95% Confidence interval of aOR.
EF = Etiologic fraction = p(aOR-1)/{p(aOR-1) + 1}.

*: aOR < 1.
#: aOR not significantly higher than 1.

DISCUSSION

In a general population of Dutch people aged 55 years and over a fifth to a quarter of the men and a third to almost half of the women reported disability in six lower limb functions. A fifth of the men suffered from pain in at least one of the joints of the lower limbs, while less than 1% of the men had pain in the hips, knees and feet simultaneously. A third of the women reported joint pain anywhere and almost 2% at al three joint-sites

simultaneously. Morning stiffness occurred in almost 5% of the males and more than 10% of the females.

Age, joint pain and morning stiffness were strongly and independently associated with disability. When the odds ratios for locomotor disability of joint pain are adjusted for morning stiffness as well as age the estimates did not change. Morning stiffness is not a confounder of the association between locomotor disability and joint pain nor is it associated with joint pain.

Multiple regression of locomotor disability for joint complaints together with selected demographic variables showed that living in a home for the elderly and suffering from morning stiffness and joint pain were the most important predictors of locomotor disability. The etiologic fractions depict the importance of the determinants of locomotor disability from a public health point of view. Although the odds ratios of living in a home for the elderly and morning stiffness are higher than the odds of joint pain, the proportion of locomotor disability attributable to joint pain is much larger. The fact that one fifth of all men and one third of all women above the age of 55 have joint pain anywhere in their lower limbs does mean that many people in this age group suffer from loss of ability in carrying out the most basic activities needed to maintain an independent life. The role of morning stiffness is more difficult to explain. This symptom originally was described as a criterion for rheumatoid arthritis,[9] but showed a low sensitivity and specificity, suggesting that the reported stiffness of the limbs was not so much arthritic in origin but had to do more with the structures surrounding the joints. We hypothesize that in those people who suffer from it, the stiffness after arising from bed sets off locomotor disability which is prolonged and enhanced by the occurrence of joint pain. In people who do not suffer from morning stiffness particularly joint pain at multiple sites is independently responsible for the loss of lower limb functions.

As in all population-surveys there are sources of bias in our study. The response-rate of 80.8% in men and 79.8% in women is high and therefore selection-bias will be limited. Yet people who refused to participate were generally older (especially above the age of 80) and more often seriously ill or bedridden. If we take into account that non-response was largely due to illness it can be expected that our prevalence estimates are biased towards lower levels. Incompleteness of data was mainly due to the fact that participants were not able to answer to the questions of the HAQ, mostly because of the presence of some cognitive impairment; this was particularly the case for the very old living in the homes for the elderly. Information-bias defined as inaccuracy of data because the participants did misinterpret the questions is possible but not likely to have occurred very frequently: all data were assembled by means of an home interview and our interviewers were trained extensively and standardized on a regular basis. The other source of information-bias is caused by the interviewers themselves. In spite of our efforts to ensure

standardized data-collection by instructing the interviewers to explain questions only and avoid recording their own judgments, it is still possible that especially in the questions on disability the assessments were influenced by the interviewers. As to the questions on joint pain the interviewers were trained to distinguish between muscle pain and joint pain, but especially whenever complaints of the hips were presented misclassification could have occurred (i.e. it is not always possible for non-medical interviewers to make the right decision whether indeed the hip joint is the origin of complaints).

The prevalence estimates of disability are in concordance with other Dutch studies as well as international data.[10-15] We previously assessed the prevalence of pain in the joints in the 1975-1978 EPOZ-study. These results are somewhat lower than the present findings: kneepain was present in 7.6% of the males and 17.5% of the females aged 45 and over, while this was 12.6% and 22.6% respectively, in our participants of 55 years and over.[16] Pain in the hips was reported by 6.9% of the EPOZ-participants versus 13.2% in our study.[17] The reason for the differences between the two studies is that in the EPOZ-study the questions on pain concerned pain at the time of investigation and not during the past month. Among 1,694 men and women aged 55 years and older and registered at a general practice in Bristol, Great Britain the prevalence of knee pain was 20.1% in the men and 27.6% in the women and therefore substantially higher than in the Dutch studies.[18] The difference again can be explained by the way joint pain was assessed: the British study asked for pain on most days for at least a month during the last year, while we asked for pain during the past month. A Finnish study assessed rheumatic complaints in the hips and knees in people aged over 50; the prevalences were in accordance with our findings: 13% for the hips and 12% for the knees in men and 11% and 22% respectively in women.[19] Our finding that the prevalence of joint pain did not rise with age is in accordance with other studies.[18,20]

Our estimates of the odds ratios for locomotor disability of joint complaints can not be compared with most other disability studies as they did not present measures of association.[10-12,21-24] The Bristol study reported a significantly higher frequency of disability (i.e. HAQ score > 0) in subjects with knee pain than those without at all ages ($p<0.05$) except in men aged over 80.[18] The 1983-1985 Framingham-study estimated odds ratios of pain in the knees for at least 1 month during the past year, in 1,416 people aged 60 and over. The odds for dependence on personal help in walking was 2.6 and for climbing stairs 3.7[15]. In our study the odds ratios for dependency in walking and climbing stairs (score = 3 on the HAQ) of knee pain were 2.1 for both functions in the 4,530 men and women aged 60 and over.

Our finding suggest that locomotor disability in an ageing population is a problem of considerable magnitude. Although age is the major determinant, morning stiffness and joint pain of the lower limb joints are strong determinants, independent of age.

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4.3 THE ASSOCIATION BETWEEN LOCOMOTOR DISABILITY AND RADIOLOGICAL OSTEOARTHRITIS OF THE HIPS AND KNEES

ABSTRACT

The objective of the present study was to assess the contribution of radiological osteoarthritis of the hips and knees to disabilities in the activities of daily living related to lower limb function. During a home interview 1,156 men and 1,739 women aged 55 years and over (the *Rotterdam Study*) were asked about locomotor disability (LD) by 6 questions of the Health Assessment Questionnaire (HAQ) and about pain in the hips and knees in the past month. Radiographs of hips and knees were scored according to the Kellgren grading-system for osteoarthritis. The prevalence of locomotor disability was 20.2% for men and 31.9% for women; hip pain was present in 8.3% of the men and 16.6% of the women; the prevalence of knee pain was 12.6% for men and 22.3% for women. Radiological osteoarthritis (ROA) grade 2+ of the hip was present in 14.1% of the men and 15.9% of the women, and of the knee in 16.3% and 29.1%, respectively. The odds ratios (OR) for locomotor disability of hip-ROA adjusted for age, hip pain and body mass index (BMI) were 1.6 (95% CI: 1.0-2.3) for men and 2.3 (1.7-3.1) for women. The OR's for locomotor disability of knee-ROA adjusted for age, knee pain and BMI were 1.0 (0.7-1.5) and 1.3 (1.0-1.6), respectively. Our conclusion is that mild ROA of the hip and knee are independent predictors of locomotor disability in women, but not in men.

INTRODUCTION

In the two preceding paragraphs of this chapter it was shown that locomotor disability (LD), defined as disability in activities related to lower limb function and assessed by six questions of the Stanford Health Assessment Questionnaire was present in one fifth of the men and one third of the women aged 55 years and over in the general population.[1,2] Locomotor disability was associated with female gender, increasing age, living in a home for the elderly, low education and low income.[2] Suffering from pain in the hips, knees or feet and from morning stiffness with a duration of more than half an hour were strongly associated with locomotor disability.[3] Another variable which is expected to contribute to the risk of disability is radiological osteoarthritis (ROA) of the hips and knees. Data from the National Health and Nutrition Examination Survey-I Epidemiologic Follow-up Study (NHEFS) and the Framingham Study suggested a large impact of ROA of the knee on disability in the activities of daily living related to lower limb function.[4-8] More recently a

British study reported an elevated risk of locomotor disability in people with pain and ROA of the knees.[9,10] However, data on the influence of pain or ROA of the hip are lacking.

In the present study the association between ROA and self-reported pain in the hips and knees and locomotor disability was investigated in 2,985 participants of the *Rotterdam Study*.

POPULATION AND METHODS

Population

The present analysis is concerned with the participants of whom complete data with respect to disability as well as radiological osteoarthritis were available. Of the 2,247 men and 3,433 women living independently who were invited to participate, complete interview data were available of 1,819 men (81.0%) and 2,817 women (82.1%).

In the second phase of the study, the participants were invited to visit the research centre of the *Rotterdam Study*, which was located at the Health Centre of the study-district, for additional measurements and tests. The average time lapse between the interview and the visit to the centre was two weeks. Of the interviewed men and women respectively 1,690 (92.9%) and 2,577 (91.4%) participated in the centre examinations. Logistic reasons obliged us to start the study with a restricted amount of measurements at the centre. For the study on the relationship between disability and radiological osteo-arthritis of the hips and knees this meant that complete data were available of 1,156 men and 1,739 women; 63.6% of the men and 61.7% of the women of the original interview study group of 1,819 men and 2,817 women.

Methods

Locomotor disability was defined according to the ambulation subcategory of the International Classification of Impairments, Disabilities and Handicaps (ICIDH)[11] and assessed with the questions about walking, climbing stairs, getting in and out of bed and a car, bending, and rising from a chair from the Stanford Health Assessment Questionnaire (HAQ).[12-15] Locomotor disability (LD) was defined as the mean score of these six questions. An extensive description of the HAQ and the way it was assessed has been presented in paragraph 4.1. The cutoff for disability was 0.50, which means that the participants have some difficulty in at least three out of six functions.

Pain of the hips and knees was defined as joint pain during the past month at the left and/or right side.[3] Morning stiffness was defined as stiffness of the joints when rising from bed in the morning and lasting for at least half an hour.

At the research centre weightbearing radiographs of the hips and knees were obtained. Radiological osteoarthritis (ROA) was assessed by means of the grading system proposed by Kellgren et al.[16] The radiographs were scored by two independent readers (Odding and Valkenburg), who were blinded to all data of the participant. There was no indication of gender or age on the film. Whenever the score of the two readers differed more than one grade or when one reader scored grade 1 and the other grade 2 or more a consensus-reading was carried out. The consensus grade, or in case of a difference between grade 2 and 3 the highest grade, was entered as the final score. A subject was considered to have ROA of the hips or knees if the Kellgren-score of one or both joints was greater or equal to two (ROA2). Severe ROA was defined as Kellgren-score $\geq$ 3 (ROA3).

Body height was measured in cm, body weight in kg with the participant barefooted and wearing light indoor clothing. Body mass index (BMI = kg/m^2) was used as a measure of overweight.

Data analysis

All analyses were done for men and women separately. We first estimated the age and sex specific prevalence of locomotor disability, joint pain and ROA of the hips and knees.

Secondly age-adjusted odds ratio's for locomotor disability of ROA, pain and BMI were estimated using a multiple logistic model. Subsequently the odds ratio's of ROA were adjusted for age, pain and BMI. In both models age and BMI were treated as continuous variables, while all other variables were dichotomized.

Age, joint pain, morning stiffness, radiological osteoarthritis and BMI were entered together in a multiple logistic regression model of locomotor disability to estimate adjusted odds ratios and etiologic fractions for all independent variables. The etiologic fraction (EF) is defined as the proportion of disabled persons which is attributable to the determinant of interest.[17] The EF was calculated using the same formula as described in paragraph 4.2. In this analysis locomotor disability, joint pain, morning stiffness and radiological osteoarthritis were entered as dichotomous variables. BMI was analyzed in quartiles with the second quartile being the reference category. All analyses were done for ROA2 and ROA3 separately.

Comparing the baseline characteristics (table 4.3.1) of the participants of the present study with those of all 1,819 interviewed men and 2,817 interviewed women revealed no significant differences in age. The distribution of demographic variables was however different from the original interviewed participants; there were relatively more divorced and unmarried people and more high educated women in the present studygroup. Detailed information on these demographic differences is given in paragraph 5.1.

Table 4.3.1. Some baseline characteristics of the participants of the *Rotterdam Study*.

	Men			Women		
Number	1,156			1,739		
	range	mean	(± SE)	range	mean	(± SE)
Age (year)	55.0- 93.2	68.6	(0.2)	55.0- 94.0	69.1	(0.2)
Body Mass Index (kg/m^2)	16.9- 37.2	25.8	(0.09)	16.4- 44.2	26.8	(0.1)

More detailed information on anthropometric data is given in table 4.3.a. of Appendix E.

RESULTS

Table 4.3.2 presents the prevalence figures of locomotor disability, joint pain and radiological osteoarthritis.

Locomotor disability and ROA2 of the hips and knees increased significantly with age, but pain in the hips or knees did not. ROA2 and joint pain were poorly associated, be it somewhat better in women. Only 16.0% of the men and 33.2% of the women with ROA2 of the hips had pain in those joints and conversely 27.1% of the men and 31.8% of the women with pain in the hips had ROA2. For ROA2 of the knees these figures were 25.4% and 34.2%, respectively and for knee pain 32.9% and 44.7%. The association between pain and ROA3 was substantially better: 31.0% of the men and 49.1% of the women with ROA3 had pain in the hips, while 63.3% of the men and 53.7% of the women with knee ROA3 had pain in the corresponding joints.

The joint specific age-adjusted odds ratios with their 95% confidence intervals for locomotor disability of pain, ROA and the combination of ROA and pain are depicted in figure 4.3.1. for the hips and in figure 4.3.2. for the knees. In all four analyses the association between ROA2 and locomotor disability yielded significantly lower odds ratios than for joint pain alone and locomotor disability. In both sexes and for both joint sites mild and severe radiological osteoarthritis either or not in combination with pain in the corresponding joints did not significantly change the odds ratios compared to that for pain alone, taking the 95% confidence intervals into account. The age-adjusted odds ratios of the figures are presented in table 4.3.1.a of Appendix E.

Table 4.3.2. Prevalence (%) of locomotor disability, joint pain and radiological osteoarthritis of the hip and knee of men and women by age.

Age group (years)	55-64 %	65-74 %	75-84 %	85 + %	Total % (95% CI)
Men Number	404	501	234	17	1156
Locomotor Disability	11.1	19.8	34.2	58.8	20.2 (17.9- 22.5)
Joint pain					
Hip	8.4	7.6	8.5	23.5	8.3 (6.7- 9.9)
Knee	13.4	10.4	16.2	11.8	12.6 (10.7- 14.5)
Radiological Osteoarthritis					
Hip ≥ 2	11.4	14.2	17.1	35.3	14.1 (21.1- 16.1)
Hip ≥ 3					2.5 (1.6- 3.4)
Knee ≥ 2	10.1	16.8	24.8	35.3	16.3 (14.2- 18.4)
Knee ≥ 3					2.6 (1.7- 3.5)
ROA + Pain					
Hip ≥ 2	2.2	2.2	1.7	11.8	2.2 (1.4- 3.1)
Hip ≥ 3					0.8 (0.3- 1.3)
Knee ≥ 2	2.0	4.6	6.4	11.8	4.2 (3.0- 5.4)
Knee ≥ 3					1.6 (0.9- 2.3)
Women Number	589	684	416	50	1739
Locomotor Disability	15.8	30.4	51.0	82.0	31.9 (29.7- 34.1)
Joint pain					
Hip	14.6	17.4	18.0	18.0	16.6 (14.9- 18.3)
Knee	21.4	24.4	20.4	18.0	22.3 (20.3- 24.3)
Radiological Osteoarthritis					
Hip ≥ 2	5.9	18.4	23.3	38.0	15.9 (14.2- 17.6)
Hip ≥ 3					6.1 (5.0- 7.2)
Knee ≥ 2	19.0	29.4	38.2	68.0	29.1 (27.0- 31.2)
Knee ≥ 3					4.7 (3.7- 5.7)
ROA + Pain					
Hip ≥ 2	2.5	5.7	8.7	4.0	5.3 (4.2- 6.4)
Hip ≥ 3					3.0 (2.2- 3.8)
Knee ≥ 2	7.1	11.3	11.3	14.0	9.9 (8.5- 11.3)
Knee ≥ 3					2.5 (1.8- 3.2)

The age-specific prevalences of people with ROA grade ≥ 3 are given in table 4.3.6.a. of Appendix E.

Figure 4.3.1. Age-adjusted odds ratios for locomotor disability of pain and radiological osteoarthritis of the *hips* in men and women.

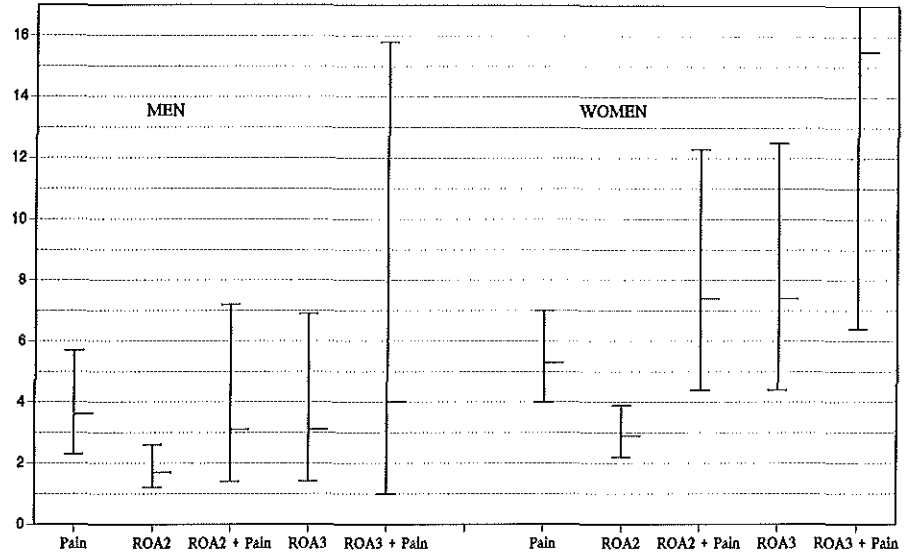
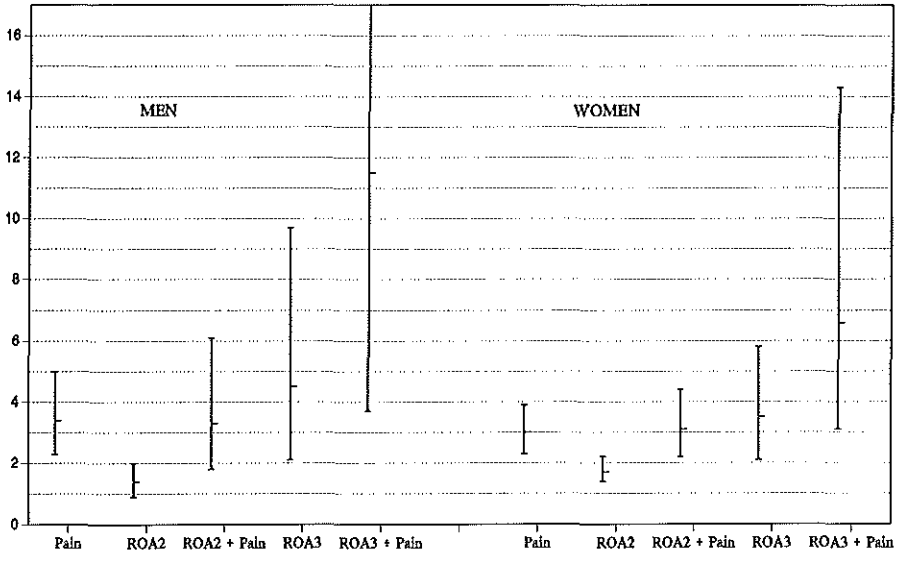


Figure 4.3.2. Age-adjusted odds ratios for locomotor disability of pain and radiological osteoarthritis of the *knees* in men and women.



Pain of the hips and knees was strongly associated with ROA of the hips and knees respectively. BMI was neither associated with ROA nor with pain of the hips. Obesity, defined as the fourth quartile of the distribution with the second quartile as the reference category was significantly associated with osteoarthritis of the knees. There was no elevated risk for knee pain in obese men, but overweight women had significantly more often pain in that joint (data in tables 4.3.2.a to 4.3.5.a. of Appendix E).

After adjustment for age, pain and BMI, ROA2 of the knee was just independently associated with locomotor disability in women but not in men (table 4.3.3.). The association of ROA2 of the hip was somewhat stronger independently associated with locomotor disability. In general the association between ROA3 and locomotor disability was stronger than for ROA2, more so in women than in men.

Table 4.3.3. Odds ratios and 95% confidence intervals (between brackets) for locomotor disability of radiological osteoarthritis of the hip and knee adjusted for age, joint pain and body mass index (BMI).

	Men		Women	
	Grade ≥ 2	*Grade ≥ 3*	*Grade ≥ 2*	*Grade ≥ 3*
Hip				
Adjusted for: (*)				
age	1.7 (1.2- 2.6)	3.1 (1.4- 7.0)	2.9 (2.2- 3.9)	7.4 (4.4-12.5)
age+pain	1.6 (1.1- 2.3)	2.3 (1.0- 5.3)	2.3 (1.7- 3.1)	5.0 (2.9- 8.6)
age+pain+BMI	1.6 (1.0- 2.3)	2.2 (0.9- 5.1)	2.3 (1.7- 3.1)	5.0 (2.9- 8.7)
Knee				
Adjusted for: (*)				
age	1.4 (0.9- 2.0)	4.5 (2.1- 9.7)	1.7 (1.4- 2.2)	3.5 (2.1- 5.8)
age+pain	1.1 (0.7- 1.6)	2.6 (1.2- 6.0)	1.4 (1.1- 1.8)	2.6 (1.5- 4.3)
age+pain+BMI	1.0 (0.7- 1.5)	2.5 (1.1- 5.5)	1.3 (1.0- 1.6)	2.3 (1.3- 3.8)

(*): age and BMI as continuous variables; pain as a dichotomous variable

In the multiple logistic regression analysis morning stiffness and pain in the hips and knees are the most important independent predictors of locomotor disability. In women mild and severe radiological osteoarthritis and being overweight (fourth quartile of BMI) are also significantly associated with locomotor disability, but in men this is restricted to overweight and severe knee-ROA (table 4.3.4.).

Table 4.3.4. Adjusted odds ratios and etiologic fractions for locomotor disability adjusted for age, joint complaints, radiological osteoarthritis (ROA) and body mass index (BMI)

	Men			Women		
	aOR	95% CI	EF	aOR	95% CI	EF
Model with ROA ≥ 2						
Hip pain	2.7	(1.7- 4.4)	12.6	3.6	(2.6- 4.9)	30.0
Knee pain	2.9	(1.9- 4.4)	19.5	2.1	(1.6- 2.8)	20.5
Morning stiffness	5.5	(3.0- 10.2)	17.0	5.1	(3.4- 7.7)	26.1
Hip ROA	1.4	(0.9- 2.1)	(5.0)#	2.2	(1.6- 2.9)	15.7
Knee ROA	1.1	(0.9- 2.1)	(1.6)#	1.4	(1.1- 1.8)	10.0
BMI 1st quartile	0.9	(0.6- 1.5)	-*	0.8	(0.6- 1.2)	-*
BMI 3rd quartile	0.8	(0.5- 1.3)	-*	1.0	(0.7- 1.5)	(1.0)#
BMI 4th quartile	1.5	(1.0- 2.3)	10.9	1.4	(1.1- 1.8)	10.0
Model with ROA ≥ 3						
Hip pain	2.7	(1.7- 4.4)	12.4	3.4	(2.5- 4.7)	28.7
Knee pain	2.7	(1.8- 4.1)	17.9	2.1	(1.6- 2.8)	16.9
Morning stiffness	5.5	(3.0- 10.3)	17.1	5.0	(3.3- 7.6)	25.6
Hip ROA	2.1	(0.9- 4.9)	(2.8)#	4.4	(2.6- 7.4)	16.9
Knee ROA	2.7	(1.2- 5.9)	4.5	2.4	(1.4- 4.1)	6.0
BMI 1st quartile	0.9	(0.6- 1.5)	-*	0.9	(0.6- 1.2)	-*
BMI 3rd quartile	0.8	(0.5- 1.3)	-*	1.1	(0.8- 1.5)	(2.2)#
BMI 4th quartile	1.5	(1.0- 2.3)	10.3	1.7	(1.2- 2.3)	14.4

aOR = Odds ratio adjusted for all variables in the model.
95% CI = 95% Confidence interval of aOR.
EF = Etiologic fraction = p(aOR-1)/{p(aOR-1) + 1}.

*: aOR < 1.
#: aOR not significantly higher than 1.

DISCUSSION

This survey among people aged 55 years and over living independently in the general population is the first to study the influence of pain and radiological osteoarthritis of the hips and knees on the occurrence of disability in the activities of daily living related to lower limb function. Contrary to our expectations the independent effect of mild radiological osteoarthritis of the hips and knees is absent in men and only minor in women.

In the multiple logistic regression analysis the musculoskeletal parameters had a much greater impact (higher etiologic fractions) on the activities of daily living related to lower limb function in women compared to men. The explanation could be that in men other disabling conditions such as intermittent claudication, heart failure, angina and chronic respiratory disease play a dominant role.[18]

The main source of bias in our study is selection-bias. In the participants of the centre study the prevalence of locomotor disability was lower than in the interview study group, but the prevalence of joint pain was of the same magnitude in the two study groups. Among the 1,819 interviewed men locomotor disability occurred in 21.9% (95% CI: 20.0-23.8) and among the 2,817 interviewed women in 34.8% (95% CI: 33.0-36.6). The prevalence of joint pain, however, did not differ (hip pain and knee pain in the men of the interview-group 8.5% and 12.5%, respectively and in the women 16.4% and 22.6%, respectively). Comparison of the odds ratios for locomotor disability of hip and knee pain in both study groups revealed no significant differences. It is therefore likely that the reduction in size of the study group has occurred randomly. See also paragraph 5.1.

The classification of ROA according to the criteria of Kellgren is a widely used method in epidemiological studies on osteoarthritis, but their usefulness in clinical practice has been discussed. The American College of Rheumatology published criteria for osteoarthritis of the knee in 1986 and of the hip in 1991, often referred to as the Altman-criteria.[19,20] These clinical criteria all start with the presence of pain and require the equivalent of grade 2 in the Kellgren grading system and for the knee one of three additional criteria: age $>$ 50 years, stiffness $<$ 30 minutes, or crepitus. The age criterion is fulfilled by all our respondents. A recent population based study on the validity of several sets of classification criteria of osteoarthritis of the knee showed high percentages of agreement between the Altman clinical and radiographic criteria and Kellgren grade 2+ with pain.[21] The combination of joint-specific pain and ROA2 in our study can therefore be considered to represent symptomatic or clinical osteoarthritis. Although the odds ratios for locomotor disability of clinical OA vary between 3 and 7 (figure 4.3.2.) they are essentially not different from the odds ratios of pain only or of ROA3 only. Except for the higher prevalence rates of signs and symptoms it is not clear why these variables associate better with locomotor disability in women than in men. Neither can the better overlap between joint pain and radiological osteoarthritis in women be explained.

With regard to the knee our data are comparable with those from the Framingham Study, the National Health and Nutrition Examination Survey-I Epidemiologic Follow-up Study (NHEFS), and a British study among community dwelling elders in Bristol.[4-10] For signs and symptoms of the hip they are unique.

The findings of the *Rotterdam Study* make it clear that although locomotor disability is a prevailing problem in an ageing population, signs and symptoms of the musculoskeletal system can only partly explain its presence. Of the people with locomotor disability only a third or less have joint pain or radiological osteoarthritis of the hips or knees. On the other hand people who do suffer from pain either or not combined with ROA are three to sevenfold as often disabled. Overweight in women increases this risk even more.

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4.4 THE ASSOCIATION BETWEEN LOCOMOTOR DISABILITY AND PHYSICAL ABNORMALITIES OF THE HIPS AND KNEES

ABSTRACT

The aim of the present analysis was to assess the influence of abnormalities on physical examination of the hips and knees on disability in activities of daily living.

During a home interview in the population-based *Rotterdam Study* 1,156 men and 1,739 women aged 55 years and over were asked about locomotor disability (LD) by means of six questions of the Health Assessment Questionnaire (HAQ). Range of motion (ROM) of the hips and knees, varus- and valgus-deformity and ligamental stability of the knees were assessed by physical examination at the research centre of the *Rotterdam Study*.

The prevalence of locomotor disability was 20.2% for men and 31.9% for women. The prevalence of moderately restricted ROM was 34.5% for men and 38.6% for women. Less than 10% of the participants had instable knees. Varus-deformity in men (10.1%) and valgus-deformity in women (15.0%) were the most common deformities. The age-adjusted odds ratio (OR) for locomotor disability of restricted flexion of the hip or knee varied for men from 4.7 (95 % CI 3.2-6.8) to 4.8 (3.0-7.7) and for women from 3.5 (2.7-4.5) to 3.2 (2.4-4.4). The OR of varus-deformity in men was 0.5 (0.3-0.9), of valgus-deformity in women 1.8 (1.3-2.4) and of knee instability in women 1.7 (1.1-2.4). Adjustment of these odds ratios for morning stiffness and pain in the relevant joint did not alter these estimates. Multiple logistic regression showed that restricted flexion of the hips was the most important physical abnormality to predict locomotor disability.

We conclude that in epidemiologic population-surveys on the association between locomotor disability and abnormalities on physical examination of the hips and knees among people aged 55 years and over only flexion of the hips and knees are worthwhile investigating.

INTRODUCTION

In paragraphs 4.2. and 4.3 we demonstrated the role of signs and symptoms of the lower limb joints on the occurrence of locomotor disability (LD) as evaluated by the Stanford Health Assessment Questionnaires in an unselected population of 55 years and older (the *Rotterdam Study*).[1-3] Locomotor disability was present in a fifth of the men and a third of the women and was associated with female sex, increasing age, living in a home for the elderly, low education and low income.[4] Suffering from pain in the hips, knees or feet and from morning stiffness with a duration of more than half an hour were strongly

associated with locomotor disability,[3] but radiological osteoarthritis of the hips and knees had only a small independent effect on the occurrence of disability. Symptomatic osteoarthritis, defined as pain and radiological osteoarthritis in the corresponding joint, was strongly associated with locomotor disability.[2] To a certain extent symptomatic osteoarthritis will be reflected in abnormalities observed on physical examination of the joints. But also in people without this condition a restricted range of motion of the hips or knees can be expected to cause more difficulties in the activities of daily living. Furthermore instability of the knee joints and a valgus-or varus-deformity could diminish one's ability to carry out such common functions as rising from a chair or climbing stairs.

The present study analyzed in 2,895 people of the *Rotterdam Study* the association between locomotor disability and restricted range of motion of the hips and knees, valgus-deformity and varus-deformity, instability of the knee joint and pelvic obliquity.

POPULATION AND METHODS

Population

The study-group of this analysis is identical to the one presented in the previous paragraph (4.3). We studied the 1,156 men and 1,739 women of whom complete data on locomotor signs and symptoms were available.

Methods

The assessment of locomotor disability (LD) was as has been described in paragraph 4.1.[4]

Pain of the hips and knees was defined as joint pain during the past month at the left and/or right side. The definition of morning stiffness was: stiffness of the joints when rising from bed in the morning and lasting for at least half an hour.[2]

At the research centre one of ten physicians examined both hips and knees. In supine position internal and external rotation of the hips, flexion of the hips and knees, and the ligamental apparatus of the knees were tested. Restriction in range of motion (ROM) was expressed in five grades, in which 0 means no restriction, 1 = doubtful, 2 = mild restriction (less than 20% restriction of the normal ROM), 3 = moderate restriction (20-60% restriction) and 4 = severe restriction (more than 60% restriction). Much effort was put in instruction and training of the physicians who for purposes of physical examination were all initially coached and standardized by an experienced orthopaedic surgeon. The cruciate and collateral ligaments of the knees were tested for instability. In case of a positive anterior drawer test, special attention was given to left and right comparison. The same procedure was followed with a positive lateral or medial stress test.

With the participant standing upright, barefoot and without trousers or dress, valgus-

and varus-deformity was assessed. The physicians were instructed to draw an imaginary line down from midway the groin through the centre of the patella towards the floor; if the medial malleolus was lateral of this line the participant was classified as having a valgus-deformity (knock-knee); if the lateral malleolus was medial of the line the knee was considered to be in a varus position (bow-leg). Pelvic obliquity, regardless of its cause, was tested by placing the thumps on the spinae iliacae anteriores superiores and deciding whether the line between the thumps was in a horizontal plane.

Data analysis

All analyses were performed for men and women separately. We first estimated the prevalence of locomotor disability and abnormalities on physical examination. All figures represent abnormalities in the left and/or right joint. Secondly age-adjusted odds ratios for locomotor disability of all physical examination variables were estimated using a multiple logistic regression model. In view of the results of the logistic regressions discussed in table 4.4.3. the cutoff for the prevalence of restricted range of motion was set at moderate severity (i.e. more than 20%).

To assess the influence of joint pain and morning stiffness all odds ratios for locomotor disability were subsequently adjusted for joint pain in the relevant joint and for morning stiffness.

Finally age, joint pain, morning stiffness, and the physical examination variables were entered together in a multiple logistic regression model of locomotor disability to estimate adjusted odds ratios and etiologic fractions for all independent variables. The etiologic fraction (EF) is defined as the proportion of disabled persons which is attributable to the determinant of interest.[5] The EF was calculated using the same formula as described in paragraph 4.2. In this analysis all variables were dichotomized using no or only mild restriction of ROM as the reference category for all ROM-variables. In the analysis the variable 'knee-deformity' was categorized in men as 0 = no deformity, 1 = varus-deformity and in women as 0 = no deformity, 1 = valgus-deformity.

Restriction of the original interviewed study group by non-response and missing data on physical examination had no effect on the age-distribution of the study group. There were more divorced and unmarried men and women in the restricted group as compared to the home situation and the women of the small group were higher educated than all interviewed women. There were no differences in educational level in men, in mean net annual income and whether the participant lived alone or with other people in men and women.

Table 4.4.1. Prevalence (%) of restriction in range of motion of the hips and knees, instability and deformity of the knees and obliquity in men and women by age.

		Men						Women					
Age group (years)		55-64	65-74	75-84	85 +	Total		55-64	65-74	75-84	85 +	Total	
Number		404	501	234	17	1156		589	684	416	50	1739	
		%	%	%	%	%	(95% CI)	%	%	%	%	%	(95% CI)
Locomotor Disability		11.1	19.8	34.2	58.8	20.2	(17.9- 22.5)	15.8	30.4	51.0	82.0	31.9	(29.7- 34.1)
Restricted range of motion													
Hip													
Flexion	mild	10.7	15.0	15.9	11.8	13.7	(11.7- 15.7)	12.5	18.8	22.5	30.0	17.9	(16.1- 19.7)
	moderate	8.0	11.4	19.0	29.4	12.0	(10.1- 13.9)	8.9	15.1	22.7	26.0	15.1	(13.4- 16.8)
	severe	1.7	1.6	4.7	11.8	2.4	(1.5- 3.3)	2.7	4.8	8.7	18.0	5.4	(4.3- 6.5)
Endorotation	mild	16.9	18.6	20.7	17.6	18.4	(16.2- 20.6)	16.8	21.0	22.0	10.0	19.5	(17.6- 21.4)
	moderate	15.4	19.8	22.0	11.8	18.6	(16.4- 20.8)	13.0	17.6	26.8	24.0	18.4	(16.6- 20.2)
	severe	3.7	9.0	14.7	35.3	8.7	(7.1- 10.3)	4.3	7.3	12.1	28.0	8.0	(6.7- 9.3)
Exorotation	mild	17.4	18.0	18.5	11.8	17.8	(15.6- 20.0)	15.2	19.4	21.5	22.0	18.5	(16.7- 20.3)
	moderate	13.2	17.0	20.7	17.6	16.4	(14.3- 18.5)	13.5	17.7	24.4	24.0	18.1	(16.3- 19.9)
	severe	2.7	8.0	10.3	35.3	7.0	(5.5- 8.5)	3.6	5.9	10.9	20.0	6.7	(5.5- 7.9)
Knee													
Flexion	mild	9.0	14.4	15.5	35.3	13.0	(11.1- 14.9)	12.5	18.5	22.0	32.0	17.7	(15.9- 19.5)
	moderate	3.0	6.4	11.2	29.4	6.5	(5.1- 7.9)	5.3	10.4	16.9	22.0	10.6	(9.2- 12.0)
	severe	0.2	1.2	3.9	0.0	1.4	(0.7- 2.1)	1.2	2.6	4.6	14.0	2.9	(2.1- 3.7)
Instability knee ligaments													
Anterior cruciate		8.7	8.4	7.3	5.9	8.2	(6.6- 9.8)	8.5	8.6	5.3	10.0	7.8	(6.5- 9.1)
Medial collateral		4.2	5.2	5.1	5.9	4.8	(3.6- 6.0)	7.3	9.9	7.9	6.0	8.5	(7.2- 9.8)
Lateral collateral		5.4	6.2	3.8	11.8	5.5	(4.5- 6.5)	8.8	9.8	6.7	10.0	8.7	(7.4- 10.0)
Deformity of the knee													
Valgus		3.5	3.0	8.5	0.0	4.2	(3.0- 5.4)	10.9	15.6	18.3	28.0	15.0	(13.3- 16.7)
Varus		7.2	11.4	11.1	29.4	10.1	(8.4- 11.8)	2.0	3.7	6.0	10.0	3.9	(3.0- 4.8)
Obliquity		10.1	10.2	10.7	0.0	10.1	(8.4- 11.8)	12.9	11.1	16.6	30.0	13.6	(12.0- 15.2)

RESULTS

Table 4.4.1. gives the prevalence of locomotor disability and abnormalities on physical examination of the hips and knees in men and women. Endo- and exorotation were the most prevalent restricted ranges of motions. Moderate and severe restriction of range of motion increased with age in both men and women, as does lateral instability. In men an increase with age of varus-deformity and in women of deformities of the knee as well as obliquity was observed. Severe restriction of motion occurred in 1.4% to 8.7% of the men and in 2.9% to 8.0% of the women. Instability of the knee joint as expressed by laxity of the ligaments of the knees was a rather uncommon finding, less than 10% of the men and women had instable knees. Valgus-deformity in men and varus-deformity in women are present in about 4%, but varus-deformity in men (bow-legs) and valgus-deformity in women (knock-knees) are two to three times as common. Pelvic obliquity while standing is somewhat more common in women than in men.

Table 4.4.2. Prevalence (%) of abnormalities on physical examination of the hips and knees in men and women by age.

Age group (years)	55-64	65-74	75-84	85 +	Total	
MEN Number	404	501	234	17	1156	
Restricted range of motion (*)	%	%	%	%	%	(95% CI)
Flexion hip	9.7	13.0	23.7	41.2	14.4	(12.4-16.4)
Endorotation hip	19.1	28.8	36.7	47.1	27.3	(24.7-29.9)
Exorotation hip	15.9	25.0	31.0	52.9	23.4	(21.0-25.8)
Flexion knee	3.2	7.6	15.1	29.4	7.9	(6.3-9.5)
ROM hip	25.2	35.5	44.4	52.9	34.0	(31.3-36.7)
ROM hip + knee	25.5	35.9	45.7	52.9	34.5	(31.8-37.2)
Instability knee ligaments	12.9	12.8	11.1	11.8	12.5	(10.6-14.4)
Abnormalities knee	17.6	21.8	18.8	35.3	19.9	(17.6-22.2)
Abnormalities total	41.6	52.7	57.3	76.5	50.1	(47.2-53.0)
WOMEN Number	589	684	416	50	1739	
Restricted range of motion (*)						
Flexion hip	11.6	19.9	31.4	44.0	20.5	(18.6-22.4)
Endorotation hip	17.3	24.9	38.9	52.0	26.4	(24.3-28.5)
Exorotation hip	17.1	23.6	35.3	44.0	24.8	(22.8-26.8)
Flexion knee	6.5	13.0	21.5	36.0	13.5	(11.9-15.1)
ROM hip	25.6	35.8	50.5	58.0	36.5	(34.2-38.8)
ROM hip + knee	26.8	38.7	52.2	62.0	38.6	(36.3-40.9)
Instability knee ligaments	16.6	18.3	14.4	18.0	16.8	(15.0-18.6)
Abnormalities knee	17.5	21.5	19.2	22.0	19.6	(17.7-21.5)
Abnormalities total	43.5	52.0	65.9	80.0	53.2	(50.9-55.5)

(*) : at least moderate restriction
ROM hip = restricted flexion and/or endorotation and/or exorotation
ROM hip + knee = restricted ROM hip and/or flexion knee
Abnormalities knee = restricted flexion knee and/or valgus/varus, and or instability knee ligaments
Abnormalities total = abnormalities knee and/or restricted ROM hip and/or obliquity

Table 4.4.2. presents the prevalence figures of composite measures. Restriction of endo- and exorotation of the hips was observed in about a quarter of the men and women, but the figures for restricted flexion of the hips and knees are two to three times less. The composite measures 'ROM hip' and 'ROM hip + knee' amounted to more than a third of the men and women. Most prevalence figures for the composite measures increased steeply with age, in women more so than in men, but instability of the knees is stable with age in both sexes. It was present in 12.5% of the men and 16.8% of the women. A fifth of the men and women had some abnormality on physical examination of the knees and half on examination of both hips and knees.

Table 4.4.3. presents the age-adjusted odds ratios for locomotor disability of the abnormalities on physical examination in men and women in detail.

Table 4.4.3. Age-adjusted odds ratios for locomotor disability of abnormalities on physical examination.

	Men			Women		
Hip						
Flexion mild	2.3	(1.5-	3.5)	1.3	(0.9-	1.7)
moderate	4.0	(2.7-	6.1)	2.8	(2.1-	3.7)
severe	9.7	(4.2-	22.3)	6.7	(4.0-	11.2)
Endorotation mild	1.2	(0.8-	1.8)	1.0	(0.8-	1.4)
moderate	1.5	(1.0-	2.2)	1.9	(1.4-	2.5)
severe	4.2	(2.6-	6.8)	3.7	(2.5-	5.6)
Exorotation mild	1.2	(0.8-	1.8)	1.1	(0.8-	1.5)
moderate	2.0	(1.3-	2.9)	1.7	(1.2-	2.2)
severe	3.2	(1.9-	5.3)	4.1	(2.7-	6.4)
Knee						
Flexion mild	1.4	(0.9-	2.2)	1.2	(0.9-	1.6)
moderate	3.9	(2.4-	6.5)	2.9	(2.1-	4.1)
severe	15.3	(4.2-	55.6)	4.6	(2.4-	8.9)
Instability anterior	0.9	(0.5-	1.5)	1.7	(1.1-	2.4)
medial	1.4	(0.7-	2.7)	1.6	(1.1-	2.3)
lateral	1.1	(0.6-	2.1)	1.8	(1.2-	2.5)
Valgus-deformity	1.5	(0.8-	2.8)	1.8	(1.3-	2.4)
Varus-deformity	0.5	(0.3-	0.9)	1.5	(0.9-	2.5)
Obliquity	1.4	(0.9-	2.2)	1.9	(1.4-	2.5)

The most striking differences between men and women in table 4.4.3. are the odds ratios for deformities of the knee, instability and obliquity. In men varus-deformity (bow-legs) was negatively associated with locomotor disability, suggesting that it protects men from getting disabled. Valgus-deformity (knock-knees), laxity of the knee ligaments and obliquity of the iliac crest were risk factors for locomotor disability in women but not in men. Mild restriction of range of motion was either not or only weakly associated with locomotor disability. For this reason we presented prevalence figures of at least moderate restriction in the table with composite measures (table 4.4.2.) and decided to estimate odds ratios at this cutoff-point.

Table 4.4.4. Age-adjusted odds ratios and 95% confidence intervals (between brackets) for locomotor disability of abnormalities on physical examination.

	Men			Women		
Restricted range of motion (*)						
Flexion hip	4.7	(3.2-	6.8)	3.5	(2.7-	4.5)
Endorotation hip	2.2	(1.6-	3.0)	2.4	(1.8-	3.0)
Exorotation hip	2.3	(1.7-	3.3)	2.1	(1.6-	2.7)
Flexion knee	4.8	(3.0-	7.7)	3.2	(2.4-	4.4)
ROM hip	2.4	(1.7-	3.3)	2.7	(2.1-	3.4)
ROM hip + knee	2.6	(1.9-	3.7)	2.9	(2.3-	3.8)
Instability knee ligaments(#)	0.9	(0.6-	1.5)	1.5	(1.1-	2.0)
Abnormalities knee	1.0	(0.7-	1.5)	2.0	(1.5-	2.6)
Abnormalities total	1.9	(1.3-	2.7)	2.7	(2.0-	3.5)

(*): ROM dichotomized: 0 = no restriction, 1 = at least moderate restriction.
(#): Ligaments dichotomized: 0 = no laxity, 1 = any laxity.

Table 4.4.4. illustrates the influence of low prevalence on measures of association in composite measures: although the odds ratios of restricted flexion of the hips and knees are, especially in men, higher than of restricted endo- and exorotation, the odds ratios of restricted 'ROM hip' and restricted 'ROM hip + knee' are close to the odds ratios of (the more prevalent) restricted endo- and exorotation.

To assess the influence of joint pain and morning stiffness all odds ratios of the composite measures were subsequently adjusted for these variables. Morning stiffness did not alter the odds for disability of abnormalities on physical examination. Pain in the relevant joint had only a minor influence, which was not significant. For instance the age-

adjusted odds ratio of restricted flexion of the hip in men decreased form 4.7 (95% CI: 3.2-6.8) to 4.1 (2.8-6.0) when adjusted for hip pain. (Data presented in tables 4.4.1.a. and 4.4.2.a. in Appendix E).

Table 4.4.5. presents the results of the multiple regression model. Both in men and women morning stiffness, joint pain and restricted flexion of the hips are independently significantly associated with locomotor disability. Additional associated variables in men were restricted flexion of the knees and varus-deformity be it that varus-deformity was negatively associated. In women restricted endorotation, valgus-deformity, obliquity of stature and instability of the knees were all weak independent associates of locomotor disability.

Table 4.4.5. Adjusted odds ratios and etiologic fractions for locomotor disability adjusted for age, joint complaints, and abnormalities on physical examination

	Men			Women		
	aOR	95% CI	EF	aOR	95% CI	EF
Hip pain	2.3	(1.4- 3.8)	9.5	3.6	(2.6- 4.9)	30.3
Knee pain	2.7	(1.7- 4.1)	17.3	2.1	(1.6- 2.8)	19.4
Morning stiffness	5.2	(2.7- 9.7)	16.0	4.8	(3.1- 7.3)	24.4
Flexion hip	2.2	(1.4- 3.6)	14.7	1.9	(1.3- 2.7)	15.3
Flexion knee	2.0	(1.1- 3.5)	7.0	1.4	(0.9- 2.0)	(4.7)#
Endorotation	1.1	(0.7- 1.8)	(3.4)#	1.5	(1.0- 2.2)	11.8
Exorotation	1.0	(0.6- 1.8)	(0.9)#	0.9	(0.6- 1.3)	-*
Knee-stability	0.9	(0.6- 1.6)	-*	1.3	(1.0- 1.8)	5.4
Valgus/varus	0.5	(0.3- 0.9)	-*	1.4	(1.0- 2.0)	5.8
Obliquity	1.4	(0.8- 2.3)	(3.4)#	1.4	(1.0- 1.9)	4.5

aOR = Odds ratio adjusted for all variables in the model.
95% CI = 95% Confidence interval of aOR.
EF = Etiologic fraction = p(aOR-1)/{p(aOR-1) + 1}.

*: aOR < 1.
#: aOR not significantly higher than 1.

Categorical values:
Range of motion: 0 = normal, 1 = at least moderate reduction of ROM. Knee-stability: 0 = normal, 1 = anterior drawer and/or stress-tests positive. Valgus/varus: 0 = absent, 1 in men = varus, 1 in women = valgus. Obliquity: 0 = absent, 1 = present.

DISCUSSION

In the present study we demonstrated the association of findings on physical examination of the hips and knees with locomotor disability (LD). LD occurred in a fifth of the men and in nearly a third of the women. The most prevalent abnormalities on physical examination were restriction of the inward and outward rotation of the hips in men as well as in women (about 25%). Moderate restricted flexion of the hips and knees was two to three times less common.

The odds ratios for locomotor disability of restricted flexion of the hips and knees were however higher than of restricted endo- and exorotation of the hips. The prevalence of other abnormalities on physical examination is much lower. Of these findings varus-deformity (bow-legs) in men proved to be negatively associated with locomotor disability. In women valgus-deformity, instability of the knee and obliquity were weak predictors of locomotor disability. The estimation of the etiologic fractions showed that, when joint complaints and findings on physical examination are analyzed together, knee pain, morning stiffness and restricted flexion of the hips attribute the most to the occurrence of locomotor disability in men. In women the same variables as well as hip pain and restricted endorotation attribute to this occurrence.

A source of bias in our study is selection-bias: not all participants of the interview were part of the present study either due to non-response (8%) or to missing data (30%). The prevalence of locomotor disability in the reduced study group is somewhat lower than the figure for all interviewed participants: for the 1,819 men the prevalence of locomotor disability was 21.9% (95% CI: 20.0-23.8) as compared to 20.2% (17.9-22.5) in the reduced study group. The prevalence of locomotor disability for the 2,817 interviewed women was 34.8% (95% CI: 33.0-36.6) as compared to 31.9% (29.7-34.1). Selection of participants as the result of the eight percent non-response to the invitation to visit the research-centre reduced the prevalence estimates of self-reported locomotor disability, but did not significantly influence the prevalence estimates of joint pain and morning stiffness. The further reduction of the study group because of missing data occurred more or less randomly as it did not materially change the prevalence estimates nor the odds ratios for locomotor disability of joint pain and morning stiffness in comparison to the results of the analyses on all interviewed participants.[6] See also paragraph 5.1.

In follow-up studies of individual *patients* it is common use to measure range of joint motion with a goniometer. If however more than one physician examines the same patient this method is subject to considerable inter-observer variation. In epidemiologic surveys it would also be preferred to have one physician carry out all measurements. In large-scale studies like the *Rotterdam Study*, where the physician has only a restricted amount of time to carry out all assessments, this is not a practical demand. In order to reduce inter-observer variation and fulfil the tight time-schedule an alternative way of measuring range

of motion of the joint is to asses *restriction* in broad categories. Earlier studies have shown that by grading ROM in rather broad categories inter-observer variation could be minimized and reproducibility enhanced.[7,8] Complete standardisation of all measurements would have been preferred, but this was not a realistic achievement. We therefore put much effort in instruction and training of the physicians. To that goal all ten participating physicians were trained by an experienced orthopaedic surgeon to minimize inter-observer variation. Furthermore we restricted the assessments to a rather coarse approach. The assessment of obliquity, for example, is by no means considered to prove a difference in length of the legs, but a rather crude way to assess possible problems with stature. In evaluating the results of the physical examination for each individual physician some doctors presented higher than average prevalence rates and some lower. The relative distribution over the ranges of restricted motion however, remained the same for each physician. Because the invitation of participants occurred in a random manner it is not likely that some physicians saw more participants with abnormalities than others. Introducing more physicians therefore increases the variance but probably leaves the mean of all physicians as a fair estimate of the prevalence intact. This is substantiated by the fact that the odds ratios of restricted range of motion in the upper part of table 4.4.3 regularly go up with increasing severity of restricted range of motion.

There are not many population-bases studies to compare our results with. The study among people aged over 70 years in Massachusetts, United States, presented a prevalence of reduced flexion of the hips and knees of 16% in men and 29% in women.[9] The study among people aged 79 years in Göteborg, Sweden, reported that 67% of the participants had 'fairly good' flexion of the hips and 80% of the knees.[10] Of the participants with joint complaints 84% had a restricted range of motion of the hips and 19% a restricted range of motion of the knees. They also reported a strong correlation between restricted ROM of the hips and climbing stairs and between restricted ROM of the knees and rising from a chair and climbing stairs.[11]

The major conclusion of the present study is that on physical examination restricted flexion of the hips and knees is the most important independent determinant of disability of the lower limb functions. Other joint functions such as endo- and exorotation of the hips and laxity of the ligaments of the knee are more difficult to examine and are only associated with locomotor disability in women. We therefore propose to restrict in epidemiologic population-surveys the assessment of limitation of joint motion to flexion of the hips and knees.

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CHAPTER 5

PARTICIPATION AND MEASUREMENTS

5.1 INFLUENCE OF NON-PARTICIPATION AND OTHER FORMS OF SELECTION ON PREVALENCE AND ASSOCIATION ESTIMATES

ABSTRACT

To assess the influence of selection-bias due to non-response and other forms of cohort-reduction prevalence estimates of locomotor disability and associations between joint complaints and disability were compared in three groups of participants of a population survey among independently living people aged 55 years and over (the *Rotterdam Study*). The *interviewgroup* was defined as the participants of the home interview (1,819 men and 2,817 women); the *centregroup* was defined by the participants who visited the research-centre two weeks after the interview (1,690 men and 2,577 women). Finally, the *locomotorgroup* was defined as the participants of whom complete data with respect to locomotor signs were available (1,156 men and 1,739 women). The prevalence of locomotor disability (LD) as assessed by six questions of the Stanford Health Assessment Questionnaire (HAQ) in the *interviewgroup* was not significantly higher than in the *centregroup*, and the prevalence of locomotor disability in the *locomotorgroup* was not significantly different from either of the former two. The prevalences of joint pain and morning stiffness and the odds ratios for locomotor disability of joint pain and morning stiffness were not affected by the reductions of the studygroup.

INTRODUCTION

The impact of bias due to non-participation and other forms of selection is an issue of great importance in epidemiologic research. In population surveys the estimates of occurrence of disease and determinants and consequently the estimates of effect can be greatly influenced by non-response and misclassification of disease- and exposure-status.[1] The present study investigated the influence of non-response and observer-induced restriction of the studygroup using the results of the *Rotterdam Study*. This population survey invited people aged 55 years and over to participate in a home interview, and to visit the research centre for further physical and laboratory examination.[2] In the present analysis we studied the influence of study-group attrition by comparing estimates of prevalence and association of disability and joint complaints for all participants of the home interview with the estimates for the smaller group of centre-visitors. Our a priori hypotheses were that non-participation would influence the estimates of prevalence in that people with major difficulties in the activities of daily living related to lower limb

function and those with pain in their joints are more likely to refuse to visit the research centre than those with less disability and pain. Because of the strong association between joint pain and disability reported in paragraph 4.2, we expected the selection of participants due to non-response to be equal for the outcome- and determinant-status (i.e. disability and joint pain), the odds ratios for disability of jointpain were therefore not expected to be affected dramatically.[3]

POPULATION AND METHODS

Population

The *Rotterdam Study* is a prospective follow-up study of the incidence and risk factors of chronic disease and disability in persons aged 55 years and over in the general population. The source population comprises all inhabitants aged 55 years and over on the first of January 1989 living in the Ommoord district of Rotterdam. Included are the inhabitants of the six homes for the elderly in the district.[2] Baseline-data on all 10,275 eligible people were gathered from April 1990 to July 1993.

The present study is concerned with those participants who were approached between April 1990 and July 1992. At this stage of the study 2,247 men and 3,433 women living independently were invited to participate; 1,830 men (81.4 percent) and 2,834 women (82.6 percent) took part in the home interview. Complete interview data were available of 1,819 men (81.0 percent) and 2,817 women (82.1 percent); these participants constitute the *interviewgroup*.

In the second phase of the study, the participants were invited to visit the research centre; the average time between the interview and the visit to the centre was two weeks. Of the interviewed men and women respectively 1,690 (92.9 percent) and 2,577 (91.4 percent) visited the centre. This group is referred to as the *centregroup*.

For logistic reasons the study started with a restricted amount of measurements at the centre; during the first year of the study gradually more measurements were added. For the study on the relationship between disability and locomotor signs and symptoms this meant that complete data were available of 1,156 men and 1,739 women; the *locomotorgroup* therefore represents 63.6 percent of the men and 61.7 percent of the women of the original interviewgroup.

Methods

The disability study of the *Rotterdam Study* investigated the association of locomotor disability with, among others, joint complaints. Locomotor disability was defined as proposed by the International Classification of Impairments Disabilities and Handicaps (ICIDH) and composed of the relevant items from the ambulation subcategory, i.e. walking, climbing stairs, getting in and out of bed and a car, bending, and rising from a chair.[4] To assess disability the Stanford Health Assessment Questionnaire (HAQ) was used.[5,6] An extensive description of the HAQ and the way it was administered during a home interview carried out by one of our nine extensively trained research-assistants, who were standardized on a regular basis, has been presented in paragraph 4.1. Locomotor disability (LD) is defined as the mean of the scores on the six questions of the HAQ most related to lower limb function. The cutoff for disability was 0.50; the rationale for this cutoff-point is that this level indicates that the participants has at least some difficulty in at least three out of six functions.

Locomotor complaints assessed at the interview that could possibly be associated with locomotor disability were joint pain and morning stiffness. Joint pain was defined as joint pain during the past month left and/or right in the joints of the hips and/or knees and/or feet. Morning stiffness was defined as stiffness of the joints when rising from bed in the morning and lasting for at least half an hour. The assessment of these joint complaints is discussed in paragraph 4.2.

Data analysis

Data analysis started with the comparison of the prevalences of interview-assessed disability and joint complaints between the *interviewgroup*, the *centregroup* and the *locomotorgroup*. Subsequently age-adjusted odds ratios for locomotor disability of joint complaints in the three groups were compared.

Data analyses were performed for men and women separately. Univariate chi-square statistics were used to compare the distribution of demographic variables between the *interviewgroup* and those people who refused to visit the centre or were removed from the studygroup by us. To test for differences in the prevalence of locomotor disability and joint complaints between the *interviewgroup*, the *centregroup* and the *locomotorgroup*, age-adjusted Mantel Haenszel chi-square tests were used.

The age-adjusted odds ratios for locomotor disability of joint pain and morning stiffness were estimated with a multiple logistic regression model.

Table 5.1.1. Some baseline characteristics of the participants of the *Rotterdam Study*

	Interviewgroup	*Centregroup*	*Locomotorgroup*
Men Number	1819	1690	1156
Age			
range	55.0 - 94.3 yr	55.0 - 94.3 yr	55.0 - 93.2 yr
mean age	68.9 (± 0.2) yr	68.5 (± 0.2) yr	68.6 (± 0.2) yr
Marital status			
married	1466 (80.6%)	*** 1375 (81.4%)	*** 929 (80.4%)
widowed	202 (11.1%)	175 (10.4%)	112 (9.7%)
divorced	89 (4.9%)	82 (4.9%)	65 (5.6%)
unmarried	62 (3.4%)	58 (3.4%)	50 (4.3%)
Living situation			
alone	236 (16.2%)	* 211 (12.6%)	151 (13.2%)
not alone	1571 (83.8%)	1468 (87.4%)	994 (86.8%)
missing	12	11	11
Educational level			
primary	700 (39.9%)	**** 628 (38.5%)	431 (38.6%)
secondary	877 (49.9%)	834 (51.1%)	566 (50.7%)
college/university	179 (10.2%)	169 (10.4%)	120 (10.7%)
missing	63	59	39
Women Number	2817	2577	1739
Age			
range	55.0 - 95.6 yr	55.0 - 95.6 yr	55.0 - 94.0 yr
mean age	69.7 (± 0.2) yr	69.2 (± 0.2) yr	69.4 (± 0.2) yr
Marital status			
married	1341 (47.6%)	**** 1258 (46.8%)	**** 816 (46.9%)
widowed	1018 (36.1%)	887 (34.4%)	609 (35.0%)
divorced	205 (7.3%)	192 (7.5%)	135 (7.8%)
unmarried	253 (9.0%)	240 (9.3%)	179 (10.3%)
Living situation			
alone	1215 (43.4%)	** 1094 (42.6%)	770 (44.5%)
not alone	1586 (56.6%)	1472 (57.4%)	959 (55.5%)
missing	16	11	10
Educational level			
primary	1586 (58.5%)	*** 1427 (57.5%)	961 (57.0%)
secondary	1002 (36.9%)	934 (37.6%)	640 (37.9%)
college/university	125 (4.6%)	122 (4.9%)	86 (5.1%)
missing	104	94	52

* $p < 0.01$
** $p < 0.025$
*** $p < 0.005$
**** $p < 0.0005$

RESULTS

Demographic data

Table 5.1.1. shows some demographic characteristics of the participants of the *Rotterdam Study*. There were no significant differences in the age-distribution of the three study-groups. The numbers of people who, after finishing the interview, refused to visit the research centre, i.e. the true non-responders were 129 (7.1 percent) for men and 240 (8.5 percent) for women.

Among the men who refused to come to the centre there were less married and more widowed and divorced men than among the men who did visit the centre. Men who did not visit the centre lived more often alone and had more often only primary education. Among the women who refused to visit the research-centre there were less married, divorced and unmarried women and more widowed women, more women with only primary education and more living alone.

The differences in the distributions of the demographic variables between the *interview-group* and the *locomotorgroup* are smaller. As can be seen in table 5.1.1. there are more divorced and unmarried men and women among the members of the *locomotorgroup*. The distributions of the other demographic variables in this group were not significantly different from those of the people who were, because of refusal or incompleteness of data, no part of this group.

Data on disability and joint complaints

The prevalence estimates of locomotor disability (LD) and of joint complaints assessed at the interview for the three groups are presented by age in table 5.1.2.a for men and 5.1.2.b. for women. In men nor women the prevalence values for locomotor disability of the *centregroup* were significantly different from the values of the *interviewgroup*. The prevalence of locomotor disability in the *locomotorgroup* was not significantly different from the frequencies in the two other groups either. The prevalence-estimates of joint pain and morning stiffness were also not affected by response and selection. The prevalence of locomotor disability among people who refused to visit the centre was 48.1% for men and 59.1% for women (table 5.1.a. in Appendix E). But the prevalences of joint pain and morning stiffness among the people who refused to visit the centre were not significantly different from the values of the *interviewgroup*. The prevalences of locomotor disability and joint complaints in the people who were excluded from the analyses after visiting the research centre were not significantly different from the values presented in table 5.1.2.

Table 5.1.2.a. Prevalence (%) of locomotor disability and joint complaints in independently living men by age and studygroup.

Age group (years)	55-64			65-74			75-84			85 +			Total		
Study-group	I	C	L	I	C	L	I	C	L	I	C	L	I	C	L
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Number	635	612	404	756	709	501	385	339	234	43	30	17	1819	1690	1156
Locomotor Disability	10.1	10.0	11.1	21.0	19.2	19.8	37.1	34.8	34.2	74.4	70.0	58.8	21.9	19.9	20.2
95 % CI													(20.0- 23.8)	(18.0- 21.8)	(17.9- 22.5)
Jointpain															
Any joint-site	18.7	19.1	19.8	20.1	19.5	19.2	22.1	22.1	23.1	30.2	26.7	29.4	20.3	20.0	20.3
95 % CI													(18.5- 22.1)	(18.1- 21.9)	(18.0- 22.6)
One joint-site	14.2	14.5	14.9	15.6	15.2	15.0	17.4	17.7	18.8	27.9	23.3	23.5	15.8	15.6	15.8
95 % CI													(14.1- 17.5)	(13.9- 17.3)	(13.7- 17.9)
Two joint-sites	3.8	3.8	4.0	3.8	3.7	3.6	4.2	3.8	3.8	2.3	3.3	5.9	3.8	3.7	3.8
95 % CI													(2.9- 4.7)	(2.8- 4.6)	(2.7- 4.9)
Three joint-sites	0.8	0.8	1.0	0.7	0.6	0.6	0.5	0.6	0.4	0.0	0.0	0.0	0.7	0.7	0.7
95 % CI													(0.3- 1.1)	(0.3- 1.1)	(0.2- 1.2)
Morning stiffness	4.1	4.2	5.2	4.8	4.4	4.2	5.2	5.3	4.7	4.7	6.7	0.0	4.6	4.6	4.6
95 % CI													(3.6- 5.6)	(3.6- 5.6)	(3.4- 5.8)

Any joint-site = hip and/or knee and/or foot
One joint-site = hip or knee or foot
Two joint-sites = hip and knee, or hip and foot, or knee and foot
Three joint-sites = hip and knee and foot

I = Interviewgroup
C = Centregroup
L = Locomotorgroup

Table 5.1.2.b. Prevalence (%) of locomotor disability and joint complaints in independently living women by age and studygroup.

Age group (years)	55-64			65-74			75-84			85 +			Total		
Study-group	I	C	L	I	C	L	I	C	L	I	C	L	I	C	L
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Number	947	909	589	1083	1009	684	665	577	416	122	82	50	2817	2577	1739
Locomotor Disability	17.3	16.5	15.8	33.4	32.3	30.4	53.7	51.5	51.0	79.7	79.3	82.0	34.8	32.5	31.9
95 % CI													(33.0- 36.6)	(30.7- 34.3)	(29.7- 34.1)
Jointpain															
Any joint-site	32.4	32.7	32.3	37.0	38.1	37.9	34.9	35.0	35.6	36.6	35.4	34.0	34.9	35.4	35.3
95 % CI													(33.1- 36.7)	(33.6- 37.2)	(33.1- 37.5)
One joint-site	22.3	22.6	23.3	25.2	26.0	25.9	24.2	25.1	24.8	22.8	20.7	20.0	23.9	24.4	24.6
95 % CI													(22.3- 25.5)	(22.7- 26.1)	(22.6- 26.6)
Two joint-sites	8.2	8.1	7.6	9.4	9.6	9.2	9.5	9.0	10.1	12.2	13.4	14.0	9.2	9.1	9.0
95 % CI													(8.1- 10.3)	(8.0- 10.2)	(7.7- 10.3)
Three joint-sites	1.9	2.0	1.4	2.4	2.5	2.8	1.2	0.9	0.7	1.6	1.2	0.0	1.9	1.9	1.7
95 % CI													(1.4- 2.4)	(1.4- 2.4)	(1.1- 2.3)
Morning stiffness	8.6	8.4	7.6	9.1	9.0	8.3	9.8	10.2	9.6	11.4	12.2	14.0	9.2	9.2	8.6
95 % CI													(8.1- 10.3)	(8.1- 10.3)	(7.3- 9.9)

Any joint-site = hip and/or knee and/or foot
One joint-site = hip or knee or foot
Two joint-sites = hip and knee or hip and foot or knee and foot
Three joint-sites = hip and knee and foot

I = Interviewgroup
C = Centregroup
L = Locomotorgroup

Table 5.1.3. shows the age-adjusted odds ratios for locomotor disability of joint pain and morning stiffness in the three groups. The odds ratios and the 95% confidence intervals are of the same magnitude in all groups.

Table 5.1.3. Age-adjusted odds ratios and 95% confidence intervals (between brackets) for locomotor disability of joint pain and morning stiffness in the three studygroups.

	Interviewgroup	*Centregroup*	*Locomotorgroup*
Men Number	1819	1690	1156
Joint pain			
Any joint-site	3.5 (2.7- 4.6)	3.3 (2.5- 4.4)	3.6 (2.6- 5.1)
One joint-site	2.4 (1.8- 3.3)	2.3 (1.7- 3.2)	2.6 (1.8- 3.7)
Two joint-sites	5.1 (3.0- 8.6)	4.8 (2.8- 8.2)	5.2 (2.8- 9.9)
Three joint-sites	8.7 (2.6-29.0)	8.1 (2.3-28.1)	6.2 (1.5-25.7)
Morning stiffness	7.6 (4.7-12.4)	7.1 (4.3-11.7)	6.5 (3.6-11.8)
Women Number	2817	2577	1739
Joint pain			
Any joint-site	4.6 (3.8- 5.5)	4.7 (3.9- 5.7)	4.4 (3.5- 5.6)
One joint-site	2.5 (2.0- 3.0)	2.5 (2.0- 3.0)	2.3 (1.8- 2.9)
Two joint-sites	4.8 (3.6- 6.5)	4.8 (3.5- 6.5)	5.0 (3.5- 7.3)
Three joint-sites	5.6 (3.0-10.3)	5.5 (2.9-10.2)	7.3 (3.2-16.7)
Morning stiffness	6.9 (5.1- 9.4)	6.5 (4.8- 8.9)	6.5 (4.4- 9.6)

Any joint-site = hip and/or knee and/or foot
One joint-sit = hip or knee or foor
Two joint-sites = hip nad knee, or hip and foot, or knee and foot
Three joint-sites = hip and knee and foot

DISCUSSION

In this study we have demonstrated the influence of non-participation and attrition on prevalence and effect estimates in a population survey among people aged 55 years and over. Selection of participants due to the invitation to visit a research centre after completing a home interview did not decline the prevalence estimates of locomotor disability as assessed by six questions on lower limb function of the HAQ, nor did it

influence the prevalence estimates of joint pain and morning stiffness significantly. A further reduction of the study-group because of missing data proved to have been occurred randomly: there was no significant change in prevalence estimates nor odds ratios for locomotor disability. These findings can be considered reassuring for researchers in population surveys on locomotor disability in the elderly. Although the non-responders are more disabled and indicate slightly less joint complaints the effect of a small non-response of seven to eight percent on the estimates of occurrence and association appear to be minor.

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5.2 SELF-ASSESSED VERSUS PHYSICIAN-ASSESSED DISABILITY AND PAIN

ABSTRACT

Estimates of prevalence and association of self-assessed and physician-assessed disability and joint pain of 2,895 independently living participants aged 55 years and over of the *Rotterdam Study* were compared to assess the influence of different measurement-tools. The studygroup was defined as the participants who visited the research centre two weeks after the interview excluding those with incomplete centre-data. The prevalence of joint pain of the hips, knees or feet assessed by a physician was significantly lower than the prevalence of the self-assessed jointpain. The percentage agreement between self- and physician-assessed joint pain was 83.3% for men and 74.2% for women, with Kappa-values of about 0.40. The prevalence of locomotor disability based on testing by a physician was also significantly lower than the self-assessed disability; the percentage agreement between the self-assessed disability and the tests was 82.6% for men and 77.7% for women, with Kappa-values varying between 0.41 and 0.47. The associations between physician-assessed disability and pain were weaker than between self-assessed disability and pain.

INTRODUCTION

The impact of bias due to misclassification of determinants and outcome is an issue of great importance in medical research. In epidemiologic population surveys the estimates of occurrence of disease and determinants and consequently the estimates of effect can be largely influenced by misclassification of disease- and exposure-status.[1] The present study investigated the influence of different measurement tools on some occurrence and association measures in the *Rotterdam Study*. This population survey invited people aged 55 years and over to participate in a home interview, and to visit the research centre for further physical and laboratory examination.[2] The repeatability of the questions on joint pain were studied by comparing the results of the home interview with those obtained at second questioning in the research centre. The self-reported disability from the interview was compared with the corresponding physician-assessed disability by means of accessory tests. We hypothesized that the influence of measurement tools would be minor as far as the questions related to joint pain were concerned, but that major differences would occur between self-assessed and physician-assessed disability.

POPULATION AND METHODS

Population

The present study was carried out within the group of participants of the *Rotterdam Study* of whom complete data on locomotor disability and its determinants were available. As was pointed out in paragraph 5.1. this was the case for 1,156 men and 1,739 women, 63.9% and 61.7%, respectively of the originally interviewed men and women.

Methods

Self-assessed disability

Locomotor disability in the *Rotterdam Study* was defined as proposed by the International Classification of Impairments Disabilities and Handicaps (ICIDH) and composed of the relevant items from the ambulation subcategory.[3] Disability during a home interview was assessed by the Stanford Health Assessment Questionnaire (HAQ).[4,5] Self-assessed locomotor disability is defined as the mean of the scores on the six questions of the HAQ most related to lower limb function. The cutoff for disability was 0.50; the rationale for this cutoff-point is that this level indicates that the participants has at least some difficulty in at least three out of six functions. The methods used during the interview are described extensively in paragraph 4.1.

Self-assessed joint complaints

Locomotor complaints assessed at the interview that could possibly be associated with locomotor disability were joint pain and morning stiffness. Joint pain was defined as joint pain during the past month left and/or right in the joints of the hips and/or knees and/or feet. Morning stiffness was defined as stiffness of the joints when rising from bed in the morning and lasting for at least half an hour. The assessment of these joint complaints is discussed in paragraph 4.2. Although the question on morning stiffness was not repeated during the visit at the research centre this variable was used in the analyses to obtain results which could be compared with previous analyses.

Physician-assessed disability

At the research centre one of the ten participating physicians assessed locomotor disability by carrying out three tests. Participants were asked to rise from an armless straight chair (sitting hight: 45 cm). While standing the examiner placed a paper towel on the floor and the participant was asked to pick it up. Next the participants was asked to sit down on a low chair with arm-rests (sitting hight: 37 cm, arm rests at 58 cm) and to rise from it. Although a researchassistant assessed difficulty in climbing up and down eight steps (steps 19 cm apart) this test of disability in this study is called physician-assessed. All test-

scores were identical to the question-scores of the HAQ; i.e. ranging from zero to three. Physician-assessed locomotor disability was calculated as the mean of the scores on the four tests, and the cutoff for disability was again 0.50.

Physician-assessed joint pain

The questions on joint pain were repeated by the physician, using the same phrasing as in the interview.

Data analysis

Data analysis started with the comparison of self-assessed disability and joint pain versus physician-assessed disability and joint pain in terms of prevalence, percentage agreement, Kappa's and odds ratios. All analyses were performed for men and women separately. For all variables which were measured during the interview as well as during the visit to the research centre the percentages agreement and Kappa's were calculated. The Kappa is the amount of actual agreement defined as the percentage of the total agreement that occurs beyond the contribution by chance.[6]

Finally age, joint pain and morning stiffness were entered together in a multiple logistic regression model of locomotor disability to estimate adjusted odds ratios and etiologic fractions for all independent variables. The etiologic fraction (EF) is defined as the proportion of disabled persons which is attributable to the determinant of interest.[7] The EF was calculated using the same formula and the same reference categories as described in paragraph 4.2.

Table 5.2.1. Prevalence (%) of self-assessed (s) and physician-assessed (p) locomotor disability and pain.

Age group (years)	55-64		65-74		75-84		85 +		Total	
Assessment	s %	p %	s %	p %	s %	p %	s %	p %	s %	p %
Men Number	404		501		234		17		1156	
Locomotor Disability	11.1	4.9	19.8	12.2	34.2	28.8	58.8	52.9	20.2	13.6
95 % CI									(17.9- 22.5)	(11.5-15.7)
Joint pain	19.8	13.4	19.2	14.8	23.1	15.4	29.4	23.5	20.3	14.5
95 % CI									(18.0- 22.6)	(12.5-16.5)
Women Number	589		684		416		50		1739	
Locomotor Disability	15.8	10.3	30.4	21.0	51.0	42.1	82.0	63.8	31.9	23.7
95 % CI									(29.7- 34.1)	(21.2-26.2)
Joint pain	32.3	23.6	37.9	25.1	35.6	25.2	34.0	18.0	35.3	24.4
95 % CI									(33.1- 37.5)	(22.4-26.4)

RESULTS

In table 5.2.1. the prevalence-figures of self-assessed locomotor disability and joint pain during the interview (s) and physician-assessed disability and pain at the research centre (p) are given. When comparing these estimates all prevalence-figures of physician-assessed disability and joint pain were significantly lower than those based on self-assessed disability and joint pain.

A comparison between self-assessed and physician-assessed disability in four separate functions is given in table 5.2.2. In both men and women the greatest differences in prevalences were found for rising from a high chair, followed by climbing stairs.

Table 5.2.2. Prevalence (%) of self-assessed (s) and physician-assessed (p) disability in the separate functions in men and women by age.

Age group (years)	55-64		65-74		75-84		85 +		Total	
Assessment	s %	p %	s %	p %	s %	p %	s %	p %	s %	p %
Men Number	404		501		234		17		1156	
Bending	13.4	7.0	15.4	13.2	22.2	23.5	23.5	47.1	16.2	13.6
Rising high chair	9.9	2.2	16.8	5.3	27.4	15.5	23.5	50.0	16.6	6.9
Rising low chair/car	10.1	5.1	14.6	11.4	33.8	26.9	41.2	62.5	17.3	13.1
Climbing stairs	10.6	2.8	20.6	10.4	36.8	29.9	82.4	42.9	21.3	11.7
Women Number	589		684		416		50		1739	
Bending	15.6	10.7	23.6	21.1	38.2	32.4	54.0	55.6	25.3	21.3
Rising high chair	12.4	5.7	23.5	12.3	40.1	25.5	70.0	48.9	25.1	14.3
Rising low chair/car	14.8	10.1	29.7	21.4	50.7	36.7	76.0	57.8	31.0	22.3
Climbing stairs	24.5	13.3	38.6	24.7	58.2	47.0	84.0	73.7	39.8	26.4

Self-assessed and physician-assessed disability and self-reported joint pain assessed during the interview and two weeks later by the physician at the research centre were compared and expressed as percentage agreement and Kappa-values in table 5.2.3. In men the percentages agreement and the Kappa's were higher than in women.

Table 5.2.3. Percentage agreement and Kappa's (K) between self-assessed and physician-assessed joint pain and disability.

	Men		Women	
	% agreement	K	% agreement	K
Joint pain	83.3	0.423	74.2	0.392
Disability				
Bending	83.5	0.347	78.6	0.392
Rising high chair	83.9	0.247	80.8	0.386
Rising low chair	83.4	0.347	78.2	0.434
Climbing stairs	82.3	0.344	74.9	0.421
$LD_{6/4}$	84.4	0.450	80.3	0.507
$LD_{4/4}$	82.6	0.409	77.7	0.466

$LD_{6/4}$ = Self-assessed LD based on 6 functions compared with physician-assessed LD based on 4 functions.
$LD_{4/4}$ = Self-assessed LD compared with physician-assessed LD both based on 4 functions.

The associations between disability and joint complaints, as expressed by the age-adjusted odds ratios given in table 5.2.4., were weaker for the physician-assessed findings in the research centre than for the self-assessed results of the home-interview.

Table 5.2.4. Age-adjusted odds ratios and 95% confidence intervals (between brackets) for self-assessed (s) and physician-assessed (p) locomotor disability of joint pain and morning stiffness.

	Men		Women	
	s	p	s	p
Joint pain	3.6 (2.6- 5.1)	3.0 (2.0- 4.7)	4.4 (3.5- 5.6)	3.6 (2.8-4.8)
Morning stiffness	6.5 (3.6-11.8)	2.2 (1.0- 4.8)	6.5 (4.4- 9.6)	4.5 (3.0-6.7)

Table 5.2.5. presents the results of the multiple logistic regression analysis of self-assessed locomotor disability and pain assessed at the interview and of physician-assessed locomotor disability and pain evaluated in the centre together with morning stiffness. Only pain attributes considerably to the occurrence of locomotor disability in both sexes and situations. The adjusted odds ratios and etiologic fractions of pain and morning stiffness are much higher for self-assessed disability than for observed disability.

Table 5.2.5. Adjusted odds ratios and etiologic fractions for self-assessed and physician-assessed locomotor disability.

	Self-assessed Disability			Physician-assessed Disability		
	aOR	95% CI	EF	aOR	95% CI	EF
Men						
Pain any joint-site	3.4	(2.4- 4.8)	33.1	3.0	(2.0- 4.7)	25.5
Morning stiffness	5.6	(3.0- 10.4)	17.5	2.0	(0.9- 4.3)	(4.2 #)
Women						
Pain any joint-site	4.1	(3.2- 5.2)	52.1	3.4	(2.6- 4.5)	40.1
Morning stiffness	5.4	(3.6- 8.2)	27.6	3.7	(2.4- 5.6)	18.2

aOR = Odds ratio adjusted for all variables in the model.
95% CI = 95% Confidence interval of aOR.
EF = Etiologic fraction = p(aOR-1)/{p(aOR-1) + 1}.
#: aOR not significantly higher than 1.

DISCUSSION

This study evaluated the influence of different methods to assess disability and joint pain on the prevalence and effect estimates in a population-survey among people aged 55 years and over. Questions on joint pain during a home interview carried out by non-medical research-assistants resulted in a much higher prevalence than the same questions asked by a physician at the research-centre two weeks later. The relatively high percentages of disagreement of 17% to 26% for joint pain with kappa values of about 0.40 indicate a considerable change in joint pain status over time. If we assume that at least one third of the population aged 55 years and over who report pain in their lower limb joints suffer from osteoarthritis in those joints it could be anticipated that a proportion of people with pain in these joints during the interview are indeed free of pain two weeks later and vice versa. Pain in osteoarthritis is known to fluctuate in time. The medium low Kappa's indicate that, because it 'adjusts' the percentage agreement for the size of each cell, the disagreement between the self-assessed pain and disability and the physician-assessed pain and disability of about 16% in men and 20% to 25% in women is considerably large. The discrepancy between self-assessed disability and tests of disability can in part be explained by the significantly lower prevalences of the physician-assessed disability. It must be noted that the test on rising from a low chair was compared with the question on getting out of a car of the HAQ. This comparison was used because the Kappa's between rising

from a low chair and getting in and out of a car were higher than the Kappa's for the comparison with the question on getting in and out of bed.

Others published a tendency for physicians to report less pain than paramedical research assistants or the patients themselves.[8] Previous studies on the correlation between self-reported disability assessed by questionnaire and interviewer assessed disability showed a tendency for participants to indicate more disability on the self-reported questionnaire than during an interview.[4,8,9] It is also known that people with severe chronic disabling diseases like rheumatoid arthritis tend to overestimate there ability to carry out the various tasks, while 'healthy' elderly people overrate the restrictions old age puts on them. The net effect is a high self-reported disability and a relatively low physician-assessed disability. Spearman correlations for the agreement between self-reported disability on questions of the HAQ and testing of disability are reported to vary from 0.77 to 0.94 ($p < 0.001$) dependent on the type of study (population-based or patient-based) and the type of functions (upper extremity or lower extremity functions).[4,5,10] However, the discrepancy between self-reported and observed disability in our study was considerably larger than in studies with rheumatoid arthritis patients.[5,10] Another explanation could be that our physicians, who were all relatively young, did have much more experience with seriously ill people during their medical education than with the relatively healthy elderly participants of the *Rotterdam Study*. The Framingham Study reported that among 1,453 participants of the study aged 63 to 94 years, self-assessed disability was greater than observed disability; 89% of the time or more a difference between the two modes of assessment was identified.[9]

The fact that the odds ratios for observed disability of joint complaints were somewhat lower than the odds ratios for self-reported disability suggests that self-reported disability is a better indicator of the association between disability and joint complaints. The results from the Framingham Study pointed in the same direction as ours. In this study age, sex and cognitive decline were all significantly associated with self-assessed disability, but not with observed disability.[9]

From a public health point of view the individual's impression of his ability to carry out the activities of daily living is more relevant than the judgment of disability by his physician. We therefore consider the Health Assessment Questionnaire a superior instrument to study determinants and consequences of locomotor disability than physician-observed disability by means of accessory tests.

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CHAPTER 6

GENERAL DISCUSSION

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INTRODUCTION

As a result of the dramatic reduction in infant, childhood and young adult mortality and the otherwise increased life expectancy the proportion of people above the age of 55 years has doubled in the Netherlands between 1900 and 1990.[1] The gain in longevity has gone hand in hand with an increase of the number of elderly people suffering from chronic diseases which seemingly inevitably accompany advancing age. Simultaneously with the growing number of economically inactive people, a heavy financial burden is put on society because of the increasing utilisation of the health care system.

Illness, but also old age itself, leads to disability in performing one's daily duties, which in turn requires more support and care from the medical and social environment. Disability exceeds illness and disease in that it reflects the person's inability of coping with the simple demands of life irrespective the underlying cause of his infirmities. One of the possible approaches to cope with a decrepit ageing population is to focus on 'compression of morbidity'.[2,3] The idea is that when onset of disease is postponed quality of life of the elderly may be enhanced.

In the World Health Organisation's definition of 1947 health is called the 'state of complete physical, mental and social well-being', which is more than the absence of disease or infirmity and implies a high perception of the quality of the individual's life.[4] From an epidemiologic point of view a prolonged duration of life along with a high quality of life is an important aspect of health outcome and at the same time is of interest as a determinant of outcome. Conceptually quality of life remains ill-defined. It is some aggregate representation of psychological and somatic distress, discomfort and disability resulting from illness and/or medical action.[5] In this concept disability can be considered as a part of the total complex which constitutes quality of life.

THE CONCEPT OF DISABILITY

It was the aim of this thesis to investigate the relationship between musculoskeletal signs and symptoms and locomotor disability. Although some research on this subject has been carried out, especially in the United States of America, the major drawback of almost all published disability studies is the lack of uniformity in outcome measures.

Disability has been described as broadly as 'any restriction of activity' up to as detailed as 'not able to perform an activity (e.g. walking) without personal assistance'. The debate on what constitutes disability and how it should be assessed and classified is still going

on. In common parlance the word disability indicates a loss or impairment of a bodily function.[6] In his manual of the classification relating to the consequences of disease, the *International Classification of Impairments, Disabilities, and Handicaps* by order of the World Health Assembly in 1976, the definition proposed by Dr Philip HN Wood is: any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.[7]

Hence, in medical practice the term disability is based on an activity-related definition. When an impairment does not lead to any loss in ability to perform certain activities there is no disability. Objectively a person with a correctable visual impairment is capable to perform all the activities he needs to carry out and is not disabled, but subjectively this individual will be disabled when his glasses get scattered in an accident. A cello-player with a traumatised left pink is objectively and subjectively disabled, but still could adapt the fingering to the impairment and would be able to continue on the stage. This is the core of the debate on disability.

Can disability be defined in an incontestable way? Is there room in the definition for the subjective opinion of the individual? There will be little discussion about major impairments and their consequences, such as in the case of the completely blind individual and the cello-player who lost power of her hands because of multiple sclerosis.[8] Likewise rheumatoid arthritis patients will suffer from their impairment, not only because they must endure a lot of pain, but it restricts them in having a 'normal' life. But what about the patient with mild osteoarthritis? He will certainly have some pain now and then, but there will be days that he is not bothered by his impairment at all. Can he be considered disabled, just because he has to restrict his activities on some days? And what about old age? It stands not to reason to label all elderly citizens as disabled, although they are indeed less capable to perform certain activities than they used to be. This is where the addition 'considered normal' leaves room for discussion. Does normality include a person's desire to perform activities he likes to carry out? It is not possible to set bounds between 'normal' and 'abnormal' ability.

The definition of disability, accurate as it is, will remain a concept affected by subjective interpretation. If we in our study on disability among people aged 55 years and over in the general population, state that we consider a disability to be present if a person says to experience 'at least some difficulty with a certain activity', we incorporate the subjective interpretation of that individual's desire of the way he would like to perform that activity. This is true for the disability assessment in other studies as well.

The idea that subjectivity can be bypassed by testing people's abilities to carry out certain activities is a wrong train of thought. As disability by definition impedes the affected it is of no interest to him what someone else, however professional he may be, thinks of his disability. The disabled person has to cope with his situation, both in a

subjective and objective way. The only valid reason to test someone's capability to carry out activities of daily living is for adjustments of the personal environment. By doing so one is able of placing the shelves of a cupboard at a level which can be reached by this particular patient with a 'frozen shoulder'. Or on a larger scale, to advise public transport companies on the level of platforms or steps on the busses, in order to accommodate elderly people with restricted flexion of hips and knees.

ASSESSMENT OF DISABILITY

In rheumatologic practice one of the first approximations of the assessment of disability was the index developed by Steinbrocker, Traeger and Batterman in 1949. For decades this measure proved to be helpful, however crude it was, in grading rheumatoid arthritis patients in four levels of increasing disability in the activities of daily living.[9] The 'Index of ADL' developed by Katz et al in 1963 ranks patients in eight categories according to their adequacy of performance in six functions.[10] The major drawback of these indices is that they have very low sensitivity and therefore are not usable in epidemiologic population surveys.

In 1980 two measures of 'Health Status' were published: the Stanford Health Assessment Questionnaire (HAQ) and the Arthritis Impact Measurement Scales (AIMS).[11,12] Fries et al developed the HAQ as a five-dimensional health-status measure including death, discomfort, disability, drug toxicity and dollar cost.[11,13,14] The AIMS of Meenan et al was constructed from two previously validated health-status measures: Bush's Index of Well-Being,[15] and the Rand Health Insurance Study batteries.[16] It incorporates physical function and psychological status.[17,18] The validity of both instruments has been demonstrated in patients as well as in general populations. In large scale population-surveys the HAQ proved to be the most useful instrument to assess locomotor disability, mainly because it is most easy to administer, either during an interview or as a self-assessed questionnaire. It only takes about five minutes to complete the HAQ-questionnaire, while the AIMS takes about twenty minutes.

The *Rotterdam Study* used the HAQ to assess disability. The cutoff for disability in our study was 0.50, meaning that there were at least some difficulties in four out of the eight components of the Disability Index, three out of the six functions of the Locomotor Disability Index (LDI) or five out of the nine functions in the Upper Limb Disability Index. A cutoff of 1.00 was considered to indicate severe disability as it represents some difficulties in all components or functions or much difficulties in half of the components or functions. Two thirds of the participants with severe locomotor disability scored between 1.00 and 1.50 on the LDI. Half of these scores belonged to people who answered 'with little difficulty' on four to five questions and 'with much difficulty' on one question while the other half expressed both little and much difficulty in two to three functions.

The HAQ has been used in an interview mode and self-administered. Both approaches proved to be reliable in test-retest assessments.[11] However, interviewers might bias the answers by their personal opinion about the subject's capability to perform certain activities, which invalidates the validity in comparison with the individual's selfreported interpretation of his disability. Applying the HAQ in an interview-mode therefore needs careful and ongoing training of the interviewers to avoid interviewer' bias.

We recommend the self-assessed questionnaire to be used in those studies in which few participants with serious cognitive or depressive impairments are expected to occur, or to ask a next of kin to complete it. When disability has to be assessed in mentally disabled patients the use of proxy-participants should be taken into consideration. Other studies applying more complicated health-status measures have shown that 'significant others', usually the partner or a child, can give valid answers to most of these questions.[19]

MEASURING OCCURRENCE

In the *Rotterdam Study* disability was assessed regardless of the presence of underlying objective impairment or disease. In his subjective assessment the participant to the study could therefore declare himself disabled merely because of old age and his ability to cope with it. People who are satisfied with the way they become older might therefore consider themselves much less disabled than people who would like to stay physically as capable as if they were at thirty years.

A study on the occurrence of disease and disability should preferably be carried out in a population group which is representative of the total population of this age group in the Netherlands. The first goal of the *Rotterdam Study*, however, was to investigate risk factors of disease and disability. For that reason a stable population sample was selected which was large enough to study the incidence of some relatively rare conditions of old age like Alzheimer's disease, but did not focus primarily on the issue of representativity. It was calculated that a population size of at least 8,000 persons would be necessary. The Ommoord district fulfilled this requirement as well, as almost 11,000 people aged 55 years and over lived in the district on January 1, 1988. The fact that the distribution of the demographic variables in the Ommoord study population proved to be comparable with the total Dutch population of 55 years and over was reassuring (paragraph 4.1).

The extent to which the requirement of representativity is fulfilled depends on the ultimate goals of the study. If one wishes to advice public health officials on issues like future needs of health care and social services for the elderly like nursing homes, it is relevant to have figures from a representative sample of the total Dutch population of elderly. If the main goal is to investigate risk factors, in order to advice on possible intervention-strategies, the representativeness of the study group is less important.

MEASURING OUTCOME

All large scale population based studies which for logistic reasons require multiple observers to collect data are subject to unavoidable inter-observer bias. The *Rotterdam Study* opted to collect all questionnaire data by means of an interview at the participant's home as it was desired to include as many cognitively impaired persons as possible in view of the study of risk factors for dementia. For that reason the interview contained a cognitive test and questions concerning depressive illness. Cognitively impaired participants were excluded from the study on disability for the obvious reason that their answers on the HAQ were not considered to be reliable.

In the case of interviewers inter-observer bias can be minimized by regular standardization rounds and application of a strict protocol. When there is no need for interviewers self-administered questionnaires such as the HAQ would be preferred. The answers should then be checked for inconsistencies in the presence of the respondent. This approach is less expensive and overcomes the problem of varying observers in a long lasting prospective study when the outcome measure has to be repeated. The change of observers over time will for certain introduce a greater inter-observer variation and consequently misclassification of participants than is the case with a steady group of observers.

The ability to carry out certain functions can also be evaluated by an observer but is inherently subject to observer bias and is difficult to standardize. Furthermore, this way of 'objective' assessment of disability concerns a completely different concept, results in a lower prevalence and is less associated with putative determinants of disability than self-reported disability (paragraph 5.2).

MEASURING DETERMINANTS

Irrespective the manner the data are collected the reproducibility of the answers to questions about joint pain and morning stiffness are difficult to study in a test-re-test design when these complaints are of short duration and can disappear and start again in a few weeks time such as is the case with early osteoarthritis. This makes it necessary to collect simultaneously data on the determinant and the outcome measure. Pain in the hips and knees was assessed during the interview. The interviewers were trained to distinguish between muscle pain and joint pain, but when complaints in the hip region were present misclassification could have occurred as it is difficult for non-medical interviewers to decide whether indeed the hip joint was the origin of the complaints. Although additional detailed information on the quality and quantity of the pain was collected and more detailed classification of the nature of the pain eventually could have enhanced the association with disability it simultaneously reduces the reproducibility of the answers and the number of people qualifying for the analysis.

The evaluation of radiographs is subject to considerable interobserver variation. This could be overcome by blinding the observer to the data of the respondent, applying a strict evaluation protocol and introducing two independent readers of the films. In case of discrepancy between the two a consensus reading will yield the decisive score. After some training and experience the number of discrepant results amounts to less than ten percent of the films.

Physical examination by doctors is even more difficult to standardize, irrespective the organ system involved. As with evaluating X-rays one observer during the whole study period would be most preferred but this is an impractical demand in large-scale and follow-up studies. Standardization rounds should therefore be regularly scheduled. They reduce inter-observer variation, be it for a short period. Misclassification remains considerable. Some physicians consistently tend to higher scores, others to lower. Their mean score for a certain sign most likely is a fair estimate of the true prevalence, but the variance of this mean is large.

When the measurement of restriction of joint motion is required as in our study two alternatives are available. In clinical practice a goniometer is used and the restriction is expressed in degrees. For follow-up studies of individual patients by their own doctor this is a reliable method. When more observers get involved in measuring joints of different subsets of individuals a better approach is the crude assessment of restriction of joint motion in three or four grades of increasing severity (e.g. normal, less than 20%, 20 to 60% and more than 60% restriction). Furthermore the physical examination should preferably be restricted to those measurements which are least subject to observer variation. In the case of lower limb joints this would be flexion restriction of both the hips and the knees. These variables also proved to associate best with disability.

STUDY RESULTS

The results of our study showed that locomotor disability, defined as difficulties in six functions most related to the lower limbs, is a common condition in people aged 55 years and over. In this age-group a fifth of the men and a third of the women reported to experience at least some difficulties with three out of the six activities concerned. This finding was in concordance with the results of other studies in the Netherlands and abroad.

At the open population level the prevalence of locomotor disability reflects nearly totally the sum of disability in the upper and lower limbs and in the back. Among disabled women 84.3% were classified as disabled in the lower limb functions; of the remaining 15.7% (159 women) only 33 (3.3% of all disabled) were disabled in the upper limb functions only. Among the disabled men 80.2% had locomotor disability and only 4

(1.0% of all 398 disabled men) had upper limb disability only. Participants with combined lower and upper limb disability had a higher mean score on the disability index than the mean score for the total population, but the mean score for people who only scored on locomotor disability was the same as the population mean. This means that in this population upper limb disability mainly occurs in people who are seriously disabled and that neglect of the small amount of people with upper limb disability only (0.2% of all men and 1.2% of all women in the study group) will hardly influence the estimates of occurrence and association.

The HAQ was initially developed to study disability in rheumatoid arthritis patients. In these patients the hands are often primarily affected and are therefore more likely to experience difficulties in the activities of the upper limbs than the 'average' elderly without this serious disease. As rheumatoid arthritis occurs in 2 to 5% of the total population above the age of 55 years the proportion of people with upper limb disability only will be small and this will not occur very often without there being difficulties in the lower limbs as well. Why locomotor disability occurred more often in women and in lower educated people with a lower income is not clear.

In a final analysis which included all the musculoskeletal complaints, signs and symptoms presented in this thesis, we estimated that in men, in this order, knee pain, morning stiffness, restricted flexion of the hip, hip pain and restricted flexion of the knee attributed most to the occurrence of locomotor disability, but not radiological osteoarthritis grade 2 or more of the hips or knees (table 6.1).

Table 6.1. Rankorder, according to etiologic fractions of independent determinants of locomotor disability

	Men		Women	
	OA 2+	OA 3+	OA 2+	OA 3+
Hip pain	4	4	1	1
Knee pain	1	3	3	3
Morning stiffness	2	1	2	2
Hip-ROA	-	-	6	6
Knee-ROA	-	5	7	8
Flexion hip	3	2	4	4
Flexion knee	5	6	-	-
Endorotation	-	-	5	5
Exorotation	-	-	-	-
Knee-stability	-	-	9	-
Valgus/varus-deformity	*	*	8	7
Obliquity	-	-	-	-

- : not significantly associated with LD
* : inversely associated with LD

The data are given in tabel 6.1.a. in Appendix E

In women the order of independent determinants of disability was hip pain, morning stiffness, knee pain, restricted flexion of the hip, restricted endorotation of the hip, radiological osteoarthritis of the hip, radiological osteoarthritis of the knees, valgus-deformity and finally instability of the knees.

A model using radiological osteoarthritis grade 3 or more did not change essentially the order of the independent determinants, but in men radiological osteoarthritis grade 3 or more of the knees attributed to the occurrence of disability, while in women instability of the knees was no longer significantly associated with locomotor disability.

The major conclusions of this comprehensive analysis can be drawn. The role of radiological abnormalities of the knee and hip joints in determining disability is so minor that in future research radiographs of these joints can be omitted. Lower limb joint pain, morning stiffness, limited flexion of the hips or knees and deformities of the knees are all independent determinants of locomotor disability and relatively easy to measure. One could, however, refrain from the more difficult assessment of inward and outward rotation of the hips, as this hardly adds to the prediction of disability. Likewise the rough assessment of obliquity is of only limited importance for explaining disability in women.

RECOMMENDATIONS FOR FUTURE RESEARCH ON DISABILITY

The concept and assessment of disability

One major issue not addressed in the present study is the validity of self-assessed disability in the elderly regardless the presence of underlying impairments. As was suggested before, participants can declare themselves disabled merely because of old age. This might indicate the participant's inability to cope with getting older.

It would be worthwhile investigating the net effect of coping with old age on the assessment of disability. There are two ways to study this. Firstly one could ask the participant to indicate if his disability is caused by some underlying impairment, and if so which kind of impairment or disease. Another approach is to ask te participant if he is satisfied with his ability to carry out the respective function, as was presented in a Modified Health Assessment Questionnaire (see Appendix A), or alternatively to ask the respondent if he is able to cope with his disability.

Measuring occurrence

All available data on the prevalence of disability, including the present study, are more or less restricted to urban areas. In the Netherlands a study of the prevalence of disability in a rural area could reveal differences with the results of the *Rotterdam Study*. It is likely that in areas where family and social support are stronger than in a large city-district,

people consider themselves less often disabled. If, on the other hand, the availability of health care facilities plays a more dominant role people in rural areas could be more disabled.

A European concerted action on the prevalence of disability would give more insight in the effect of educational level and income on the distribution of disability, especially when more deprived societies, in which considerable differences in socio-economic status exist, are part of the study. The availability of health care and social services are quite different between countries. This may increase the differences in prevalence of disability even more. In order to get more insight in the influence of disease and impairments on the occurrence of disability the variability between countries in the prevalence of chronic diseases in old age may be valuable.

Apart from the need for more data on the prevalence of disability and associated factors studies on the incidence of disability are almost completely absent. It is therefore of great importance that future research will not restrict itself to the assessment of prevalence but will focus more on the follow-up of people. This would clearly enhance our knowledge on the occurrence and determinants of disability.

Measuring outcome

In future studies on disability the HAQ should be the measurement tool of first choice. As was stated before it is an easy and reliable instrument to use in large scale epidemiological studies, especially when administered in a self-assessed form. An attendant advantage of using this instrument in more population-based studies is that the study-results will be comparable.

The need for studies on observed disability is restricted to only a few research-questions. Observed disability is advisable if the research-questions are related to intervention strategies like adaptation of the personal environment or to advise to public health care systems.

Measuring determinants

The assessment of joint pain should preferably not be restricted to the mere existence of pain, but should include a more qualitative and quantitative assessment of pain as well, especially when the most prevalent arthritic disease of old age, osteoarthritis, is the subject of investigation. In the *Rotterdam Study* the quality of pain was assessed by asking for 'starting-pain', 'pain on exercise', 'pain at rest' and 'pain at night' and the frequency of these types of pain. Furthermore the assessment of the severity of pain by means of a 11-point box scale was part of the study. Analyses of these data will increase the understanding of the association of joint pain with disability.

In osteoarthritis research the scoring of radiographs according to the Kellgren grading-

system is the most common way to assess osteoarthritis. However, the X-rays of the present study were scored in more detail. As was described in paragraph 3.2.2. all radiographic features of osteoarthritis of the hips and knees were scored separately. The a priori rationale of these assessments was that the detailed information of the radiographs would give more insight in the contribution of osteoarthritis to disability. We thought that it would be likely that, although both classified as grade two osteoarthritis of the knee, someone with just one small osteophyte would experience less pain or disability than someone with large osteophytes at all joint-sites. Likewise the *amount* of joint space narrowing in the hips could have been of importance in the occurrence of pain and disability. However, the results of our study, as described in paragraph 4.3., indicated that the association between osteoarthritis and disability is very weak. Based on these results it can be questioned whether the detailed information of the radiographs will add to the understanding of the determinants of disability.

The effect on the validity of study results of reducing the physical examination of the joints to the coarse approach we choose has not been studied. Standardization of physicians is part of the standard protocol, but studies of interobserver variation are scarce. A drawback of our study is that we were not able to measure muscle strength, especially quadriceps strength as this sign was reported to be a significant determinant of locomotor disability.[21] This factor does need more investigation.

Although there is a strong risk of disability in people suffering from pain and morning stiffness in the joints of the lower limbs, the majority of people who reported some extent of locomotor disability does not have these complaints. In the study of the general population aged 55 years and over it is conceivable that locomotor disability is associated with impairments like intermittent claudication, heart failure, angina pectoris, ever having had a stroke, respiratory diseases and visual impairments.

Apart from physical impairments it is likely that psychological factors have an impact on the ability of people to carry out the activities of daily living. It is known from studies among rheumatoid arthritis patients that coping-strategies are very important to predict future outcome of disease and accompanying disability. There is no reason why people in the general population would not be subject to similar psychological factors. Ageing alone apparently is a burden to some, but not to others. It would be interesting to study the psychological aspects of coping with old age and of disability in old age especially.

Psychiatric impairments are even more difficult to study. The most important psychiatric impairment of old age is dementia. The nature of the cognitive impairments rules out the use of self-assessed questionnaires. In a case-control design the usefulness of answers from 'significant others' should be studied. If the data of cases and controls are assembled in the same way the real effect of cognitive impairments on the occurrence of disability can be measured. In this specific context it would be interesting to study the results of

questionnaire-data with observed disability. We demonstrated a large discrepancy between self-reported and observed disability in our study (paragraph 5.2), but it is unknown whether the answers from 'significant others' are equally different from observed disability.

Depressive mood and illness constitute the transition area between psychiatric and psychological disorders. In subjecting depressed people to self-assessed questionnaires on disability one should keep in mind that the depressive illness itself will lead to considerable disability. The prevalence of disability could be so high that it masks other sources of disability in these people. This should be further studied.

Intervention studies

The results of the present study have already suggested some possible ways for intervention. The finding that morning stiffness and restricted flexion of the hips are such important determinants of disability led us to the question if there is enough attention for the need for the elderly to keep in motion.

Before implementing these interventions, some studies should be carried out. Research-questions could be related to the availability of health care and social services. An example is a study of the effect of swimming under (therapist) guidance on the occurrence and development of locomotor disability in a randomized trial allocating people to a swimming group or not. It would be worthwhile to know if interventive action directed towards alleviation of pain of the hip and knee will diminish disability or even prevent it to occur.

The utilization of physiotherapist care is high among the elderly, but a scientific basis for a lot of exercises and other treatments offered by physiotherapists is completely lacking. It is of utmost importance that the decreasing financial means for an increasing group of people will be allocated towards meaningful treatments. If physiotherapists are not able to prove the value of their treatments it could be that the elderly will eventually be deprived of all physiotherapeutic care, including the effective ones.

A different perspective is the more psychological approach in which the inventory of coping-strategies may lead to possible interventions.

Conclusion

The quantitatively and qualitatively large impact of old age on the ability to maintain an independent life, demonstrated in this thesis, justifies future research on the occurrence and risk factors of disability in the activities of daily living. There is a great need for intervention-studies on this issue in order to develop a public health care system which can offer meaningful advise and treatment to elderly people suffering from the burden old age put on them.

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CHAPTER 7

SUMMARY

SUMMARY

Disability in the activities of daily living is a rather new topic in epidemiologic population-surveys among the elderly. As was described in *chapter 2* of this thesis the definition and classification of disability is and has been a matter of discussion in the past two decades. After reviewing the measurement-tools currently used in the study of the association between disability and locomotor signs and symptoms we concluded that in epidemiologic population-surveys among people aged 55 years and over the Stanford Health Assessment Questionnaire is the most suitable. The, mainly American, large-scale population studies on disability were reviewed in *paragraph 2.3*. This led to the conclusion that the prevalence of disability in the activities of daily living among people aged over 55 years are varies between eight and sixty-one percent, depending on the definition used and whether or not the subjects suffered from musculoskeletal signs and symptoms. Knee pain was found to be a strong predictor of present and future disability in all studies. The studies which used Kellgren-grade two as cutoff-point for osteoarthritis of the knee concluded that osteoarthritis alone did not increase the odds for disability substantially. Data on the association between hip complaints and disability are lacking.

The *Rotterdam Study* is a prospective follow-up study on the occurrence and risk factors of chronic disease and disability in a Dutch general population of 55 years and over. In *chapter 3* the design, including population and methods of the study, was described. Research-questions were categorized to four groups: neurogeriatric disease, cardiovascular disease, musculoskeletal disease and ophthalmologic disease. The chapter ends with a description of the response-rates to the study.

The aim of this theses was to investigate the occurrence of disability and especially locomotor disability and its associations with signs and symptoms of the lower limbs.

The prevalence of disability in 1,819 men and 2,817 women living independently and 82 male and 315 female residents of homes for the elderly was assessed by the Disability Index (DI) of the Health Assessment Questionnaire (HAQ). For the independently living participants overall disability was present in 21.9% of the men and in 36.0% of the women. The prevalence of locomotor disability (LD), as assessed by six questions of the HAQ, was 21.9% for men and 34.8% for women. The prevalence of upper limb disability (ULD), as assessed by nine questions of the HAQ, was 4.1% in men and

10.6% in women. The corresponding percentages for people living in homes for the elderly were DI: 84.0% in men, 96.5% in women; LD: 81.5% in men and 91.1% in women; ULD: 45.7% in men and 75.9% in women. Locomotor disability was associated with female sex, increasing age, living in a home for the elderly, low education and low income (*paragraph 4.1*).

In *paragraph 4.2* the association between locomotor disability and locomotor complaints was investigated. Because the residents of the homes for the elderly are considered to be independent of human assistance in carrying out the basic activities of daily living they are included in this analysis. The prevalence of locomotor disability in 1,901 men and 3,135 women was 24.5% and 40.5% respectively. The prevalence of joint pain in men was 0.7% for pain in the hips, knees and feet simultaneously, 3.7% for pain at two joint-sites, 16.0% for pain at one joint-site and 20.4% for pain in the hips and/or knees and/or feet (any joint-site); the corresponding estimates for women were 1.9%, 9.0%, 23.7% and 34.5% respectively. The prevalence of morning stiffness which lasted at least half an hour was 4.9% for men and 10.4% for women.

The age-adjusted odds ratios for locomotor disability in men ranged from 2.4 of pain at one joint-site to 8.8 of pain at all three joint-sites; for women the odds ratios varied between 2.5 and 5.7 respectively. The age-adjusted odds ratios of morning stiffness were 8.0 for men and 7.3 for women.

The contribution of radiological osteoarthritis of the hips and knees to locomotor disability was described in *paragraph 4.3*. Radiographs of hips and knees were scored according to the Kellgren grading-system for osteoarthritis. The prevalence of locomotor disability in the 1,156 men and 1,739 women, living independently and of whom complete data on disability and radiological signs were present, was 20.2% for men and 31.9% for women. Hip pain in the past month was present in 8.3% of the men and 16.6% of the women; the prevalence of knee pain was 12.6% for men and 22.3% for women. Radiological osteoarthritis (ROA) grade 2+ of the hip was present in 14.1% of the men and 15.9% of the women, and of the knee in 16.3% and 29.1% respectively. The odds ratios of hip-ROA adjusted for age, hip pain and body mass index (BMI) were 1.6 (95% CI: 1.0-2.3) for men and 2.3 (1.7-3.1) for women. The odds ratios of knee-ROA adjusted for age, knee pain and BMI were 1.0 (0.7-1.5) and 1.3 (1.0-1.6) respectively.

The conclusions of this analysis were that ROA of the hip is only a weak independent predictor of locomotor disability, but that ROA of the knee is not associated with locomotor disability. Age and pain of the hips and knees appear to be the most important independent determinants of locomotor disability.

To conclude the study of the determinants of disability the influence of abnormalities on physical examination of the hips and knees was presented in *paragraph 4.4.* The prevalence of moderate restricted range of motion was 34.5% for men and 38.6% for women. Less than 10% of the participants had instable knees. Varus-deformity in men (10.1%) and valgus-deformity in women (15.0%) were the most common deformities. The age-adjusted odds ratio for locomotor disability of restricted flexion of the hip or knee varied for men from 4.7 to 4.8 and for women from 3.5 to 3.2 respectively. The odds ratio of varus-deformity in men was 0.5 (0.3-0.9), of valgus-deformity in women 1.8 (1.3-2.4) and of knee instability in women 1.7 (1.1-2.4). Adjustment of these odds ratios for morning stiffness and pain in the relevant joint did not alter these estimates. Multiple logistic regression showed that restricted flexion of the hips was the most important physical abnormality to predict locomotor disability. We concluded that in epidemiologic population surveys on the association between locomotor disability and abnormalities on physical examination of the hips and knees among people aged 55 years and over only flexion of the hips and knees are worthwhile investigating.

In *paragraph 5.1* the data of the *Rotterdam Study* were used to assess the influence of selection-bias. The interviewgroup was defined as the participants of the home interview (1,819 men and 2,817 women); the centregroup was defined by the participants who visited the research centre two weeks after the interview (1,690 men and 2,577 women). Finally the locomotorgroup consisted of the participants of whom complete data with respect to locomotor signs were available (1,156 men and 1,739 women). The prevalence of locomotor disability (LD) as assessed by six questions of the Stanford Health Assessment Questionnaire (HAQ) in the interviewgroup was not significantly higher than in the centregroup, and the prevalence of locomotor disability in the locomotorgroup was not significantly different from either of the former two. The prevalences of joint pain and morning stiffness and the odds ratios for locomotor disability of joint pain and morning stiffness were not affected by the reductions of the study-group.

In *paragraph 5.2.* the data of the locomotorgroup were used to assess the influence on prevalence and effect estimates of self-assessed versus physician-assessed disability and joint pain. The prevalence of joint pain assessed by a physician at the centre was lower than the rates of the interview-assessed jointpain. The percentage agreement between self- and physician-assessed joint pain was 83.3% for men and 74.2% for women. The prevalence of disability based on tests of locomotor disability was lower than the interview-assessed disability; the percentage agreement between the questions and the tests was 82.6% for men and 77.7% for women. Estimation of age-adjusted odds ratios for

locomotor disability of joint pain resulted in weaker associations between physician-assessed disability and pain than between self-assessed disability and pain.

In *chapter 6* (General Discussion) we added one final analysis to the ones already presented. In this analysis all variables examined in chapter 4 were included. In men restricted flexion of the hip, age, morning stiffness, hip-pain, knee-pain, restricted flexion of the knee, and varus-deformity of the knee, are, in this order, independent determinants of locomotor disability. In women the order of independent determinants of disability was age, hip-pain, morning stiffness, restricted flexion of the hip, knee-pain, radiological osteoarthritis of the hip, radiological osteoarthritis of the knees, obliquity of the stature and valgus-deformity of the knees. A model using osteoarthritis grade 3+ instead of grade 2+ did not change the order of the independent determinants. In men radiological osteoarthritis grade 3+ of the knees entered the model in an eighth step, being the weakest significant determinant of locomotor disability. In women obliquity was no longer significantly associated with locomotor disability.

The final conclusions of the study are that the most important determinants of locomotor disability are age, morning stiffness, pain in the hips and knees and restricted flexion of the hips. In men radiological findings are of little importance: only radiological osteoarthritis grade 3+ of the knees is independently associated with disability. In women both radiological osteoarthritis grade 2+ and 3+ of the hip as well as the knee are significant, although weak, determinants of locomotor disability. In men the range of flexion of the knees as well as varus-deformity (bow-legs) is still of some importance. Likewise valgus deformity (knock-knees) and the rough assessment of obliquity is of limited importance only in women.

CHAPTER 8

SAMENVATTING

SAMENVATTING

Het onderzoek naar de beperkingen in de activiteiten van het dagelijks leven is een betrekkelijk nieuw onderwerp in epidemiologisch bevolkingsonderzoek onder ouderen. Zoals in *hoofdstuk 2* van dit proefschrift werd beschreven is de definitie en classificatie van beperkingen een onderwerp van discussie gedurende de laatste 20 jaar. Nadat de meetinstrumenten, die momenteel in gebruik zijn in het onderzoek naar de relatie tussen beperkingen en klachten en afwijkingen van het bewegingsapparaat, op hun merites waren onderzocht concludeerden wij dat in epidemiologisch bevolkingsonderzoek onder mensen boven de 55 jaar de Stanford Health Assessment Questionnaire het meest geschikt is. De, voornamelijk Amerikaanse, grootschalige bevolkingsonderzoeken over beperkingen werden besproken in *paragraaf 2.3*. Dit leidde tot de conclusie dat de prevalentie van beperkingen in de activiteiten van het dagelijks leven bij mensen van 55 jaar en ouder varieert tussen de acht en eenenzestig procent, afhankelijk van de gebruikte definitie en het feit of the onderzochte mensen afwijkingen van het bewegingsapparaat hadden. Knie pijn bleek een sterke voorspeller voor huidige en toekomstige beperkingen in alle studies. De studies, die Kellgren-graad twee als cutoff-point voor radiologische osteoarthrose van de knie gebruikten concludeerden dat osteoarthrose alleen de odds ratio's voor beperkingen niet substantieel verhoogt. Gegevens over de associatie tussen heup klachten en beperkingen ontbreken.

Het *ERGO-onderzoek* (Erasmus Rotterdam Gezondheid en Ouderen, in engelstalige publikaties "the *Rotterdam Study*") is een prospectief follow-up onderzoek naar het vóórkomen en de risico factoren van chronische ziekte en beperkingen in een Nederlandse algemene bevolking van 55 jaar en ouder. In *hoofdstuk 3* wordt het ontwerp, waaronder de populatie en methoden, van het onderzoek beschreven. De onderzoeks-vragen waren in vier groepen verdeeld: neurogeriatrische ziekten, cardiovasculaire ziekten, ziekten van het bewegingsapparaat en oogheelkundige ziekten. Het hoofdstuk eindigt met een beschrijving van de respons op het onderzoek.

Het doel van dit proefschrift was de prevalentie van beperkingen en met name van beperkingen in the activiteiten gerelateerd aan de functie van de onderste extremiteiten en de associaties met klachten en afwijkingen van de heupen en knieën te onderzoeken.

De prevalentie van beperkingen in 1,819 zelfstandig wonende mannen en 2,817 zelfstandig wonende vrouwen en van 82 mannen en 315 vrouwen, die in een verzorgingshuis verbleven, werd vastgesteld middels de Disability Index (DI) van de Health Assessment Questionnaire (HAQ). Onder de zelfstandig wonende deelnemers was de prevalentie van beperkingen (DI) 21.9% voor de mannen en 36.0% voor de vrouwen. De prevalentie van beperkingen in de activiteiten van onderste extremiteit functies (LD), vastgesteld met zes vragen van de HAQ, was 21.9% voor mannen en 34.8% voor vrouwen. De prevalentie van beperkingen in de activiteiten van de bovenste extremiteiten (ULD), vastgesteld met negen vragen van de HAQ, was 4.1% voor mannen en 10.6% voor vrouwen. De corresponderende percentages voor de bewoners van de verzorgingshuizen waren DI: 84.0% voor mannen, 96.5% voor vrouwen; LD: 81.5% voor mannen en 91.1% voor vrouwen; ULD: 45.7% voor mannen en 75.9% voor vrouwen. LD was geassocieerd met het vrouwelijk geslacht, toenemende leeftijd, het wonen in een verzorgingshuis, laag opleidingsniveau en laag inkomen (*paragraaf 4.1*).

In *paragraaf 4.2* werd de associatie tussen LD en klachten van het bewegingsapparaat onderzocht. Omdat de bewoners van de verzorgingshuizen geacht worden onafhankelijk van personele ondersteuning te zijn in de basale activiteiten van het dagelijks leven werden zij opgenomen in deze analyse. De prevalentie van LD bij 1,901 mannen en 3,135 vrouwen was 24.5% respectievelijk 40.5%. De prevalentie van gewrichtspijn in mannen was 0.7% voor pijn in de heupen, knieën en voeten gelijktijdig, 3.7% voor pijn in twee gewrichten (meestal heup en knie), 16.0% voor pijn in één gewricht (meestal de knie) en 20.4% voor pijn in de heupen en/of knieën en/of voeten (ergens pijn); de corresponderende frequenties voor vrouwen waren 1.9%, 9.0%, 23.7% en 34.5%. De prevalentie van morgenstijfheid die ten minste een half uur duurt was 4.9% voor mannen en 10.4% voor vrouwen. De voor leeftijd gecorrigeerde odds ratio's voor LD in mannen variëren van 2.4 voor pijn in één gewricht tot 8.8 voor pijn in alle drie gewrichten; voor vrouwen varieerden de odds ratio's tussen 2.5 en 5.7. De voor leeftijd gecorrigeerde odds ratio's voor morgenstijfheid waren 8.0 voor mannen en 7.3 voor vrouwen.

De bijdrage van radiologische osteoarthrose van de heupen en knieën aan LD wordt beschreven in *paragraaf 4.3*. Röntgenfoto's van de heupen en knieën werden gescoord volgens het graderings-systeem voor osteoarthrose van Kellgren. De prevalentie van LD in de 1,156 mannen en 1,739 vrouwen, die zelfstandig woonden en van wie alle gegevens met betrekking tot beperkingen en radiologie aanwezig waren, was 20.2% voor mannen en 31.9% voor vrouwen. Heuppijn in de afgelopen maand was aanwezig bij 8.3% van de mannen en 16.6% van de vrouwen; de prevalentie van kniepijn was 12.6% voor mannen en 22.3% voor vrouwen. Radiologische osteoarthrose (ROA) graad 2+ van de heup was

aanwezig bij 14.1% van de mannen en 15.9% van de vrouwen, en van de knie bij 16.3% respectievelijk 29.1%. De odds ratio's voor heup-ROA gecorrigeerd voor leeftijd, heuppijn en overgewicht waren 1.6 (95% BI: 1.0-2.3) voor mannen en 2.3 (1.7-3.1) voor vrouwen. De odds ratio's voor knie-ROA gecorrigeerd voor leeftijd, kniepijn en overgewicht waren 1.0 (0.7-1.5) respectievelijk 1.3 (1.0-1.6). De conclusies van deze analyse waren dat ROA van de heup slechts een zwakke onafhankelijke voorspeller van LD is, maar dat ROA van de knie niet geassocieerd is met LD. Leeftijd en pijn in de heupen en knieën blijken de meest belangrijke onafhankelijke determinanten van LD.

De laatste factoren die in het onderzoek naar de determinanten van beperkingen werden onderzocht waren de afwijkingen bij lichamelijk onderzoek van de heupen en knieën. *Paragraaf 4.4.* presenteert allereerst de prevalentie van deze afwijkingen. Matige restrictie van de bewegingsmogelijkheid van de heupen en knieën kwam voor in 34.5% van de mannen en 38.6% van de vrouwen. Minder dan 10% van de deelnemers had instabiele knieën. Varusstand van de knieën bij mannen (10.1%) en valgusstand bij vrouwen (15.0%) waren de meest voorkomende standsafwijkingen. De voor leeftijd gecorrigeerde odds ratio voor LD van afgenomen flexie van de heup en knie varieerde bij mannen van 4.7 tot 4.8 en bij vrouwen van 3.5 tot 3.2 respectievelijk. De odds ratio voor varusstand bij mannen was 0.5 (0.3-0.9), voor valgusstand bij vrouwen 1.8 (1.3-2.4) en van instabiliteit van de knieën bij vrouwen 1.7 (1.1-2.4). Correctie van deze odds ratio's voor morgenstijfheid en pijn in het betreffende gewricht deed deze niet significant veranderen. Een multiple logistische regressie analyse liet zien dat, ter predictie van LD, afgenomen flexie van de heupen de meest belangrijke afwijking bij lichamelijk onderzoek was. De conclusie is dat in epidemiologisch bevolkingsonderzoek naar de relatie tussen beperkingen en afwijkingen bij lichamelijk onderzoek van de heupen en knieën onder mensen van 55 jaar en ouder alleen flexie van de heupen en knieën van belang zijn.

De gegevens van het *ERGO-onderzoek* werden gebruikt om de invloed van selectie-bias vast te stellen. De interviewgroep was gedefinieerd als de deelnemers aan het interview (1,819 mannen en 2,817 vrouwen), de centrumgroep als de deelnemers die, twee weken na het interview, het onderzoek-centrum bezochten (1,690 mannen en 2,577 vrouwen) en de bewegingsapparaatgroep bestond uit de deelnemers waarvan alle gegevens over het bewegingsapparaat beschikbaar waren (1,156 mannen en 1,739 vrouwen). De prevalentie van LD in de interviewgroep was niet significant hoger dan in de centrumgroep, en de prevalentie van LD in de bewegingsapparaatgroep was niet significant verschillend van de twee eerder genoemde groepen. De prevalentie van gewrichtspijn en morgenstijfheid en de odds ratio's voor LD van gewrichtspijn en morgenstijfheid werden niet beïnvloed door het verkleinen van de onderzoeksgroep.(*paragraaf 5.1*)

In *paragraaf 5.2.* werden de gegevens van de bewegingsapparaatgroep gebruikt om te bepalen wat de invloed van verschillende manieren van gegevens-verzameling (eigen rapportage versus observatie) op prevalentie-schattingen en effectmaten was. De prevalentie van gewrichtspijn vastgesteld door een arts op het centrum was lager dan die van pijn aangegeven tijdens het interview bij de deelnemer thuis. Het percentage overeenstemming tussen pijn tijdens het interview en op het centrum was 83.3% voor mannen en 74.2% voor vrouwen. De prevalentie van beperkingen gebaseerd op het testen van onderste extremiteit functies was lager dan de op het interview gebaseerde beperkingen; het percentage overeenstemming tussen de vragen en de testen was 82.6% voor mannen en 77.7% voor vrouwen. De voor leeftijd gecorrigeerde odds ratio's voor geobserveerde LD van geobserveerde gewrichtspijn waren zwakker dan die voor de associatie tussen zelf gerapporteerde LD en pijn.

In *hoofdstuk 6* (General Discussion) werd nog een analyse toegevoegd aan de reeds gepresenteerde. In deze analyse werden alle variabelen uit hoofdstuk 4 opgenomen. Bij mannen waren afgenomen flexie van de heup, leeftijd, morgenstijfheid, heuppijn, kniepijn, afgenomen flexie van de knie, en varusstand van de knie, in deze volgorde, onafhankelijke determinanten van locomotore beperkingen. Bij vrouwen was de volgorde van onafhankelijke determinanten: leeftijd, heuppijn, morgenstijfheid, afgenomen flexie van de heup, kniepijn, radiologische osteoarthrose van de heup, radiologische osteoarthrose van de knie, scheefstand en valgusstand van de knie. Een model met osteoarthrose graad 3+ in plaats van graad 2+ veranderde deze volgorde niet. Bij mannen kwam radiologische osteoarthrose graad 3+ van de knie in een laatste stap, als zwakste significante determinant van LD, uit de analyse. Bij vrouwen was scheefstand niet langer significant geassocieerd met LD.

De uiteindelijke conclusies van het onderzoek zijn dat de belangrijkste determinanten van locomotore beperkingen zijn: leeftijd, morgenstijfheid, pijn in de heupen en knieën en afgenomen flexie van de heupen. Bij mannen zijn radiologische kenmerken van weinig belang: alleen radiologische osteoarthrose graad 3+ van de knie is onafhankelijk geassocieerd met beperkingen. Bij vrouwen zijn zowel radiologische osteoarthrose graad 2+ en 3+ van de heup als ook de knie (zwakke) significante determinanten van locomotore beperkingen. Bij mannen is de flexie van de knie en varusstand (O-benen) en bij vrouwen de valgusstand (X-benen) en de grove bepaling van scheefstand nog van enig belang.

APPENDICES

A International Classification of Impairments, Disabilities, and Handicaps.

B Modified Stanford Health Assessment Questionnaire

C Measurements in the *Rotterdam Study*

D Questionnaires and Scoring-forms

E Additional tables

INTERNATIONAL CLASSIFICATION of IMPAIRMENTS, DISABILITIES, and HANDICAPS

Classification of disabilities

1. Behaviour disabilities
   - 1.1 Awareness disabilities
   - 1.2 Disabilities in relations
2. Communication disabilities
   - 2.1 Speaking disabilities
   - 2.2 Listening disabilities
   - 2.3 Seeing disabilities
   - 2.4 Other communication disabilities
3. Personal care disabilities
   - 3.1 Excretion disabilities
   - 3.2 Personal hygiene disabilities
   - 3.3 Dressing disabilities
   - 3.4 Feeding and other personal care disabilities
4. Locomotor disabilities
   - 4.1 Ambulation disabilities
   - 4.2 Confining disabilities
   - 4.3 Other locomotor disabilities
5. Body disposition disabilities
   - 5.1 Domestic disabilities
   - 5.2 Body movement disabilities
   - 5.3 Other body disposition disabilities
6. Dexterity disabilities
   - 6.1 Daily activity disabilities
   - 6.2 Manual activity disabilities
   - 6.3 Other dexterity disabilities
7. Situational disabilities
   - 7.1 Dependence, endurance disabilities
   - 7.2 Environmental disabilities
   - 7.3 Other situational disabilities
8. Particular skill disabilities
9. Other activity restrictions

4. Locomotor disabilities

- 4.1 Ambulation disabilities
  - 40 Walking disability
  - 41 Traversing disability
  - 42 Climbing stairs disability
  - 43 Other climbing disability
  - 44 Running disability
  - 45 Other ambulation disability
- 4.2 Confining disabilities
  - 46 Transfer disability
  - 47 Transport disability
- 4.3 Other locomotor disabilities
  - 48 Lifting disability
  - 49 Other locomotor disability

Modified Health Assessment Questionnaire
(1983)

1 question from each HAQ-category

How satisfied are you with your ability to..?	0 = satisfied, 1 = dissatisfied
Do you need help to....?	0 = don't need help, 1 = need help
Compared to 6 months ago, how difficult is it now to..?	0 = less difficult, 1 = no change, 2 = more difficult

dress yourself including handling of closures?
get in and out of bed?
lift a full cup or glass to your mouth?
walk outdoors on flat ground?
wash and dry your entire body?
bend down to pick up clothing from the floor?
turn taps on and off?
get in and out of a car?

Disability Index HAQ

0.00 - 0.50: completely self-sufficient
0.50 - 1.25: reasonable self-sufficient
1.25 - 2.00: still self-sufficient but has many major problems with ADL
2.00 - 3.00: severely handicapped

MEASUREMENTS IN THE *ROTTERDAM STUDY*

First visit to the research centre

Give in of bottle with urine	All urine collected between the time he/she went to bed the preceding night and the scheduled visit
Give in nutritional questionnaire	
Venous blood-sampling	Albumin, aPase, ALAT, anorganic phosphate, ASAT, calcium, fructosamin, gamma GT, glucose, HDL cholesterol, creatinin, LDH, magnesium, total cholesterol, total protein, ureum, uric acid, sodium, potassium, calcium, red bloodcell count, haemoglobin, haematocrit, white blood cell count, platelet count, erythrocyte sedimentation rate.
Glucose tolerance	Non-fasting 2 hour glucose tolerance test. Glucose-solution: 75 gram glucose
Standing body height, body weight	Height in cm, weight in 0.1 kg. With light indoor clothes and no shoes.
Examination by ophthalmologist	Ocular pressure, visual acuity, visual fields, slit-lamp examination, examination and photography of the retina.
Radiology	Dorsopalmar X-rays of both hands and wrists. Weightbearing anteroposterior X-rays of both hips and knees 3 lateral X-rays of the vertebral column. Measurement of bone density of the lumbar vertebrae and right femoral neck with Dual Energy X-ray Absorptiometry (DEXA).
Electrocardiography	Resting standard 12-lead electrocardiogram.
Short cognitive screening	Mini Mental State Examination and Geriatric Mental Schedule
Examination by physician	Psychiatric history of participant and first degree family-members. Histories of transient ischaemic attacks, head trauma and joint complaints. Current usage of drugs. Short neurological examination to screen for Parkinson's disease. Check of carotid arteries and abdominal aorta for bruits. Check of distal tibiae for pitting edema and ulcus cruris. Minimal waist circumference and maximal hip circumference in mm. Physical examination of the hips and knees. Four tests of locomotor disability.
Climbing stairs, walking speed	Difficulty climbing stairs. Outdoor walking speed

Second visit to the research centre

Blood pressure	Left arm systolic and diastolic bloodpressure in duplicate. Random-zero sphygmomanometer.
Heartrate	number/minute, regularity
Orthostase	Bloodpressure right arm in duplicate participant supine. Participant rises: bloodpressure and heartrate after 1,2 and 5 minutes
Peripheral atherosclerosis	Systolic blood pressure level of posterior tibial artery left and right. 8 Mhz continuous wave probe and a random-zero sphygmomanometer
Echo aorta abdominalis	Screening for aneurysms of the abdominal aorta 2-D echographic measurement of abdominal aorta dimensions. 3.5 Mhz transducer
Echocardiography	Left ventricular volume
Carotid ultrasonography	Left and right carotid arteries. Stenosis, wall thickness, plaques, wall-elasticity 7.5 Mhz linear array transducer.
Cognitive screening test	Extensive cognitive screening test for dementia (Camdex) if the screening at the first visit indicated possible cognitive impairment.
Depression	Hamilton depression rating scale.
Nutritional questionnaire	Check of questionnaire on nutritional habits. Some supplementary questions.
Physician	All available study results were presented to the participant. In case of newly diagnosed disease: advise to contact general physician. Questions of the participant were answered and he/she was informed about the follow-up study, which started in September 1993.

QUESTIONNAIRE ON JOINT COMPLAINTS IN INTERVIEW

1. Did you have any pain or other complaints in or around your joints in the past month?
   Answers no, yes

2. Can you point out the painful joints? (multiple list)
   Answers right hand, left hand, right shoulder, left shoulder, neck, low back, right hip, left hip, right knee, left knee, right foot, left foot.

3. How long do you have these complaints?
   Answers less than one month, 1 to 3 months, 3 to 6 months, 6 to 12 months, 1 to 5 years, more than 5 years

4. Did you visit your general physician for these joint complaints?
   Answers no, yes

5. Did your physician prescribe analgesics?
   Answers no, yes, don't know.

6. Did your physician refer you to a physiotherapist?
   Answers no, yes

7. Have you been treated by a specialist for these joint complaints? (multiple list)
   Answers no, rheumatologist, internist, orthopaedic surgeon, other:.....

8. Did your physician give you a diagnosis?
   Answers no, osteoarthritis, rheumatoid arthritis, gout, lumbago, M Bechterew, other:....., don't know.

10. Did you have, apart from the joint complaints just mentioned, other joint complaints in the past 5 years?
    Answers no, yes, more then 5 years ago

questions 2 - 8 repeated.

20. Did you ever had joint complaints?
    Answers no, yes

QUESTIONNAIRE ON JOINT COMPLAINTS DURING CENTRE-VISIT

1. Do you suffer from less muscle strength in your legs?
   Answers no, yes, no answer

2. Have your knees been swollen in the past 5 years?
   Answers no, yes, once (month/year:..), > once a year (year:..), at least once a month (year:..), weekly (year:..), daily (year:..), no answer

3. Did you ever had an accident or other trauma involving your knees?
   Answers no, fell hard on knees, street-accident, occupational accident, bumped hard on knees, sports injury, no answer

   3.1. How often did that happen?
   Answers once, 1 to 5 times, 5 to 10 times, 10 to 20 times, > 20 times, no answer

   3.2. How long ago did the worst accident happen?
   Answers > 5 years ago, 1 to 5 years ago, last year, last month, last week, no answer

4. Did you have any pain or other complaints in or around your joints in the past month?
   Answers no, yes

5. Can you point out the painful joints? (multiple list)
   Answers right hand, left hand, right shoulder, left shoulder, neck, low back, right hip, left hip, right knee, left knee, right foot, left foot.

In case of complaints of hips and/or knees:

When do you have pain? (multiple list)
Answers When rising and starting to walk, at exercise (walk long distance,climb stairs,bending, carrying), at rest (sitting still), wake up at night from pain, no answer

Frequency of pain (for each type of pain separately)
Answers < once a month, > once a month, every week, once a week, daily, always, no answer

Score 11-point Box Scale: [ ] score: 0-10

6. Did you have, apart from the joint complaints just mentioned, other joint complaints in the past 5 years?

7. Can you point out the painful joints? (multiple list)
   Answers right hand, left hand, right shoulder, left shoulder, neck, low back, right hip, left hip, right knee, left knee, right foot, left foot.

8. Have you ever been operated upon your joints?
   Answers no, yes, no answer

   Which joints? (multiple list)
   Answers right hip, left hip, right knee, left knee, other:.....

   Kind of operation on hips and/or knees Score left and right separately
   Answers total hip, fusion hip, after hip fracture, other hip operation:.....
   medial meniscectomy, lateral meniscectomy, total knee, fusion knee, valgus osteotomy, varus osteotomy, other knee operation:.....
   no answer

In case of recent or former knee complaints:

Did or do your knee(s) ever "lock"?
Answers no, yes, no answer

Which knee?
Answers right, left, no answer

Frequency of locking
Answers once, > 5 times a year, > once a month, weekly; (year..)

Did or do your knee(s) "give way"?
Answers no, yes, no answer

Which knee?
Answers right, left, no answer

Frequency of giving way
Answers once, > 5 times a year, > once a month, weekly; (year..)

SCORING FORM PHYSICAL EXAMINATION

	Right	Left	
Flexion knee	[ ] [ ]	[ ] [ ]	1. normal 2. dubious
Flexion hip	[ ] [ ]	[ ] [ ]	3. < 20% restriction 4. 20-60% restriction
Endorotation	[ ] [ ]	[ ] [ ]	5. > 60% restriction
Exorotation	[ ] [ ]	[ ] [ ]	6. pain
Crossing legs	[ ] [ ]	[ ] [ ]	

[ ]: score for difficulty
[ ]: score for pain

Medial collateral	[ ] [ ]	[ ]	1. normal 3. left=right	2. instable 4. left > right 5. right > left
Lateral collateral	[ ] [ ]	[ ]		
Cruciate ligaments	[ ] [ ]	[ ]	1. normal 3. left=right	2. anterior instable 4. left > right 5. right > left
Valgus/varus	[ ]	[ ]	1. normal	2. valgus(X) 3. varus (O)
Obliquity	[ ]		1. none	2. right higher 3. left higher
Other	[ ] [ ]	[ ] [ ]	1. no 2. flexion contracture knee 3. flexion contracture hip 4. paralysis 5. hydrops knee 6. posterior drawer test positive 7. rheumatoid arthritis 8. amputation 9. other text:	

SCORING INSTRUCTIONS HAQ

Rising from chair	1 = rises with hands on legs 2 = support from table or needs armrests to stand up 3 = needs personal assistance to rise up from a chair
Getting in/out bed	1 = must roll on side first 2 = roll on side and difficulty getting in sitting position and standing up or need devices to get out of bed 3 = needs personal assistance to get in and out of bed
Walking	1 = can not walk as smoothly as before 2 = needs aids, walks only short distances, shuffles 3 = needs personal assistance to walk
Climbing stairs	1 = needs handrail and/or has more difficulty descending stairs 2 = must have two feet on a step to take the next one; hoist up on the handrail 3 = needs personal assistance to climb stairs
Bending	1 = stiff; difficulties with balance;needs support from something 2 = must kneel or sit down to pick up thing; uses aids 3 = can't get things from the floor
Getting in/out car	1 = needs support from door of the car (because of low seat) 2 = slowly with support of door of the car or person 3 = can't get into a car;is carried into a car; goes with wheelchair in van.

0 = without difficulty

SCORE-INSTRUCTIES HAQ

Opstaan uit rechte stoel	1 = zet zich af op bovenbenen 2 = steunt op tafel; zit alleen op stoel met leuningen om zich af te kunnen zetten. 3 = heeft hulp van anderen nodig om op te staan.
In/uit bed komen	1 = eerst op zij draaien/voorzichtig op rand zitten. Heeft verhoogd bed. 2 = als 1. plus moeite met overeind komen van lig naar zit/ moeite met overeind komen van zit naar staan; gebruikt hulpmiddelen (papegaai). 3 = wordt door anderen in en uit bed geholpen.
Lopen	1 = niet meer zo vlot als vroeger; moeite met glad oppervlak (herfst/winter). 2 = gebruikt hulpmiddelen; loopt alleen heel korte stukje; schuifelt voetje voor voetje. 3 = wordt door iemand ondersteund.
Trap lopen	1 = gebruikt altijd trapleuning; heeft meer moeite met trap afdalen. 2 = voetje voor voetje, tree voor tree; ophijsen aan trapleuning. 3 = wordt door iemand geholpen.
Bukken	1 = stram; voorzichtig met evenwicht; houdt zich aan iets vast. 2 = moet op de knieën; moet gaat zitten; gebruikt hulpmiddelen om iets van de grond te rapen. 3 = kan niet zelf iets van de grond rapen
In/uit auto komen	1 = moet zich goed vasthouden aan deur/stijlen (omdat zitting zo laag is). 2 = erg langzaam zich vasthoudend aan deur of persoon. 3 = wordt in auto gedragen/ met rolstoel en al in busje.

0 = zonder moeite

SCORING FORMS ADL-TESTS

	Right	Left	
Bending	[ ] [ ]	[ ] [ ]	0.without difficulty
			1.with difficulty
Rising(high chair)	[ ] [ ]	[ ] [ ]	2.with much difficulty
			3.unable to do without personal assistance
Reaching toes	[ ] [ ]	[ ] [ ]	4.pain
Rising(low chair)	[ ] [ ]	[ ] [ ]	

[ ]: score for difficulty
[ ]: score for pain

Step height

Maximal number of steps		Use of handrail
[ ] 1		[ ] yes
[ ] 2		[ ] no
[ ] 3	[ ] impossible	[ ] not done
[ ] 4	[ ] not done	

Climbing stairs

	Use of handrail	Use of other aids
[ ] without difficulty	[ ] yes	[ ] yes, which:..
[ ] with some difficulty	[ ] no	[ ] no
[ ] with much difficulty	[ ] not done	[ ] not done
[ ] not able to do; reason.....		

Walking outside

Time comfortable walkingspeed	Use of aids
[ ] seconds	[ ] no
	[ ] walking cane
	[ ] crutches
Time walking fast	[ ] triangle without wheels
[ ] seconds	[ ] triangle with wheels
	[ ] arm support research assistant
	[ ] not done

Reason why the participant couldn't fulfil this test:.....

Table 4.2.1.a. Age-adjusted odds ratios for disability in separate lower limb functions of joint complaints in men and women in descending order.

	Odds ratio (95 % confidence interval)				
	Three joint-sites	Two joint-sites	One joint-site	Any joint-site	Morning stiffness
Men					
Getting in/out of bed	13.3 (4.0-44.1)	5.0 (3.0- 8.3)	2.0 (1.5- 2.7)	2.6 (2.0- 3.3)	10.5 (6.5-16.9)
Rising from chair	14.1 (4.2-47.5)	5.0 (3.0- 8.4)	2.1 (1.5- 2.8)	2.6 (2.0- 3.4)	7.6 (4.7-12.1)
Bending	8.2 (2.6-26.0)	3.2 (1.9- 5.5)	2.2 (1.6- 2.9)	2.4 (1.9- 3.2)	8.0 (5.1-12.6)
Getting in/out of a car	6.9 (2.0-23.2)	4.2 (2.5- 7.1)	2.2 (1.6- 2.9)	2.5 (1.9- 3.3)	5.7 (3.5- 9.2)
Walking	8.3 (2.5-27.5)	5.5 (3.2- 9.3)	2.4 (1.8- 3.2)	2.9 (2.2- 3.8)	5.3 (3.3- 8.4)
Climbing stairs	6.7 (2.0-22.0)	4.3 (2.5- 7.3)	2.0 (1.5- 2.7)	2.4 (1.9- 3.1)	5.1 (3.2- 8.2)
Women					
Getting in/out of bed	5.9 (3.4-10.3)	5.4 (4.0- 7.1)	2.6 (2.1- 3.2)	2.8 (2.3- 3.5)	13.0 (9.7-17.6)
Rising from chair	11.5 (6.2-21.3)	5.3 (4.0- 7.2)	3.0 (2.4- 3.6)	2.8 (2.3 3.5)	7.5 (5.6-10.0)
Bending	8.4 (4.7-15.1)	4.1 (3.1- 5.4)	2.3 (1.9- 2.7)	2.4 (2.0- 2.6)	8.2 (6.2-10.9)
Getting in/out of a car	11.9 (6.2-22.8)	5.9 (4.4- 8.1)	2.9 (2.4- 3.6)	2.7 (2.2- 3.3)	9.8 (7.2-13.4)
Walking	5.7 (3.2-10.3)	5.6 (4.1- 7.5)	3.3 (2.7- 4.1)	2.8 (2.3- 3.5)	8.7 (6.5-11.8)
Climbing stairs	7.2 (3.8-13.5)	5.1 (3.8- 7.0)	3.1 (2.5- 3.7)	2.9 (2.4- 3.6)	4.8 (3.6- 6.3)

Table 4.3.a. Some baseline charachteristics of the participants of the *Rotterdam Study*.

	Men		Women	
Number	1,156		1,739	
	range	mean (± SE)	range	mean (± SE)
Age (year)	55.0 - 93.2	68.6 (0.2)	55.0 - 94.0	69.1 (0.2)
Bodyhight (cm)	152.0 - 198.0	174.3 (0.2)	137.0 - 182.0	161.4 (0.2)
Bodyweight (kg)	47.6 - 115.2	78.6 (0.3)	40.1 - 119.0	69.7 (0.3)
Body Mass Index(kg/m^2)	16.9 - 37.2	25.8 (0.09)	16.4 - 44.2	26.8 (0.1)
Q1		23.9		23.9
Q2		25.7		26.3
Q3		27.8		29.2
Waisthip-Ratio	0.723 - 1.167	0.969 (0.002)	0.640 - 1.266	0.878 (0.002)
Q1		0.925		0.809
Q2		0.970		0.867
Q3		1.001		0.941

Q1, Q2, Q3: first, second and third quartile

Table 4.3.1.a. Age-adjusted odds ratios and 95% confidence intervals (between brackets) for locomotor disability of body mass index (BMI), pain of the hip and knee and radiological osteoarthritis (ROA).

	Men		Women	
BMI (*)	1.7 (1.1- 2.6)		1.7 (1.3- 2.3)	
Pain				
Hip	3.6 (2.3- 5.7)		5.3 (4.0- 7.0)	
Knee	3.4 (2.3- 5.0)		3.0 (2.3- 3.9)	
	Grade ≥ 2	*Grade ≥ 3*	*Grade ≥ 2*	*Grade ≥ 3*
ROA				
Hip	1.7 (1.2- 2.6)	3.1 (1.4- 6.9)	2.9 (2.2- 3.9)	7.4 (4.4-12.5)
Knee	1.4 (0.9- 2.0)	4.5 (2.1- 9.7)	1.7 (1.4- 2.2)	3.5 (2.1- 5.8)
ROA + Pain				
Hip	3.1 (1.4- 7.2)	4.0 (1.0-15.8)	7.4 (4.4-12.3)	15.5 (6.4-37.5)
Knee	3.3 (1.8- 6.1)	11.5 (3.7-36.0)	3.1 (2.2- 4.4)	6.6 (3.1-14.3)

(*) = fourth quartile versus second quartile

Table 4.3.2.a. Age-adjusted odds ratios and 95% confidence intervals (between brackets) for locomotor disability of body height, body weight, body mass index and waist-hip-Ratio (WHR).

	Men	Women
Body height low (@)	1.1 (0.6- 1.9)	1.0 (0.7- 1.5)
Body height high	1.7 (0.9- 3.0)	1.3 (0.8- 1.9)
Body weight low	0.9 (0.5- 1.4)	0.8 (0.6- 1.1)
Body weight high	1.4 (0.9- 2.3)	1.5 (1.1- 2.2)
BMI (*)	1.7 (1.1- 2.6)	1.7 (1.3- 2.3)
WHR (#)	1.4 (0.9- 2.1)	1.5 (1.1- 2.1)

(@): low = first quintile versus middle quintile; high = last quintile versus middle quintile
(*): fourth quartile versus second quartile
(#): fourth quartile versus first quartile

Table 4.3.3.a. Age-adjusted odds ratios and 95% confidence intervals (between brackets) for radiological osteoarthritis grade ≥ 2 of the hip and knee of pain, body mass index (BMI) and waist-hip-ratio (WHR).

	Men	Women
Hip		
Pain	2.5 (1.5- 4.1)	3.3 (2.4- 4.5)
BMI (*)	0.9 (0.6- 1.5)	1.0 (0.7- 1.5)
WHR (#)	1.0 (0.6- 1.6)	0.9 (0.6- 1.4)
Knee		
Pain	3.1 (2.1- 4.5)	2.7 (2.08- 3.4)
BMI (*)	2.4 (1.5- 3.9)	2.9 (2.17- 4.0)
WHR (#)	1.1 (0.7- 1.7)	1.4 (1.01- 1.9)

(*): fourth quartile versus second quartile
(#): fourth quartile versus to first quartile

Table 4.3.4.a. Age-adjusted odds ratios and 95% confidence intervals (between brackets) for joint pain of body mass index (*).

	Men	Women
Hip	1.4 (0.8- 2.6)	1.4 (0.9- 2.0)
Knee	1.4 (0.8- 2.4)	1.7 (1.2- 2.3)

(*): fourth quartile versus second quartile

Table 4.3.5.a. Relationship between radiological osteoarthritis (ROA) and joint pain.

		Men						Women					
		ROA						ROA					
		Hip			Knee			Hip			Knee		
		-	+	T	-	+	T	-	+	T	-	+	T
Pain	-	923	137	1060	869	141	1010	1265	185	1450	1019	333	1352
	+	70	26	96	98	48	146	197	92	289	214	173	387
	T	993	163	1156	967	189	1156	1462	277	1739	1233	506	1739

Table 4.3.6.a. Prevalence (%) of radiological osteoarthritis (ROA) grade ≥ 3 of the hip and knee of men and women by age.

Age group (years)	55-64 %	65-74 %	75-84 %	85 + %	Total % (95% CI)
Men Number	404	501	234	17	1156
Hip ROA	1.5	2.4	3.8	11.8	2.5 (1.6- 3.4)
Hip ROA + pain	0.2	1.0	0.9	5.9	0.8 (0.3- 1.3)
Knee ROA	0.2	3.0	5.1	11.8	2.6 (1.7- 3.5)
Knee ROA + pain	0.2	1.8	3.0	11.8	1.6 (0.9- 2.3)
Women Number	589	684	416	50	1739
Hip ROA	1.5	6.6	9.6	24.0	6.1 (5.0- 7.2)
Hip ROA + pain	0.8	3.2	5.0	3.9	3.0 (2.2- 3.8)
Knee ROA	1.4	5.1	7.0	20.0	4.7 (3.7- 5.7)
Knee ROA + pain	0.8	2.9	3.8	6.0	2.5 (1.8- 3.2)

Table 4.3.7.a. Prevalence (%) of joint pain and radiological osteoarthritis of the hip or knee of men and women by age.

Age group (years)	55-64 %	65-74 %	75-84 %	85 + %	Total % (95% CI)
Men Number	404	501	234	17	1156
Joint pain	18.6	16.4	21.8	29.4	18.4 (16.2- 20.6)
Radiological osteoarthritis	20.3	28.1	35.9	58.8	27.4 (24.8- 30.0)
ROA + Pain	6.4	8.6	10.7	23.5	8.5 (6.9- 10.1)
Women Number	589	684	416	50	1739
Joint pain	30.1	33.6	31.5	30.0	31.8 (29.6- 34.0)
Radiological osteoarthritis	22.4	40.9	51.0	78.0	38.1 (35.8- 40.4)
ROA + Pain	10.9	18.1	21.4	22.0	16.6 (14.9- 18.3)

Table 4.4.1.a. Odds ratios and 95% confidence intervals (between brackets) for locomotor disability of abnormalities on physical examination adjusted for age and pain in the relevant joint(s).

	Men	Women
Restricted range of motion (*)		
Flexion hip	4.1 (2.8- 6.0)	2.9 (2.2- 3.8)
Endorotation hip	2.0 (1.4- 2.8)	2.0 (1.6- 2.7)
Exorotation hip	2.2 (1.5- 3.0)	1.9 (1.4- 2.4)
Flexion knee	4.0 (2.5- 6.5)	2.6 (1.9- 3.5)
ROM hip	2.2 (1.6- 3.1)	2.3 (1.8- 3.0)
ROM hip + knee	2.3 (1.6- 3.3)	2.5 (1.9- 3.2)
Obliquity	1.3 (0.8- 2.1)	1.6 (1.2- 2.2)
Instability knee ligaments(#)	0.9 (0.5- 1.4)	1.4 (1.1- 1.9)
Abnormalities knee	0.9 (0.6- 1.3)	1.8 (1.3- 2.4)
Abnormalities total	1.7 (1.2- 2.4)	2.3 (1.7- 3.0)

(*): ROM dichotomized: 0 = no restriction, 1 = at least moderate restriction.
(#): Ligaments dichotomized: 0 = no laxity, 1 = any laxity.

Table 4.4.2.a. Odds ratios and 95% confidence intervals (between brackets) for locomotor disability of abnormalities on physical examination adjusted for age and morning stiffness.

	Men	Women
Restricted range of motion (*)		
Flexion hip	3.3 (2.4- 4.5)	2.1 (1.7- 2.6)
Endorotation hip	1.6 (1.2- 2.2)	1.7 (1.3- 2.1)
Exorotation hip	1.7 (1.2- 2.3)	1.6 (1.2- 2.0)
Flexion knee	2.3 (1.7- 3.3)	1.7 (1.4- 2.2)
Obliquity	1.3 (0.9- 2.2)	1.8 (1.3- 2.4)
Instability knee ligaments(#)	0.9 (0.6- 1.5)	1.5 (1.1- 2.0)
Men varus, Women valgus	0.5 (0.3- 0.9)	1.7 (1.3- 2.3)

(*): ROM dichotomized: 0 = no restriction, 1 = at least moderate restriction.
(#): Ligaments dichotomized: 0 = no laxity, 1 = any laxity.

Table 5.1.a. Prevalence (%) of locomotor disability, joint pain and morning stiffness in men and women who refused to visit the research centre (nr) and who were subsequently excluded from the analyses (e)

Age group (years)	55-64		65-74		75-84		85 +		Total	
	% nr	% e	% nr	% e	% nr	% e	% nr	% e	% nr	% e
Men Number	23	208	47	208	46	105	13	13	129	534
Locomotor disability	13.0	7.7	48.9	17.8	54.3	36.2	84.6	84.6	48.1	19.1
95% CI									(39.5- 56.7)	(15.8-22.4)
Jointpain										
Any joint-site	8.7	17.8	29.8	20.2	21.7	20.0	38.5	23.1	24.0	19.3
95% CI									(16.6- 31.4)	(16.0-22.6)
One joint-site	4.3	13.9	21.3	15.9	15.2	15.2	38.5	23.1	17.8	15.2
95% CI									(11.2- 24.4)	(12.2-18.2)
Two joint-sites	4.3	3.4	6.4	3.8	6.5	3.8	0.0	0.0	5.4	3.6
95% CI									(1.5- 9.3)	(2.0-5.2)
Three joint-sites	0.0	0.5	2.1	0.5	0.0	1.0	0.0	0.0	0.8	0.6
95% CI									(-0.7- 2.3)	(0.0-1.3)
Morning stiffness	0.0	2.4	10.6	4.8	4.3	6.7	0.0	15.4	5.4	4.5
95% CI									(1.5- 9.3)	(2.7-6.3)
Women Number	38	320	74	325	88	161	40	32	240	838
Locomotor disability	36.8	17.8	48.0	36.3	68.2	52.8	80.5	75.0	59.1	33.9
95% CI									(52.9- 65.3)	(30.7-37.1)
Jointpain										
Any joint-site	26.3	33.4	22.7	38.5	34.1	33.5	39.0	37.5	30.2	35.6
95% CI									(24.4- 36.0)	(32.4-38.8)
One joint-site	15.8	21.3	14.7	26.2	18.2	26.1	26.8	21.9	18.2	24.1
95% CI									(13.3- 23.1)	(21.2-27.0)
Two joint-sites	10.5	9.1	6.7	10.5	12.5	6.2	9.8	12.5	9.9	9.2
95% CI									(6.1- 13.7)	(7.2-11.2)
Three joint-sites	0.0	3.1	1.3	1.8	3.4	1.2	2.4	3.1	2.1	2.3
95% CI									(0.3- 3.9)	(1.3-3.3)
Morning stiffness	13.2	9.7	10.7	10.5	6.8	11.8	9.8	9.4	9.5	10.4
95% CI									(5.8- 13.2)	(8.3-12.5)

Table 5.2.3.a. Percentage agreement, Kappa's and χ^2 between self-assessed and physician-assessed joint pain and disability in 1,156 men and 1,739 women.

Self/physician	-/- %	+/+ %	+/- %	-/+ %	K	χ^2
Men						
Joint pain	74.2	9.1	11.2	5.4	0.42	215.84
Disability						
Bending	76.9	6.6	9.5	7.1	0.35	121.71
Rising high chair	80.1	3.8	13.0	3.1	0.25	77.54
Rising low chair	76.8	6.6	10.1	6.5	0.35	122.73
Climbing stairs	75.3	7.0	12.8	4.9	0.34	91.04
$LD_{6/4}$	75.3	9.1	11.0	4.6	0.45	217.52
$LD_{4/4}$	73.6	9.0	12.7	4.7	0.41	184.64
Women						
Joint pain	57.2	17.0	18.3	7.5	0.39	286.41
Disability						
Bending	66.5	12.1	12.0	9.4	0.39	235.05
Rising high chair	71.3	9.5	14.4	4.8	0.39	250.83
Rising low chair	63.3	14.9	14.5	7.3	0.43	296.07
Climbing stairs	56.3	18.6	17.5	7.6	0.42	198.27
$LD_{6/4}$	62.8	17.5	13.4	6.3	0.51	416.50
$LD_{4/4}$	59.8	17.9	16.4	5.9	0.47	364.42

$LD_{6/4}$ = Self-assessed LD based on 6 functions compared with physician-assessed LD based on 4 functions.

$LD_{4/4}$ = Self-assessed LD compared with physician-assessed LD both based on 4 functions.

Table 6.1.a. Adjusted odds ratios and etiologic fractions for locomotor disability adjusted for age, joint complaints, signs and symptoms.

	Men			Women		
	aOR	95% CI	EF	aOR	95% CI	EF
Morning stiffness	5.2	(2.7- 9.8)	16.0	4.9	(3.2- 7.6)	25.1
Hip pain	2.2	(1.4- 3.7)	9.3	3.5	(2.5- 4.8)	29.0
Knee pain	2.6	(1.7- 4.0)	16.9	2.0	(1.5- 2.7)	18.5
Hip-ROA	1.2	(0.8- 1.8)	(2.3 #)	1.7	(1.2- 2.4)	10.2
Knee-ROA	1.0	(0.7- 1.6)	(0.6 #)	1.3	(1.0- 1.7)	8.5
Flexion hip	2.2	(1.3- 3.6)	14.4	1.7	(1.2- 2.4)	12.7
Flexion knee	2.0	(1.1- 3.5)	7.0	1.3	(0.9- 1.9)	(3.8 #)
Obliquity	1.3	(0.8- 2.3)	(3.3 #)	1.3	(0.9- 1.8)	(3.8 #)
Valgus/varus-deformity	0.5	(0.3- 0.9)	-*	1.4	(1.0- 1.9)	5.3
Knee-stability	0.9	(0.6- 1.6)	-*	1.3	(1.0- 1.8)	4.8
Endorotation	1.1	(0.7- 1.8)	(2.9 #)	1.5	(1.0- 2.2)	11.2
Exorotation	1.0	(0.6- 1.7)	(0.9 #)	0.9	(0.6- 1.3)	-*

aOR = Odds ratio adjusted for all variables in the model.
95% CI = 95% Confidence interval of aOR.
EF = Etiologic fraction = p(aOR-1)/{p(aOR-1) + 1}.

*: aOR < 1.
#: aOR not significantly higher than 1.

Categorical values:
ROA: 0 = grade < 2, 1 = grade ≥ 2. Range of motion: 0 = normal, 1 = at least moderate reduction of ROM. Valgus/varus-deformity: 0 = absent, 1 in men = varus, 1 in women = valgus. Obliquity: 0 = absent, 1 = present. Knee-stability: 0 = normal, 1 = anterior drawer and/or stress-tests positive.

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About the author

Else Odding was born on August 17th, 1960 in Eindhoven, the Netherlands. She attended secondary school (athenaeum B) at the Gemeentelijke Scholengemeenschap Woensel in Eindhoven and graduated in 1980. She started her medical study in 1980 at the Erasmus University Rotterdam. During this period extracurricular training on rehabilitation medicine was acquired. She obtained her medical degree in 1988 and started her training in epidemiology at the Department of Epidemiology & Biostatistics, Erasmus University Medical School (head Prof Dr. A. Hofman) at the time the work described in this thesis was initiated. In 1990/1991 she was study-coordinator of the Rotterdam Study. Since 1993 she teaches epidemiology to postgraduate students in occupational physiotherapy at the School for Physiotherapy, Rotterdam. At present she is a research associate on studies on disability at the Department on Epidemiology & Biostatistics, Erasmus University.
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