

Disability in old age

Longitudinal population-based studies of the disablement process

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1. INTRODUCTION

This thesis focuses on five related themes in the study of the aging process. The first theme is the study of changes in functional ability, which takes into account that the aging process is dynamic and involves various changes both in the biological/ physiological level and in the ability to perform daily activities. The second theme is the study of tiredness, which is hypothesized to be an early sign of the aging process. Social position in old age may be a good indicator of the influence of the living conditions throughout the life on functional ability in old age. That is why the relationship between social position and changes in functional ability is the third theme of the thesis. The fourth theme is the study of the associations between social relations and changes in functional ability. Both social position and social relations are hypothesized to affect the pace and direction of the aging process. The aging process does not stop once people become disabled. Therefore the final theme of the thesis is the study of the consequences of disability on mortality, utilization of social and health services, oral health and social relations.

The following sections of this chapter include 1) a description of two perspectives of the aging process, 2) a description of a model of the disablement process, 3) a short review of well-known risk factors of the disablement process, and 4) a rationale for the themes of the thesis.

The present and future of our society are characterized by an increase in number and proportions of old and very old people. This concerns and worries both the aging individuals themselves and health care planners in the society. The aging individuals worry about declining intellectual abilities and physical health. The changing demographic patterns are also coupled with worries that society may have to struggle with in order to deal with difficult issues such as the financial burden of providing for old age, increasing demands on social and medical care, growing needs for assistance and care in cases of disability.

These combined points of views of the individual and the society constitute the main reason why one important goal of gerontological research, geriatric medicine, and public health is to increase active life expectancy, which refers to years without limitations in activities because of disability.

Increasing life expectancy does not inevitably mean improving health at the population level. Two main perspectives have been proposed for the effect that continued decreases in death rates might have on the morbidity and disability of older people in the future (152). The *expansion of morbidity theory* puts forward the pessimistic view that the gains in life expectancy are predominantly through the technological advances that have been made in extending the life

of those with disease and disability (265). In addition, living longer exposes more of us to the non-fatal disabling diseases of old age such as Parkinson's disease, dementia and arthritis. The consequence will be a longer life with more years of disability. The opposing theory is that of *compression of morbidity* (109, 110). This optimistic hypothesis suggests that improvements in health behavior and improved medical care, which modify the risk factors of mortality will also delay the age-at-onset and the progression of non-fatal disabling diseases. Thus, the time lived with disease and disability will be compressed into a short period before death.

These perspectives constitute the background for several studies in the 1980s and 1990s, which tried to understand whether the mortality reduction is accompanied by improvement or, on the contrary, deterioration of the population's health status (103). The studies have typically compared two or three cohorts of older people, for example birth cohorts (e.g. 344) or total study populations of older adults (e.g. 73).

These studies did not provide consistent results, although some demonstrated rather clear decreases in disability over 9 to 17 years (6, 102, 169, 186, 205, 310). However, these improvements did not hold across all specific measures of disability (103). To the contrary, late-life disability declines have been concentrated among difficulties with Instrumental Activities of Daily Living (IADLs) (73, 186, 205), such as household chores, shopping, and medication management, and among functional limitations in basic physical tasks, such as lifting, climbing stairs, and walking (6, 102, 186). However, several studies found no cohort changes in disability in the Physical Activities of Daily Living, such as bathing, dressing and managing toilet visits (6, 73, 186, 205, 275, 344), the most severe type of disability, generally associated with long-term care needs. Hoeymans et al. (141) found no differences at all over a 5 year period in a Dutch male population. A French study (255) showed a rather clear decrease in disability measured by a global question about functional ability, and an English study (300) found that later cohorts of older people had lower levels of severe disability, while there were no cohort differences with regard to moderate disability. A recent study showed improvement in functional ability in the Finnish population over 14 years (310).

Thus, the studies referred to show no clear pattern. The findings regarding IADL should be taken with caution because ability to perform those activities depend on both physical health, gender, environmental factors, interests, etc. (22, 33, 222). The findings regarding functional limitations are based on only three American studies (6, 102, 186). It is not possible to sort out whether the results are due to different measurement methods and/or different cultures, and we do not know whether the results would be the same had the studies taken place 20 years later or with larger intervals in between surveys. However, studies of different cohorts have shown that the increase in life expectancy in the 1990s has been followed by a decrease in the main disabling diseases (255) and that younger cohorts of older adults are better educated (74) which may lead to better strategies to limit restrictions in daily life. In total, the general picture is that the functional ability of older populations in the Western world has improved.

The strength of the studies, which compare different birth cohorts are that they are period specific and thus explore whether populations vary in different periods. There are large variations between different time periods, which may influence the functional ability in old age, for example, the general attitude to the value of physical activity, the knowledge about nutrition and health, and the possibilities for health interventions and treatment. However, studies which compare different cohorts are rough and may hide important differences in various subgroups. Thus, if the focus is on factors, which shape the aging process at the individual level, it is necessary to perform longitudinal studies. Longitudinal data provide one with the opportunity to explore factors that influence functional ability in the same individuals over time.

1.1 MODELS OF DISABLEMENT

An important focus in the study of the aging process has been the transition from health to disability. A description of the consequences of chronic diseases that is often used is "The International Classification of Impairments, Disabilities, and Handicaps" (ICIDH), which is a taxonomy of disease impacts, developed by the World Health Organization (341). The ICIDH identifies three central concepts: Impairment, Disability, Handicap. This model has recently been revised into the International Classification of Functioning, Activities and Participation (ICF) (342). The ICF is positioned as a universal model of human functioning designed to classify and catalog personal and environmental factors that interact with health conditions to influence an individual's body function and structures, activities, and participation in life domains. There is no formal definition of disability within this model. Instead, the ICF attempts to articulate environmental and personal factors, and their interactions, that facilitate the assessment of the impact of disability on the individual.

Another frame of reference which was conceived and developed by Nagi relies exclusively on sociological theory and works with a general frame of reference that can be adapted and operationalized in specific research endeavors, clinical as well as sociomedical (223, 224).

1.1.1 The disablement process

In 1994 Verbrugge and Jette (329) presented extensions and innovations of the ICIDH and the Nagi approaches in their model called "The Disablement Process", which is especially useful in epidemiological, gerontological and clinical research. This new model describes 1) how chronic and acute conditions affect functioning in specific body systems, basic physical and mental actions, and activities of daily life, and 2) the personal and environmental factors that speed or slow disablement. The model of the disablement process may thus be used as an indicator of the aging process. In recent years this conceptual model has been increasingly used in American and North European gerontological research (27, 178, 235, 256, 261, 269, 277, 297, 302, 307). (See Figure 1).

1.1.2 The main pathway

According to the model *pathology* refers to biochemical and physiological abnormalities that are detected and medically labeled as disease, injury or congenital/developmental conditions (e.g. osteoarthritis and enduring sensory abnormalities). Detection of pathology often relies on the evaluation of more manifest signs and symptoms. Defined this way pathology may be caused by a disease and/or by physiological and biological age-related declines in the individual. *Impairments* are dysfunctions and significant structural abnormalities in specific body systems. Medical procedures to evaluate impairments include clinical examination, laboratory tests, and patients' medical history and symptom reports. Impairments reflect

the consequences and degree of pathology. *Functional limitations* are restrictions in performing basic physical and mental actions used in daily life by one's age-sex group. These are generic actions which indicate the general abilities of body and mind to do purposeful "work". Fundamental physical actions include overall mobility and discrete motions and strengths. Basic mental actions include central cognitive and emotional functions. In short, such physical and mental actions constitute the basic interface between a person and the physical and social milieu in which she or he does daily activities. *Disability* is experienced difficulty doing activities in any domain of life (the domains typical for one's age-sex group) due to health or physical problems. According to Verbrugge and Jette (329) the words "action" and "activity" are simple devices to distinguish the concepts of functional limitations and disability. They help convey the generic (situation-free) features of one and the social (situational) features of the other. Functional limitations refer to individual capability without reference to situational requirements. Disability is a social process – the pattern of behavior arising from the loss or reduction of ability to perform expected or specified social role activities of extended duration because of a chronic disease or impairment. Disability thus refers to the expression of a functional limitation in a social context. In many studies the term functional ability is used as the positive term for both absence of functional limitations and disability.

Most current studies of *disability* among elderly people focus on the ability to carry out the activities of daily living (ADL), which involve daily activities in the home, at work and in leisure time. Most measures comprise two phenomena: PADL (Physical Activities of Daily Living) and IADL (Instrumental Activities of Daily Living). PADL include basic daily tasks, which need to be performed by all people regardless of gender, culture, housing conditions, housing environment and leisure time interests (20). They include bathing, dressing, using the toilet, eating (163, 203). IADL comprise more complex, outgoing activities, which are essential for living an independent life in society (22, 24, 30, 98, 179, 299, 350). Work is the best example of an IADL activity, but after retirement daily tasks become more relevant for living a meaningful life. The activities most often used in measures of IADL are use of public transportation, shopping, cooking, housework, and administration of medicine and economy. For a further description of these measures, see 33.

Several factors contribute to shaping the dimensions and severity of disability. Studies have shown that lack of control (166, 214) and poor self-efficacy (209) are risk factors of functional decline. People who feel they cannot control or manage difficult situations may also be more likely to act negatively once they become disabled, e.g. they may not do the training that would be good for them or they may refrain from social contacts. Thus, the individual's perception of the situation and reactions to disability may be important factors in determining how the situation will turn out. The perception of the situation by others, and their reactions and expectations may also play a

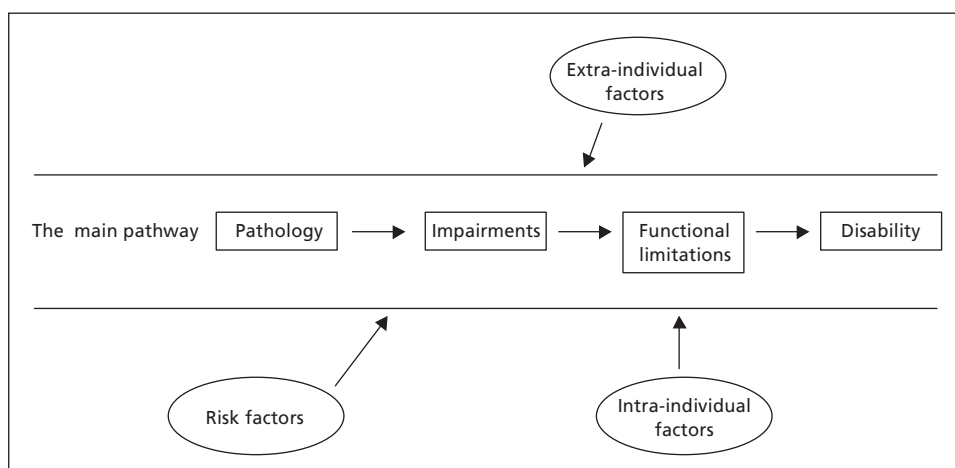


Figure 1. The Disablement Process.

role (224). Bookwala & Schultz (51) showed that caregivers with one or more characteristics of neuroticism were more likely to report higher levels of disability in the care recipient than the care recipients reported for themselves. Finally, the characteristics of the environment and the degree to which it is free from, or encumbered with physical and sociocultural barriers may be important (180). Recently, Shumway-Cook et al. (287) demonstrated that individuals with disability were more likely to avoid busy streets, streets with traffic lights, stairs and uneven surfaces and avoid going out in snowy weather compared to nondisabled persons. Thus, persons who live in areas without these barriers may experience less disability compared to persons who live in such areas. The disablement process explicitly includes factors that affect the pace and direction of disablement. These factors can be external, e.g. the physical environment or the social relations and internal, e.g. health behavior.

Over time, the disablement process can prompt some global outcomes and feedback effects (329): 1) Disability is a predictor of important outcomes such as hospitalization, institutionalization and death. It also has a powerful effect on happiness and life satisfaction. 2) A given disablement process can lead to a vicious circle and sometimes even cause new pathologies and associated consequences. Within a disablement process these feedback loops are often seen in frail persons, e.g. a woman with painful arthritis may no longer be able to walk with her dog (disability); this eventually reduces her aerobic capacity and muscle strength (impairments), further reducing mobility and social activities (functional limitations and disability).

1.1.3 Risk factors of disablement

There is a large number of longitudinal studies, which have examined risk factors of functional decline at the individual level (for a review, see 307). The majority of these studies has had a focus on factors in the main pathway of the disablement process.

It is thus well documented that a number of chronic diseases is observed more frequently in disabled older adults than in those who are nondisabled. However, not all diseases cause disability and some diseases cause more disability than others. Diseases with large effects on functional ability include stroke and other neurological diseases (105, 168), heart diseases (271, 276), respiratory diseases (68, 105, 276), high body mass index (173), diabetes (105, 228), depression (168), dementia (2, 334) and musculoskeletal diseases (105, 234, 239, 272). Although different medical conditions impose functional problems that are specific to each disease (64, 104), musculoskeletal disease is the chronic disease, which affects most dimensions of functional ability, including functional limitations and disability: *mobility* (paper XI, 127, 326, 327), *lower body limitations* (239), *upper body limitations* (127), *Physical Activities of Daily Living* (9, 326, 327), and *Instrumental Activities of Daily Living* (9, 127, 326, 327).

It has also been reported that the presence of more than one chronic disease in an individual – or co-morbidity – is related to the presence of disability and to that person's future risk of disability (41, 128, 272). For example, the number of chronic diseases in a disability-free group at baseline is directly associated with risk of losing mobility over 4 years (128). Also, after 4 years the risk of becoming disabled is 4-fold higher for a person with four chronic diseases than for a person with no chronic diseases (52). In some instances, a disease may not be sufficient to cause substantial disability in itself, but it may increase risk of subsequent functional decline when a new condition develops (328). Schroll et al. (270) found a step-wise increase in disability with increasing number of chronic conditions.

In addition, several types of impairments have been shown to be related to disability, e.g. hearing impairment (105, 238), visual impairment (238, 339), poor balance (87, 112), poor muscle strength (23, 156, 244), loss of muscle mass (331), motor impairment (165), pulmonary impairment (276, 279), and cognitive problems (paper II, 32, 36, 38, 118). Rantanen et al. (245) showed that the burden of co-impairments on disability e.g. having both poor balance and

poor muscle strength seemed to be greater than the sum of the single impairments involved.

It is also well-established that the behavioral risk factors play a large role in the disablement process. This has been shown for smoking (paper XI; 93, 173, 304, 306, 309), nutrition (173), and alcohol (173, 306). However, physical activity is probably the factor which is most important for promoting health into the latest years of life. Exercise is relevant to primary, secondary, and tertiary prevention; older adults at all levels of health and function can improve or maintain their exercise tolerance and strength through targeted exercise programs (96). Lack of exercise is strongly associated with disability onset, while, conversely, regular exercise appears protective in maintaining function (paper XI, 23, 272, 273, 274, 308). Longitudinal studies of aging have shown strong associations between health behavior and the incidence of disability with substantial postponement of the onset of disability. Vita et al. (332) documented postponement of disability by 7.75 years in those persons who exercised, had normal body mass indexes and did not smoke compared to those who did not exercise, were obese and smoked. The cumulative lifetime disability of those with low risks was one fourth of that in those with high risks.

1.2 RATIONALE FOR THE THESIS

Thus, in line with the disablement process, there is well-documented evidence that persons with diseases, impairments, and lack of exercise are more likely to develop functional limitations and disability than others. There is also ongoing abundant research on the biological and physiological processes of aging (65, 158), which influence the development of disability (95). Accordingly, it is well-established that the disablement process may accelerate because of biological and physiological age-related changes, because of disease and/or because of behavioral factors. However, in real life, the aging process does not occur in a pure untampered way. The aging process also includes early undetected signs of aging experienced by the old people themselves as well as specific external factors, e.g. social factors, which regulate the pace and direction of the disablement process (241, 329). Thus, there is a need to focus on pertinent aspects related to the aging process, where the knowledge is more limited. The rationale for the focus of the thesis will be presented in the following sections.

1.2.1 Changes in functional ability

First, it may give more insight in the aging process to study changes over time in functional ability. The aging process is dynamic and involves changes in all the steps in the disablement process, the most marked ones being the changes into disability and recovery from disability. Of this follow that studies of the dynamic processes of changes in functional ability give more information about the aging process than the study of functional ability measured at one point in time. During the last decades several studies on changes in functional ability have been published (9, 26, 68, 71, 106, 128, 136, 144, 145, 151, 162, 173, 181, 201, 210, 217, 279, 297, 303-305, 325). These studies show consistently 1) that a substantial proportion of elderly persons sustained a good functional ability during several years, 2) that several old people had a general functional decline during follow-up periods, but also 3) that a considerable proportion of elderly people recovered from disability over time. The studies are difficult to compare because of differences in study designs, study populations, measurements of functional ability, follow-up periods and because the changes in functional ability have been analyzed in different ways.

The change has been measured by a) comparing functional ability at baseline and at follow-up (26, 144), b) by calculating mean change in functional ability (162, 237, 304), c) by describing functional decline among the well-functioning elderly (106, 119, 231, 238), d) recovery among the poor-functioning (221), e) by analyzing both recovery and decline in the measurements (71, 210, 227,

237), or f) by studying functional ability at follow-up controlling for functional ability at baseline (41, 227, 273, 305).

An additional problem with regard to the measurement of change is the selection due to loss to follow-up because of death or non-participation for other reasons (77). This may be especially problematic in very old study populations because of the high mortality rates among these groups. If persons who die during follow-up periods are excluded from a study of functional decline there is a risk of missing important information both about different trajectories in function in old age and about the effect of different determinants on functional ability. There is also a risk of selection, however, because those with poorest functional ability at baseline are more likely to have died at follow-up (91). It will depend on the focus of a study whether this results in selection bias or not.

Nearly all studies of functional decline have excluded those who died during follow-up from the analyses (e.g. 230, 237, 238, 249, 279-281). Some authors report simultaneous analyses about predictors of mortality and transitions in function (136, 231, 258) and a few studies have combined death and various levels of functional ability in one scale. Some researchers have used a scale with four categories as outcome measure: independent, dependent, institutionalized, dead (128, 151). Other studies have had change from baseline to follow-up as outcome: functional decline, functional stability, functional improvement. Among these studies a few have considered death as part of a decline pattern: better, same, worse (incl the dead) (50, 303), and others have recoded the deaths as the most extreme value: better, same, worse, dead (9, 151, 328).

It is also possible that the various ways of measuring change with or without the dead may influence the associations between risk factors and functional decline. A few studies examined whether different risk factors had the same influence on functional decline and death. Hubert et al. (148) evaluated the potentially biasing effects of mortality in a 10-year follow-up study by including the deceased in the group of the most disabled. They found that predictors such as various diseases, education and physical activity had the same effect in the analyses with and without the dead. Lynch et al. (195) showed that the cumulative effect of low income was in the same direction when functional ability and death were used as outcome measures. Mendes de Leon et al. (210) and Boulton et al. (52) demonstrated that indicators of low socio-economic position and poor health were significantly associated with risk of developing disability, but that the same variables were not nearly as predictive of mortality risk. Beland & Zunzunegui (41) found that social position measured by education was related neither to functional decline nor death. In the study by Lee (181) social activities were related to both functional decline and death, while Liu et al. (188) demonstrated that social participation was related to death but not to functional decline. Although the results are somewhat contradictory, it seems important to include the dead in the analyses of the effect of risk factors on functional decline.

1.2.2 Early signs of the aging process

Second, it may be important also to study early signs of the aging process. Causes of disability are multifactorial, including physiological, psychological and social risk factors (307). Even though it is evident that the aging process is influenced by all the factors included in the disablement process, it is possible that there are some early signs that can be measured but which are not yet manifested in the disablement process. Knowledge about such early signs is important, because it will open up for deeper insight in the aging process. In addition, it might be useful in primary prevention to identify individuals at high risk of functional decline before it actually occurs by characterizing early functional states that are associated with later disability. For many individuals with co-morbidity and complex problems, targeting a single risk factor may have little value. Consequently, it may be important to explore common factors that increase the risk of disability, regardless of specific causes.

Recently studies have introduced biological markers of the aging process, which can be identified before the disablement process has large consequences. Examples of such biomarkers are signs of inflammation, immunological parameters and antioxidants (95). Other researchers have proposed that early signs of the aging process may be captured by a physiological cycle of frailty, including decreasing aerobic power, grip strength and endurance (108). It is also important to examine whether there are early signs of the aging process that can be experienced by the old people themselves. Such a factor that could be an indicator of a beginning disablement might be manifested as tiredness in daily activities.

1.2.3 Social position and functional decline

Third, studies of social position and functional decline offer an excellent opportunity to examine how factors throughout the life course influence the aging process. There is an abundant body of evidence showing strong associations between low social position at various ages and mortality, increased risk of chronic diseases and poor self-rated health (172). However, research on the relationship between social position and functional decline in older adults is limited. The available studies have shown that social position seems to influence functional decline in old age, however, with contradictory results: thus, higher education has been identified as a protective factor in some (52, 67), but not all (68, 162) studies of decline. Lower income has also been associated with subsequent disability in some (52, 67), but not all (68, 137) studies of decline.

To some extent the contradictory evidence may result from differences in the conceptualization and measurement of social position. School education and vocational training are primarily related to childhood and youth; occupation and income are more related to the working ages; material wealth reflects accumulation of living conditions and lifestyle throughout the life-course. It may thus be important to focus on the importance of the different measurement approaches to studies of social inequalities in functional decline among old people.

1.2.4 Social relations and functional

Fourth, it may also be important to study the associations between social relations and aging. It is well-established that persons with strong social relations are more likely to survive and to recover from serious illness (44). However, studies of the influence of structural and functional aspects of social relations on functional decline among older adults have produced contradictory results: Social network size has been identified as a protective factor in some (211, 320), but not all (188) studies of functional decline. Social participation has more consistently indicated a protective effect on functional ability (e.g.181). Boulton et al. (52) identified social support as a protective factor against functional decline, while Seeman et al. (280) found that social support had a negative effect on function, and that emotional social support was protective only among those with little instrumental support. Mendes de Leon et al. (211) found no effect of social support at all. These inconsistent patterns may partly reflect different measures of social relations.

The measures used in the studies referred to reflect only limited aspects of both structural and functional components of social relations. Other components of social relations, including telephone contact, diversity in social relations, and reciprocity of social relations may also be important and require study. Thus, the content of telephone contact may vary from that of face-to-face contacts (159). It is possible that the issues discussed over the telephone are different from and/or cause less strain than those taken up face-to-face. However, the influence of telephone contact on maintenance of functional ability is unknown. Other studies have shown that little diversity in social relations is a stronger predictor of morbidity and mortality than the actual number of friends in the network and the frequency of contacts with those friends (333). Antonucci and Akiyama (11) have shown that the give and take relationship is im-

portant to both men and women and that both men and women prefer to provide more than they receive. They also showed that reciprocity of social relations was protective of morbidity, but no studies have investigated whether or not this factor influences functional ability.

1.2.5 Consequences of disability

Fifth, an important part of the aging process is the process that goes on once there is no recovery from disability. The studies about consequences of disability are mostly limited to studies, which have shown that functional ability is a strong predictor of mortality. However, although some persons recover from disability and some people die soon after they have become disabled other older adults spend several years in a disabled state. There is a scarcity of studies with a focus on other consequences of the disablement process, such as utilization of health services, oral health, and social relations. Studies concerned with these consequences may not only add further to knowledge about factors related to the aging process, but this knowledge may also form the basis for prevention of these consequences, once there is no recovery from disability.

1.2.6 Gender differences

Finally, it will give more insight in the aging process to perform the analyses separately for men and women. Numerous studies have found gender differences in the various steps in the main pathway leading to disability, but also in the way behavioral, external and internal risk factors are associated with disability. The age-related changes in the endocrinological system vary for men and women (330). The diseases which cause disability tend to be different among men and women (276), and it has been suggested that men's lives are shorter due to fatal diseases, whereas women's lives are longer with more chronic conditions (324). Further, women have throughout life a lower pulmonary peak capacity function, less muscle mass and lower bone density and thus, in old age, physiological reserves will be exhausted sooner than in men.

In some cases the gender differences are in favor of the women. Females may be more aware of healthy behaviors throughout life because of a more continuous contact with the preventive and health services caused by pregnancies and childbirths (5, 324). A couple of Danish studies has confirmed that women are more inclined to try to eat less fat and to do more exercise (229) and that older women are more likely than older men to increase their physical activity level (277). However, American studies found no gender differences in adherence to physical activity programs (60, 167), and Reuben et al. (251) showed that patient adherence to recommendations from comprehensive geriatric assessment was higher among males than females.

Studies have also found gender differences in some of the determinants of interest for this thesis. A recent population study among adults in The Netherlands showed several gender differences in the experience of fatigue (43). Among women gender-specific biological problems, psychosocial problems and socio-demographic variables were related to fatigue. Among men fatigue was particularly related to having handicaps and severe chronic complaints.

Most studies of how social position and social relations influence functional ability have included gender as a covariate in the analysis (e.g. 68, 211) but have not considered that the influence of social position and social relations on functional decline may differ for men and women. This involves the risk of overlooking potential different patterns of associations between men and women. Only a few studies have performed the analyses separately for men and women. Strawbridge et al. (304) found that education and income were associated with functional decline among men but not among women, while Mor et al. (217) demonstrated that education was related to functional decline among women but not among men. Seeman et al. (281) and Unger et al. (320) demonstrated that poor social relations had a stronger effect on functional decline among men than among

women. However, to my knowledge, no other studies have examined these associations separately for men and women.

It is well-known that men's social relations in general are smaller than women's (4). Men are more likely than women to rely on a single confidant, most often their spouse, while women throughout life have learned how to recruit social network members to provide support in the appropriate ways at the appropriate times (288).

On this background it is important to stratify the analyses by gender, in order to analyze for different patterns of associations among men and women.

2. PURPOSE OF THE THESIS

The thesis has three main purposes:

1. To analyze changes in functional ability over time in old age.
2. To examine whether tiredness, social position and social relations are related to changes in functional ability in older adults. These factors are hypothesized to affect the pace and direction of the disablement process.
3. To analyze consequences of disability in old age on mortality, utilization of social and health services, oral health and social relations.

3. MATERIAL AND METHODS

The thesis is based on data (1) from the longitudinal studies of the 1914-population at the Center of Preventive Medicine in Glostrup from 1984-1999/2000, when the participants were 70, 75, 80, and 85 years old (papers IV, V, VI, VII, VIII, IX, XI), (2) from the longitudinal NORA-study of the 1914-populations in Glostrup, Göteborg and Jyväskylä from 1989-1994 at the ages 75 and 80 (papers I, II, X, XII) and (3) from the 1½ year follow-up survey in the Danish Intervention Study on Preventive Home Visits from 1999-2001 (paper III).

The analyses are based on longitudinal studies in 11 of the papers, and a cross-sectional study in one paper (VIII). I have chosen to include these 12 articles in the thesis, because their results all contribute to at least one of the purposes described above.

Figure 2 gives an overview of the determinants, outcomes and study populations in the analyses.

3.1 THE GLOSTRUP STUDIES OF THE 1914-POPULATION

The primary purpose of the first two studies of the 1914 population in 1964 and 1974 was to explore risk factors of coronary heart diseases (133, 267). Since the 70-year study was implemented in 1984 the focus has been on epidemiology of aging (See flowchart in Figure 3).

3.1.1 The 70-year study in 1984

The data in the 70-year study (See Figure 3) were derived from a sample survey of 1119 70-year-old people born in 1914 including two different groups: 1) 736 survivors from the Glostrup cohort study of 50-year-olds initially investigated in 1964 and 1974; 2) 383 additional individuals born in 1914 drawn from the Civil Registration Office in 1984 to supplement the survivors in order to increase the sample size of the 70-year-old cohort and to ensure representativity. Altogether 734 individuals (66% of the total sample) participated in all phases of the 70-year study. These individuals constituted the total sample studied in paper V. For a further description, see 19, 27, 276, 277. These two groups were compared with regard to social situational variables, biological functions, chronic diseases and behavioral variables. No statistical differences were found between the groups (21). The non-participants did not significantly differ from those who participated with regard to social and demographic characteristics or to days spent in hospital for all causes and for five specific diseases (stroke, cancer, diabetes mellitus, bronchitis and ischemic heart diseases) (276). However, there was a tendency that more non-participants had lower education and lower social class compared to participants (277).

Papers	Determinants	Outcomes	Study populations
Paper I	Changes in household composition from age 70 to 75 (retrospective question) Live with others 70 - live with others 75 Live with others 70 - live alone 75 Live alone 70 - live alone 75	Lower Limb-T (revised) not tired - not tired not tired - tired tired - not tired tired - tired PADL-H (revised) no help - no help no help - help help - no help help - help	NORA follow-up study age 75-80 Glostrup Göteborg Jyväskylä 1989-1994
Paper II	Lower Limb-T age 75	Mob-H (revised) Onset of need of help in mobility 75-80 PADL-H (revised) Onset of need of help in PADL 75-80	NORA follow-up study age 75-80 Glostrup and Jyväskylä 1989-1994
Paper III	Mob-T at baseline	Mob-H - Onset of need of help in mobility at 1½ year follow-up	Danish Intervention Study on Preventive Home visits - two age cohorts at baseline (age 75 and 80) 1999-2001
Paper IV	Changes in tiredness (Mob-T) age 75 to 80 not tired - not tired not tired - tired tired - not tired tired - tired	Functional decline age 80 to 85 (Mob-H) no help - no help no help - help no help - help or dead no help - dead	Combined study of the 1914-follow-up survey and the Danish part of NORA Ages 75-80-85 1989-1994-1999/2000
Paper V	Mob-T age 70 Lower Limb-T age 70 Mob-H age 70 PADL-H age 70	Mortality from age 70 to 80	1914-follow-up study from age 70 to 80 1984-1994
Paper VI	Mob-T age 75 Lower-Limb-T age 75 Mob-H age 75 PADL-H age 75	Hospitalization age 80 Use of home help age 80	Danish part of the NORA-study age 75-80 1989-1994
Paper VII	Mob-T age 75 and 80 (cross-sectional) Mob-H age 75 and 80 (cross-sectional) Changes in tiredness (Mob-T) age 75-80 increased or sustained good decreased sustained poor Changes in need of help (Mob-H) age 75-80 increased or sustained good decreased sustained poor	Oral health age 75 Number of teeth Chewing difficulties Regular visits to the dentist Oral health age 80 Number of teeth Chewing difficulties Regular visits to the dentist	Combined study of the 1914- follow-up survey and the Danish part of NORA Age 75-80 1989-1994
Paper VIII	Social position age 75 Vocational training Occupation Social class Income Housing tenure	Health age 75 Chronic diseases Mob-T Mob-H Oral health Well-being (CES-D)	Combined study of the 1914- follow-up study and the Danish part of NORA Age 75 Cross-sectional study in 1989
Paper IX	Social position age 75 Vocational training Income Housing tenure	Functional decline age 75 to 80 (Mob-H) no help - no help no help - help no help - help or dead no help - dead	Combined study of the 1914- follow-up study and the Danish part of NORA Age 75-80 1989-1994
Paper X	Social relations age 75 Frequency of telephone contact Membership of retirement club Social participation Diversity in social relations Instrumental social support Help to others	Functional decline age 75 to 80 (PADL-H - revised) no help - no help no help - help no help - help or dead no help - dead	NORA follow-up study age 75-80 Glostrup and Jyväskylä 1989-1994
Paper XI	Musculoskeletal diseases MSD + other diseases Only MSD Only other diseases No diseases	Mob-T age 75 (cross-sectional) Mob-H age 75 (cross-sectional) Mob-T Onset of tiredness in mobility 75-80 Mob-H Onset of need of help in mobility 75-80	Danish part of the NORA follow-up study Age 75-80 1989-1994
Paper XII	Lower-Limb-T (revised) age 75 PADL-H (revised) age 75	Changes in social relations (frequency of social contacts, diversity of social relations, social participation, social support) Sustained good Decrease Improvement Sustained poor	NORA follow-up study age 75-80 Glostrup Göteborg Jyväskylä 1989-1994

Figure 2. Determinants, outcomes and study populations in the presented analyses.

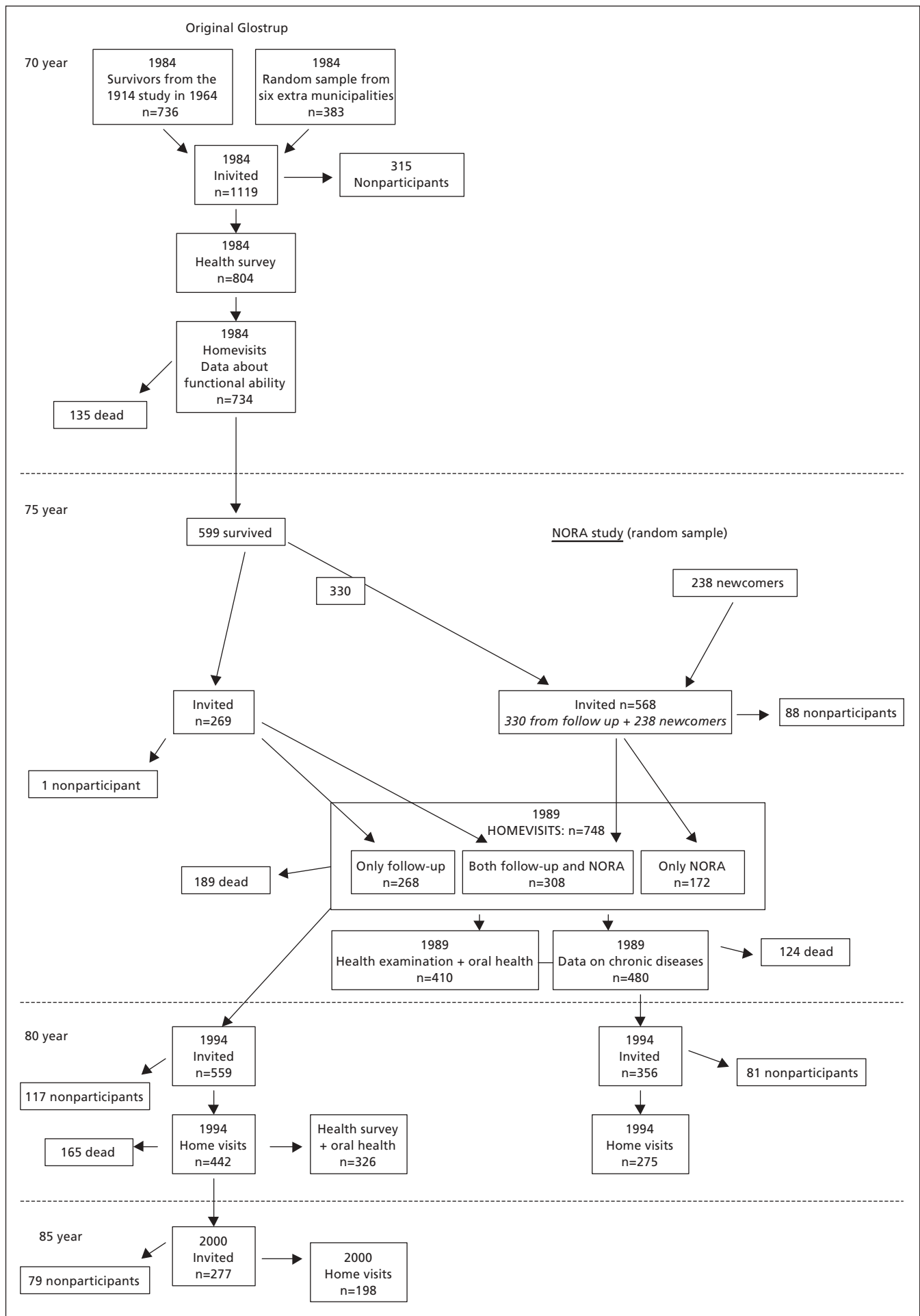


Figure 3. Flow diagram of the study population combined by the original 1914-cohort in Glostrup and the Danish part of the NORA study.

3.1.2 The 75-year study in 1989

The design of the 75-year study is complex as it is constituted by two studies (See Figure 3): The first study is the Danish part of the baseline NORA study in 1989. This study is based on a random sample of 568 men and women born in 1914 and living in 11 municipalities around Glostrup. A total of 480 persons (85%) agreed to receive a home visit and 410 (72%) took part in the health examination, which also included an interview with questions about oral health at Glostrup County Hospital. The persons who had a home visit but did not want to have a health examination answered a short questionnaire about chronic diseases. Consequently, we have information about diseases from all 480 participants. These two groups did not differ with regard to functional ability. Data obtained by short telephone interviews showed no statistical differences between the participants and non-participants with regard to socio-demographic characteristics. However, the participants tended to have a better functional ability compared to the non-participants (23).

The second 75-year study is designed as a 5-year follow-up of the 70-year survey in 1984. At follow-up 135 persons had died and 23 surviving subjects did not want to participate. Thus the study population in the follow-up survey at age 75 included 576 participants (participation rate 96). All persons in this group were interviewed at a home visit. A comparison of the participants in these two studies showed no statistically significant differences with regard to social situational variables and functional ability.

As the Danish part of the NORA study is based on a random sample of persons born in 1914 living in the same area as the individuals in the follow-up study of the 1914-population, a rather large proportion of this sample was also part of the original 1914-population. This means that only 172 participants in the NORA-study were newcomers to the 1914-cohort, that 308 of the participants form part of both studies, and that only 268 of the participants in the follow-up study from age 70 to 75 did not take part in the NORA-study. Unfortunately it was not possible to invite these 268 persons to the health examination for economical and practical reasons.

The combined population of 748 persons who participated in these two 75-year surveys constitutes the baseline study population for the tables 1, 2, 10-13 in this thesis about changes in functional ability and for the papers IV, VI, VII, VIII, IX and XI. Unfortunately, there are some inaccuracies in the description of the formation of the study population in paper VI and XI. The correct description can be seen in Figure 3. In addition, the size of the specific study populations varies in the papers 1) because the analyses in many cases are restricted to the non-disabled participants, 2) because the data analysis may include data both from the home visits and from the health survey, which have fewer participants, and/or 3) because of missing data on single variables.

3.1.3 The 80-year survey in 1994

The surviving participants from both groups of the 75-year study (n=559) were invited to take part in the 80-year study five years later (in 1994) (See Figure 3). Altogether 442 persons agreed to receive a home visit (participation rate 79), and 326 persons took part in the health examination (participation rate 58%). Unfortunately the number of survivors at age 80 is incorrectly described in paper VI and XI because of discrepancies between the preliminary and actual

number of deceased persons between the 75- and 80-year study. The correct numbers are indicated in Figure 3. As a consequence detailed analyses of loss to follow-up using the correct number of deaths and non-participation for other reasons than death are performed and shown in tables 1-4.

The 70-, 75- and 80- year studies all included a comprehensive medical survey at the Copenhagen County Hospital in Glostrup and a home visit with interviews about functional ability, social relations, social position, use of services, etc.

3.1.4 The 85-year study in 1999-2000

In 2000 when the participants were 85-86 years old all surviving participants (n = 277) from the 80-year survey were invited to participate in the 85-year study (See Figure 3). The 85-year study involved five different home visits with focus on 1) functional ability and psychosocial factors, 2) physiological factors and health, 3) psychological factors, 4) oral health, and 5) nutrition. Altogether 198 agreed to participate in the first home visit (71%) where the data were collected for the present study.

3.1.5 Loss to follow-up in the Glostrup Study

Table 1 shows the distribution of participants, non-participants and deaths at each follow-up study in the Glostrup study. The numbers in the columns for the 75-year study show what happened to the participants since the 70-year study, the numbers in the 80-year study columns what happened to the participants from the 75-year study, and the numbers in the 85-year columns what happened to the participants in the 80-year study. The patterns of losses to follow-up were the same in each period: Most participants were lost because of deaths, with more men dying than women. The proportion of persons who died and did not participate for other reasons increased with increasing age.

In order to examine for selection bias the analyses of loss to follow-up examine whether the main determinants for functional decline in the thesis are related to non-participation and death at follow-up.

Table 2 shows the association between functional ability in the preceding study (five years before) and participation in the actual studies. Functional ability is measured as tiredness and need of help in daily activities (The Mob-T Scale and the Mob-H Scale) (See page 12). The pattern is the same in all follow-up periods: Persons who felt tired or were in need of help in their daily activities were more likely not to participate in the follow-up study, first of all because they had died.

Table 3 shows the association between having musculoskeletal diseases at baseline (age 75) in relation to loss to follow-up at 5-year follow-up. The table demonstrates an association between having musculoskeletal and other diseases and both non-participation and death at follow-up among men (marginally significant). Among women the association was in the opposite direction: Significantly fewer women with musculoskeletal and other diseases were non-participants at follow-up compared to women with no diseases and there were no relationships between musculoskeletal diseases and death. Table 4 shows the association between social position measured by housing tenure and income at baseline (75-year study) and non-participation and death at follow-up at age 80. The table shows

Table 1. Loss to follow-up in the 75-, 80-, and 85-year follow-up studies in Glostrup.

	75-year follow-up study			80-year follow-up study			85-year follow-up study		
	men (n=364) %	women (n=367) %	p	men (n=337) %	women (n=411) %	p	men (n=190) %	women (n=252) %	p
Participants	73	83		56	61		41	48	
Dead before the study ¹	24	13		31	21		43	33	
Non-participants ²	3	4	0.001	13	18	0.005	16	19	0.135

1) Participated in the preceding study but died before the beginning of the actual study

2) Participated in the preceding study but did not participate in the actual study for reasons other than death

P-values describe differences between men and women

Table 2. Functional ability in the preceding study 5 years earlier in relation to loss to follow-up in the 75-, 80-, and 85-year surveys (Glostrup 1914-population).

	Tired in daily activities in the preceding study (Mob-T)						Need of help in daily activities in the preceding study (Mob-H)					
	men			women			men			women		
	tired %	not tired %	p	tired %	not tired %	p	help %	no help %	p	help %	no help %	p
75-year study	(n=186) (n=178)			(n=201) (n=166)			-	-	-	-	-	-
Participants	62	84		82	85		-	-	-	-	-	-
Dead from 70 to 75	35	12		15	10		-	-	-	-	-	-
Non-participants*	3	4	0.001	3	5	0.105	-	-	-	-	-	-
80-year study	(n=197) (n=140)			(n=281) (n=130)			(n=47) (n=290)		(n=95) (n=316)			
Participants	48	68		56	72		26	61		38	68	
Dead from 75 to 80	37	23		25	12		57	27		44	14	
Non-participants*	15	9	0.002	19	16	0.003	17	12	0.001	18	18	0.001
85-year study	(n=108) (n=77)			(n=168) (n=80)			(n=57) (n=127)		(n=100) (n=148)			
Participants	32	53		42	61		19	50		31	59	
Dead from 80 to 85	50	31		41	16		63	33		53	20	
Non-participants*	18	16	0.013	17	23	0.001	18	17	0.001	16	21	0.001

*) Non-participation for reasons other than deaths

Table 3. Musculoskeletal diseases (MSD) at age 75 in relation to loss to 5-year follow-up (Glostrup 1914-population)

	Men age 75 (n=221)				p	Women age 75 (n=259)				p
	no diseases (n=103) %	only other diseases (n=70) %	only MSD (n=29) %	MSD and other diseases (n=19) %		no diseases (n=114) %	only other diseases (n=68) %	only MSD (n=41) %	MSD and other diseases (n=36) %	
Participants	57	44	76	42		49	74	71	58	
Dead from 75 to 80	14	19	7	26	0.095 ^{p1}	28	9	10	11	0.240 ^{p1}
Non-Participants*	29	37	17	32	0.092 ^{p2}	23	18	20	31	0.001 ^{p2}

*) Non-participation for reasons other than deaths

p1) describes differences between participants and death by chisquare tests

p2) describes differences between participants and non-participants by chisquare tests

Table 4. Social position at age 75 in relation to loss to 5-year follow-up (Glostrup 1914-population)

	Men (n = 337)					Women (n = 411)								
	housing tenure			income		housing tenure			income					
	renter (n=168) %	other (n=26) %	owner (n=143) %	p	low (n=96) %	high (n=241) %	p	renter (n=221) %	other (n=30) %	owner (n=160) %	p	low (n=138) %	high (n=273) %	p
Participants	51	35	66		51	59		60	47	66		66	51	
Dead	33	62	23	0.021 ^{p1}	33	30	0.361 ^{p1}	21	43	16	0.228 ^{p1}	30	16	0.003 ^{p1}
Non-participants*	16	4	10	0.050 ^{p2}	16	12	0.405 ^{p2}	19	10	18	0.625 ^{p2}	18	18	0.352 ^{p2}

*) Non-participation for reasons other than deaths

p1) describes differences between participants and death by chisquare tests

p2) describes differences between participants and non-participants by chisquare tests

that men who rented their housing were more likely to die and to be non-participants than owners while income had no influence on loss to follow-up. Women with low income were more likely to die, while income made no difference in relation to non-participation for women. Tenure had no influence on loss to follow-up among women.

3.2 THE NORA STUDY (NORDIC RESEARCH ON AGING)

The NORA-study (Nordic Research on Ageing) was initiated in three different Nordic urban localities: Jyväskylä (Finland), Göteborg (Sweden) and Glostrup (Denmark) with the major aims 1) to describe and compare levels of functional capacity and health, and 2) to analyze associations between different indicators of functional capacity. The NORA-study includes a baseline study of 75-year old persons and a 5-year follow-up study when the participants were 80 years old (See flowchart in Figure 4).

3.2.1 The NORA baseline study of 75-year olds

The NORA-study (Nordic Research on Ageing) in 1989 included 75-year old men and women selected by random sampling from the

populations of Göteborg (Sweden) and Glostrup (138, 164, 168). In Jyväskylä (Finland) all people aged 75 formed the target population. The surveys included a home visit with interviews about functional ability and psychosocial factors and a health examination at the study center. The participants included 355 persons in Jyväskylä (participation rate 93), 368 75-year olds in Göteborg (participation rate 80), and 480 75-year olds in Glostrup (participation rate 85) (31, 32, 143). The participants and non-participants were compared based on data obtained by short telephone interviews. No major differences were found between the two groups in any of the three localities with regard to education and functional ability. Only the Glostrup non-participants tended to have somewhat poorer functional ability compared to the participants (23).

3.2.2 The NORA follow-up study of 80-year olds

Of the 268 survivors from Jyväskylä 243 persons took part in the 80-year study in 1994 (participation rate 91), among the 298 survivors from Göteborg 226 participated in the 80-year study (participation rate 76), and among the 356 survivors from Glostrup 274 took part in the 80-year survey in 1994 (participation rate 77 %). The same

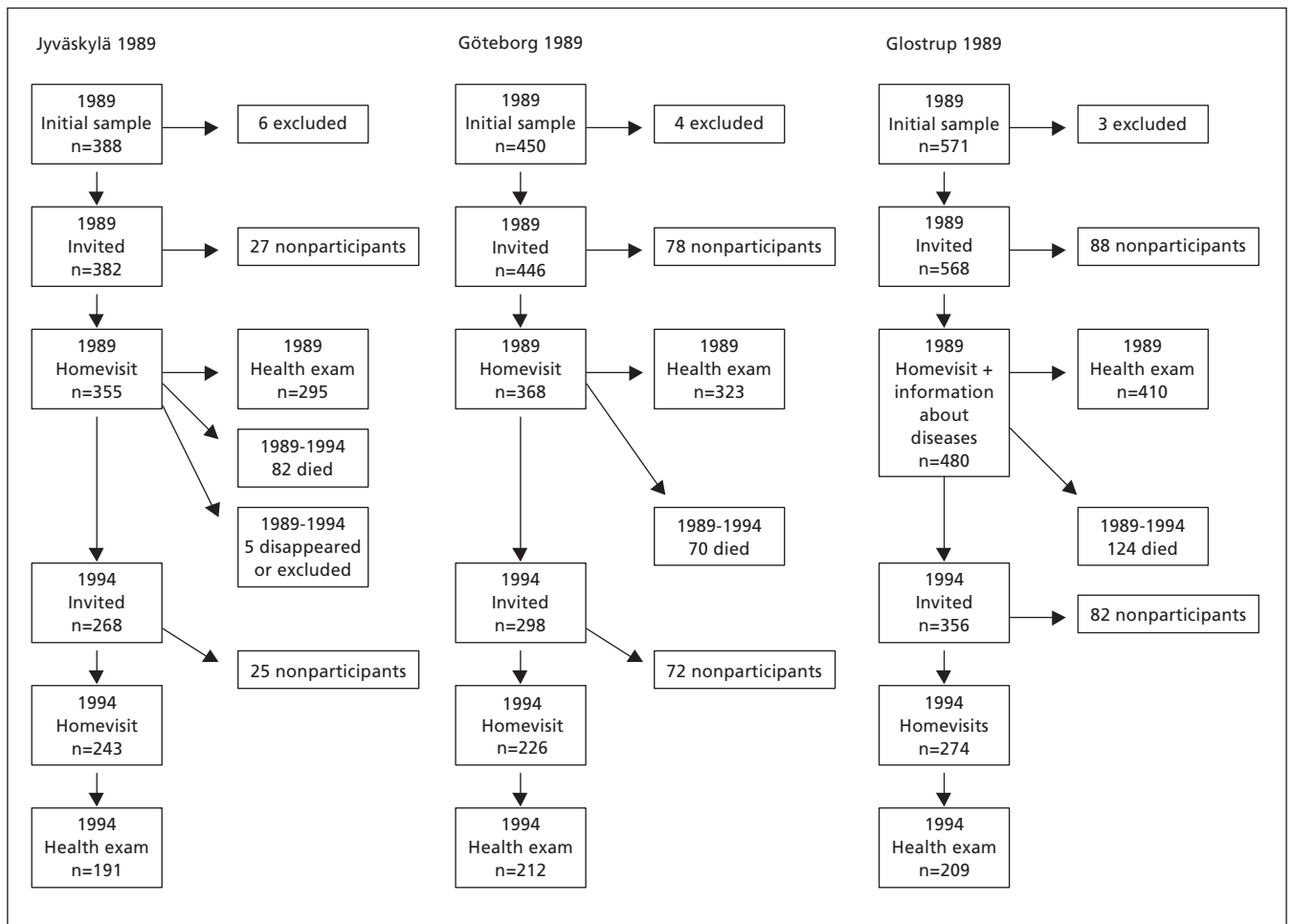


Figure 4. Flow diagram of the study populations in the NORA study.

procedures and methods were used as in the baseline study five years earlier (164). The analyses presented in the papers I and XII are based on participants from all three localities (n=743); the analyses in the papers II and X are based only on participants from Jyväskylä and Glostrup (n=517). Unfortunately the number of survivors at age 80 is incorrectly described in paper I, II and X because of discrepancies between the preliminary and actual number of deceased persons between the baseline and follow-up study. The correct numbers are indicated in Figure 4. As a consequence detailed analyses of loss to follow-up using the correct number of deaths and non-participation for other reasons than death are performed and shown in tables 5-7. In addition, the size of the specific study populations varies in some of the papers 1) because the analyses in many cases are restricted to the non-disabled participants, 2) because the data analysis may include data from both the home visits and the health survey, which have fewer participants, and/or 3) because of missing data on single variables. Finally, one person has continuously been giving prob-

lems, because he by mistake had a health examination in the baseline study, although he was only part of the follow-up study from the 70-year study. This person has been excluded from the preliminary database and included in the final database.

3.2.3 Loss to follow-up in the NORA-study

Table 5 shows the associations between functional ability at baseline in the NORA-study and loss of participants to follow-up. Participants who felt tired at baseline had significantly larger risk of dying during follow-up compared to persons who did not feel tired, and women who felt tired had a larger risk of not participating in the 80-year follow-up study for other reasons.

In general, changes in household composition (Table 6) did not significantly influence loss to follow-up in the NORA-study; however, more men who became alone or who continuously lived alone were non-participants at follow-up compared to men who sustained lived with others.

Table 5. Functional ability at baseline (age 75) in the NORA-study in relation to loss 5-year follow-up.

	Tired in daily activities (Lower Limb-T)						Need of help in daily activities (PADL-H)					
	men			women			men			women		
	tired (n=144) %	not tired (n=376) %	p	tired (n=252) %	not tired (n=391) %	p	help (n=106) %	no help (n=394) %	p	help (n=183) %	no help (n=521) %	p
Participants	51	71		51	76		49	64		49	69	
Dead from 75 to 80	40	19	0.000 ^{p1}	35	10	0.000 ^{p1}	34	23	0.009 ^{p1}	31	14	0.000 ^{p1}
Non-participants*	10	10	0.378 ^{p2}	13	13	0.075 ^{p2}	17	12	0.053 ^{p2}	21	17	0.017 ^{p2}

*) Non-participation for reasons other than deaths

p1) describes differences between participants and death by chisquare tests

p2) describes differences between participants and non-participants by chisquare tests

Table 6. Changes in household composition from age 70 to 75 in relation to loss to 5-year follow-up (NORA-study).

	Men			p	Women			p
	live with others - live with others (n=410) %	live alone - live alone (n=29) %	live alone - live alone (n=67) %		live with others - live with others (n=256) %	live with others - live alone (n=92) %	Live alone - live alone (n=283) %	
Participants	68	59	58		66	66	69	
Dead	23	7	18	0.388 ^{p1}	15	17	11	0.841 ^{p1}
Non-participants*	9	34	24	0.078 ^{p1}	20	16	20	0.192 ^{p2}

*) Non-participation for reasons other than deaths

p1) describes differences between participants and death by chisquare tests

p2) describes differences between participants and non-participants by chisquare tests

Table 7. Social relations at age 75 in relation to loss to follow-up (NORA-study - only participants from Glostrup and Jyväskylä).

	Weekly telephone contact			Club membership			Social participation			Take care of others			Sew for others		
	yes %	no %	p	yes %	no %	p	high %	low %	p	yes %	no %	p	yes %	no %	p
<i>Men</i>															
Participants	72	62		68	62		72	61		68	64		-	-	
Dead	21	29	0.071 ^{p1}	26	27	0.638 ^{p1}	23	28	0.146 ^{p1}	27	26	0.964 ^{p1}	-	-	
Non-participants*	8	9	0.501 ^{p2}	6	11	0.079 ^{p2}	5	11 ^{p2}	0.024 ^{p2}	5	10	0.201 ^{p2}	-	-	
<i>Women</i>															
Participants	73	58		82	60		75	60		83	63		78	64	
Dead	18	28	0.004 ^{p1}	13	26	0.000 ^{p1}	17	27	0.002 ^{p1}	10	25	0.000 ^{p1}	11	25	0.002 ^{p1}
Non-participants	9	15	0.023 ^{p2}	4	14	0.000 ^{p2}	8	13	0.023 ^{p2}	7	12	0.048 ^{p2}	11	11	0.661 ^{p2}

*) Non-participation for reasons other than deaths

p1) describes differences between participants and death by chisquare tests

p2) describes differences between participants and non-participants by chisquare tests

More men with poor social relations tended to be lost to follow-up compared to men with stronger social relations (Table 7). Significant or marginally significant associations were seen between no weekly telephone contacts and mortality during follow-up and between no club membership and low social participation in relation to non-participation at follow-up for other reasons than death. Among the women the associations between social relations and loss to follow-up were significant in nearly all comparisons. Thus, women with poor social relations were more likely to die during the follow-up period and to be non-participants at follow-up.

3.3 THE DANISH INTERVENTION STUDY ON PREVENTIVE HOME

The Danish Intervention Study on Preventive Home Visits had the main aim to examine whether preventive home visits to elderly people enhance active life expectancy, if carried out in a systematic and standardized way (322). The study is a randomized controlled intervention study with randomization and intervention at community level and outcome measured among the old people living in those communities (See flowchart in Figure 5).

The baseline study, performed October 1998 to January 1999, included all non-institutionalized citizens born in 1918 (80 years old) or 1923/1924 (74-75 years old) in 34 municipalities in four counties in Denmark. Altogether 5788 home dwelling persons in 34 municipalities were invited to take part in the study by answering the questionnaire, which included written consent. Fifty-three percent answered the questionnaire spontaneously. The non-responders were contacted by telephone or by mail, if no telephone number was available. Altogether 350 (6%) persons returned the signed questionnaire by mail after a telephone reminder, 463 (8%) persons after remailing the questionnaire, 145 (3%) persons were interviewed by telephone and signed the mailed questionnaire afterwards, and 64 (1%) returned the questionnaire after the mailed reminder.

This stringent recruitment process elevated the participation rate to 70%, leaving 4060 persons to participate in the study. In total 1446 persons refused to participate. Among half of the persons, who refused to participate it was possible to achieve an explanation for the refusal and answers to questions about their functional ability. The main reasons for refusal were being too healthy, too ill, fear of

registers and by principle not participating in research projects. We found no statistical differences in participation rates for the study populations in the intervention and control municipalities, neither were there differences in functional ability between the two groups (322).

Follow-up data were collected after 1½ and 3 years. The analyses in Paper III are restricted to data from the baseline and the 1½ year follow-up study in the control municipalities (n = 1956). In order to

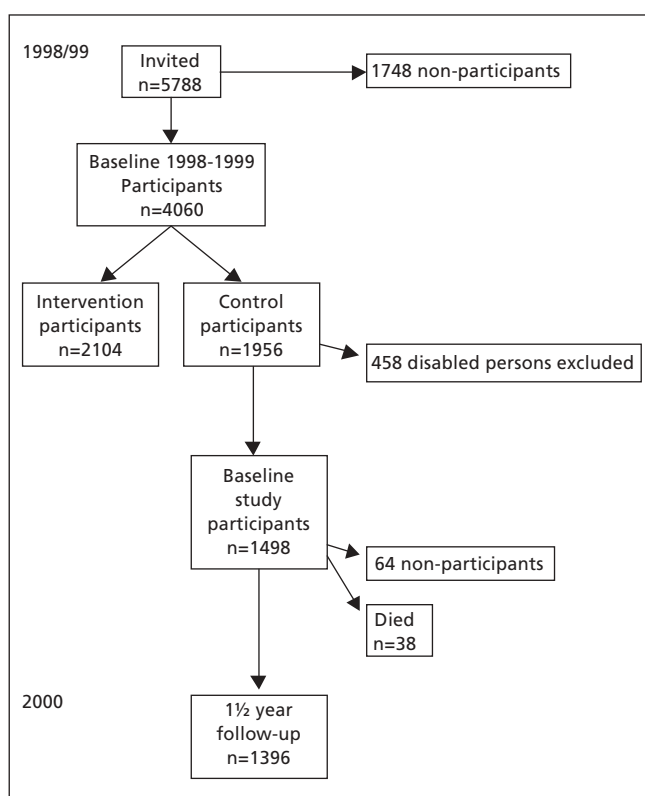


Figure 5. Flow diagram of the study population from the Danish Intervention Study on Home Visits.

select an initially non-disabled cohort, we excluded 458 persons reporting being in need of help in transferring, walking indoors, going outdoors, walking outdoors in nice weather and poor weather, and climbing stairs (n = 1498). At 1½ year follow-up 38 persons had died and 64 surviving subjects did not want to participate. After exclusions, the study population for this investigation consisted of 1396 older adults (participation rate among survivors: 96). These data constitute the basis for the results reported in paper III.

3.3.1 Loss to follow-up in The Danish Intervention Study on Preventive Home Visits

Table 8 shows the association between tiredness in daily activities at baseline and loss to 1½ year follow-up in the non-disabled study population. Tiredness was not related to non-participation in the follow-up study and to death at follow-up.

3.4. VARIABLES

3.4.1 Age

The Glostrup- and NORA-study populations are based on the birth cohorts from 1914. This means that it was not necessary to adjust the results by age. The study population in the Danish Intervention Study on Preventive Home Visits is composed by the birth cohorts from 1918 and 1923/24. Consequently the analyses in Paper III are adjusted by those two birth cohorts (older vs. younger).

3.4.2 Gender

In order to analyze whether patterns of associations differed for men and women, we wanted to perform the analyses separately for men and women. However, because of small sample sizes this was not possible in the papers II, IV, VI, VII and XI. In these papers we first performed preliminary analyses stratified by gender, which showed that the associations between the main determinants and the outcomes were in the same direction for men and women. Then we made combined analyses for men and women and included gender as a covariate, thus retaining the statistical power in the analyses. In the remaining seven papers and in the tables 10-13 on changes in functional ability in this thesis all analyses were performed.

3.4.3 The measure of functional ability

Functional ability was measured in the same way in all included study populations: by four scales based on questions about six mobility items and nine items on physical activities of daily living (See Figure 6). Every activity was described relative to two different dimensions: 1) With or without being tired afterwards, 2) Could or could not manage without help. The Mob-T Scale (Mobility-Tiredness) (6 items) and the Lower Limb T Scale (Lower Limb-Tiredness) (5 items) count the number of activities managed without tiredness. The Mob-H Scale (Mobility-Help) (6 items) and the PADL-H Scale (PADL-Help) (9 items) count the number of activities managed without help. High scale value thus describes better function.

The *content validity* of the scales is high as the included activities and categories can be said to be meaningful to all people. Both in the 70- and 75-year survey of the Glostrup population (20, 28) and in the baseline NORA-study (24) we found that all the included ques-

Table 8. Tiredness in daily activities at baseline in relation to loss to 1½-year follow-up (Data from the Study of Preventive Home Visits).

	Men			Women		
	tired (n=131) %	not tired (n=582) %	p	tired (n=191) %	not tired (n=566) %	p
Participants	88	92		95	95	
Dead	8	5	0.215 ^{p1}	3	3	0.970 ^{p1}
Non-participants*	5	3	0.488 ^{p2}	2	2	0.957 ^{p2}

*) Non-participation for reasons other than deaths

p1) describes differences between participants and death by chisquare tests

p2) describes differences between participants and non-participants by chisquare tests

Tiredness Mob-T (Mobility-Tiredness) ¹	Need of help Mob-H (Mobility-Help)
Transfer Get outdoors Walk indoors Walk outdoors in nice weather Walk outdoors in poor weather Walk on stairs	Transfer ² Get outdoors Walk indoors ² Walk outdoors in nice weather Walk on stairs Walk outdoors in poor weather ²
Lower Limb-T (Lower Limb-Tiredness)	PADL-H (PADL-Help)
Use toilet Wash lower body Dress lower body Take shoes/ stockings on/off ² Cut toenails	Comb hair Wash upper body Use toilet Dress upper body Dress lower body Wash lower body Take shoes/ stockings on/off ³ Cut fingernails Cut toenails
1) Item bias with regard to Nordic locality on all items in the scale (29) 2) Item bias with regard to Nordic locality on this item (29) 3) Item bias with regard to gender in the NORA data base (29) Consequently the Mob-T Scale is not recommended for use in the NORA-study and the biased items are removed in the Lower Limb-T Scale, the Mob-H Scale and the PADL-H Scale when used in the NORA-study.	

Figure 6. The four functional ability scales.

tions about mobility and PADL in relation to tiredness and need of help were relevant and well-known to nearly all participants, whereas this was not the case for the questions about Instrumental Activities of Daily Living.

The *construct validity* of the scales was tested on data from the 70- and 75-year study in Glostrup by the Rasch model for item analysis. The items in the four scales used in the thesis were homogeneous in relation to age, gender, household composition and self-rated health (21, 28). We also performed item bias analysis on the NORA-base-line data set (29). With regard to Nordic locality we found strong item bias on the total Mob-T Scale, on one item in the Lower Limb-T Scale, and on three items on the Mob-H Scale. We also found item bias with regard to gender on one item on the PADL-H Scale. The biased items were removed from the scales, and the adjusted Lower Limb-T Scale, the adjusted Mob-H Scale and the adjusted PADL-H Scale thus constitute the functional ability measures used in the analyses of the NORA-data base (See Figure 6).

Discriminatory power

When the functional ability scales were first used in the 70- and 75-year surveys we found a reasonable variation in levels of functional ability when the tiredness scales were used. In contrast, when the dependency scales were used the variation was very small: a large proportion of the study participants managed all the included activities without help (20, 26). Only 3%/20% of the 70-year olds/75-year olds needed help in at least one PADL-activity. The only exception to this was on the item "cut toenails", where the proportion who needed help was larger.

The scales were also used in a study of the discriminatory power of the functional ability scales among older adults in three service settings: residents in elderly-friendly flats, users of home care and non-users of home care (35). The results showed that the whole range of the Mob-T Scale could be used in all three populations, while the whole range of the Mob-H Scale could be used only among the oldest residents and the users of home services. This means that the Mob-T Scale is able to show variations among both people with good and poor function, and that the Mob-H Scale is able to show variations only in groups with relatively poor functional ability.

Reliability

Table 9 shows the results of the reliability analyses. Reliability tests

Table 9. Inter- and intra-rater reliability of the functional ability scales.

	Mob-T		Lower Limb-T		Mob-H		PADL-H	
	AP	kappa	AP	kappa	AP	kappa	AP	kappa
Inter-rater reliability	95.3	0.79	98.3	0.88	100.0	0.82	98.3	0.95
Intra-rater reliability	94.3	0.72	96.1	0.84	100.0	1.0	100	1.0

AP = Agreement percent

The results are based on data from the third Copenhagen City Heart Study (25)

on the functional ability scales showed agreement per cents from 94.3 to 1.0 and kappa values from 0.72 to 1.0 for the included items on intra-rater and inter-rater tests (See also 25).

Criterion-related validity

Further, functional ability as measured by the scales was strongly associated with isometric muscle strength ($p < 0.01$ in relation to hand grip, arm flexion, knee extension, and body extension) (23), simple function tests ($p < 0.05$ in relation to walking speed and step test) (23) and postural balance ($p < 0.05$ in relation to tests for speed of anteroposterior and mediolateral movement of the center of pressure and mean moment of velocity) (87).

Functional decline

All the papers in the thesis have focus on functional ability. For an overview, see Figure 2. In some of the papers functional ability is seen as determinant of 1) onset of use of health and social services (paper VI), 2) mortality (paper V), and 3) changes in social relations (paper XII). In one paper changes in functional ability are studied as determinant of oral health and use of dental services (paper VII). In the remaining papers functional decline is seen as outcome. In four of these papers functional decline (from good to worse) is measured only among the survivors (paper I, II, III, XI). In the most recent papers in the thesis we performed the analyses of functional decline both including and excluding the dead (IV, IX, X). Thus, functional decline was assessed as 1) Functional decline among the survivors measured as becoming in need of help in at least one activity during follow-up; (2) Functional decline during follow-up, including the dead. Persons with decline are defined as having either become in need of help or having died. Death is thus regarded as part of a functional decline pattern; (3) Death. Functional decline may include more aspects of decline than actual onset of disability. However, in the analyses of functional decline in this thesis we have restricted the study populations at baseline to those who were non-disabled. This means that we have not studied further functional decline among persons who already had some disability at baseline. As a consequence the terms onset of disability and functional decline are used synonymously in this thesis.

3.4.4 Other outcome measures than functional ability

Mortality (paper V):

Information about deaths was obtained from the Civil Registration Office.

Use of health and social services (paper VI):

Measured by questions about 1) Hospitalization during the last year: Yes/no. 2) Use of home help during the last year: Yes/no.

Use of dental services (paper VII) measured by questions about frequency of visits to a dentist or denturist: (1) regularly, 1-2 times every year, (2) 3-4 times within the last 5 years, (3) 1-2 times within the last five years, and (4) not within the last five years.

Oral health (paper VII)

was measured roughly by self-reported number of teeth (0-4 vs. 5 or more) and chewing ability by a question about ability to chew or bite in hard food items: (1) without difficulty, (2) with some difficulty, (3) with much difficulty, (4) not able.

Chronic diseases (paper VIII)

were measured by an open question: "Do you suffer from any long-standing illness...?" If the answer was positive, questions were asked about type, localization, duration, medical diagnosis, etc. (272). The answers were checked during the medical examination by a physician. Based on this information the physician coded relevant diagnoses for each participant, in accordance with WHO International Classification of Diseases-8. The main groups used for the present paper were: musculoskeletal diseases (ICD 710-849), mental, nervous and sensory disorders (ICD 290-389), disorders of the circulatory system (ICD 390-458), respiratory disorders (ICD 460-503), disorders of the digestive system (ICD 520-577), endocrinological and metabolic disorders (ICD 240-279), and various tumors (ICD 140-239). In paper VIII we distinguished persons with 0-1 and persons with 2-7 chronic diseases.

Well-being (paper VIII)

was measured by the Center for Epidemiological Studies Depression Scale (CES-D Scale) (242) based on 20 items, each rated from 0 (rarely or none of the time) to 3 (most of the time). The total score is a sum of all items, ranging from 0 to 60. The CES-D Scale is one of the best known survey instruments for identifying symptoms of depression with a cut-off score of 16 to distinguish individuals considered to be depressed from those classified as non-depressed (139, 242). In the present study we made a random cut-off score at 12 to get a reasonable distribution of feelings of well-being across the different socioeconomic groups (>12 : poorer well-being, ≤ 12 : better well-being).

Social relations (paper XII)

The structure of social relations was measured by

1. *Frequency of contact* with children, grand/greatgrandchildren, relatives, close friends, acquaintances, neighbors. We distinguish those with weekly and fewer contacts.
2. *Diversity of social relations*: Number of categories with whom the person had personal contact at least once per week: children, grand/greatgrandchildren, relatives, confidants, acquaintances, neighbors (range 0-6). Persons who had contact with 2-6 different network categories every week were categorized as having "high diversity". Persons with 0-1 different network contacts per week were categorized as having "little diversity".
3. *Telephone contact* with a) children and b) friends. We distinguished those with weekly and less telephone contacts.
4. *Social participation*: Three items about a) paying visits to others, b) receiving visits at home, and c) participating in social activities outside the home (37). For each of these three items we assigned one point for having done so weekly (range 0-3), and we dichotomized the participants into groups with low social participation (0-1 points) vs. high social participation (2-3 points).

The function of social relations was measured by

1. *Instrumental social support*. We asked four separate questions: Who does the housework, cooking, shopping, repairs in the house? For each of these four questions the respondent could mention herself/himself, the spouse, relatives or friends, and a formal home helper (143). Combined measures of quantity of social support were formed by the number of these four activities

performed by a) spouse and b) other social network. In this article we distinguished between persons without social support (0 points) and with social support (1-4 points).

Changes in social relations from age 75 to 80 is described in the following groups: With regard to frequency of contacts and social participation: 1) weekly, weekly, 2) weekly, < weekly, 3) < weekly, weekly, 4) < weekly, < weekly. With regard to social support: 1) with, with, 2) with, without, 3) without, with, 4) without, without. With regard to diversity in social network: 1) many, many, 2) many, few, 3) few, many, 4) few, few.

A test-retest study of the included items of social relations showed that the agreement per cents were between 72 and 100 and the kappa values between 0.501 and 1.0 for all items, with the structural items having the highest reliability. Further, in-depth interviews demonstrated high face and content validity of the social relations measures used (81).

3.4.5 Other determinant variables than functional ability

Musculoskeletal diseases (paper XI)

This measure was based on the variable Chronic Diseases (see page 13). We distinguished persons with 1) musculoskeletal diseases and other diseases, 2) only musculoskeletal diseases, 3) other diseases but no musculoskeletal diseases, and 4) no longstanding diseases at all.

Social position

Vocational training (paper VIII and IX): less than 3 years vs. 3 or more years.

Occupation (paper VIII) was measured by two separate indicators: Longest held occupation and last held occupation: unskilled and semiskilled workers, skilled workers, low managerials, high managerials, other which included self-employed and housewives. In the preliminary analyses we examined whether both longest held occupation and last occupation before retirement were related to the various health outcome variables. The patterns of association were in the same direction. Therefore longest held occupation was chosen for the final analyses.

Social class (paper VIII) measured by a combination of two variables: qualifications needed to hold the position and influence (number of subordinates) attached to the position. The participants and their spouses were classified by their last held occupation before retirement into five social classes according to the standards of the Danish National Institute of Social Research (134). Last held occupation was chosen here as we thought this had more influence on prestige at age 75 than longest held occupation. The participants were classified by their own individual social class, their spouse's social class, and the family social class according to the highest ranking spouse. We examined whether individual social class, social class of spouse, and family social class were all related to the health variables. The association between the social class of the spouse and the health of the participant was not very clear, whereas the association between family social class and individual social class were in the same direction. We chose the individual social class measurement for the analyses.

Income (papers VIII and IX): low (only compulsory old age pension), high (both compulsory old age pension and other income sources).

Housing tenure (papers VIII and IX): owners, renters, other (the majority of these was institutionalized).

Changes in household composition from age 70 to 75 (paper I)

was measured by two questions: 1) "Do you live alone – yes/no?" and 2) "Have there been changes in your household composition during the last 5 years – yes/no?" The answers to these two questions were combined into the following three categories: 1) Live with others at age 70 and age 75, 2) from living with others to

living alone from age 70 to 75, and 3) live alone both at age 70 and age 75.

Social relations (paper X)

measured as page 13 except that it was measured at one point in time when used as a determinant.

3.5 GENERAL CONSIDERATIONS WITH REGARD TO THE MEASUREMENT OF CHANGE

Important considerations in longitudinal studies of the aging process are the measurement of change in the determinants (in this case social position, household composition, social relations, tiredness, need of help) and in the outcome measures (functional ability, use of health and social services, oral health, social relations). The majority of these factors is dynamic and changes over time, and some of the factors may fluctuate considerably within short time periods (e.g. tiredness, social relations). It is necessary, however, to use measurements with rather long time intervals for economic and practical reasons. As a consequence we have no knowledge about changes in these variables between the measurement points. This makes it impossible to analyze e.g. whether persons with large fluctuations in tiredness or unstable social relations are more susceptible to functional decline than others. Lund (192) describes these limitations in a "traditional" longitudinal study design, which examines the determinant measure at one point in time and the outcome measure at another point in time.

One way of overcoming this limitation is to measure a determinant at one point (time 1) and measure the outcome both at time 1 and time 2. This has been done in paper II, III, IX, X, XI with functional decline as outcome, in paper VI with onset of use of services as outcome and in paper XII with changes in social relations as outcome. This design implies a careful selection of the study population at point one, e.g. that the study population includes participants without disability or with good social relations. It is then possible to analyze the predictive value of the determinant at one point in time on decline in the outcome, since all participants had an equal score on the outcome at baseline.

Another possibility is to measure the determinant at two points in time and study the effect of change on the outcome either at the second point in time (as in paper VII), at a third point in time, or to study the influence of change in the determinant from time 1 to time 2 on changes in the outcome from time 2 to time 3 (as in paper I and IV). This design may be viewed as further extension of the traditional design, because it provides some information about the consequences of changes in the determinant over time.

When we used mortality as outcome (paper V) we had the advantage of knowing the exact dates of the deaths. Consequently, we used the Cox proportional hazards regression model to examine the association of the score on the functional ability scales with subsequent 10-year mortality risk, while simultaneously adjusting for the other variables. The parameter of interest in the Cox-model is the relative hazard, which may be regarded as a kind of relative risk. The proportional hazard regression model utilizes information about time to death.

3.6 STATISTICAL ANALYSIS

Although there were some variations in the 12 papers the statistical analyses were performed almost in the same way in all the articles. The first step was to test whether the main determinants and the covariates were associated with the outcome measures at the bivariate level by chi-square tests. The covariates found to be individually related to the outcome measures were then incorporated as independent variables in the multivariate regression analyses to determine whether the association between the main determinants and the outcomes was influenced by these factors. In paper V the Cox proportional hazards regression model was used as mentioned above. In the remaining papers we used a multivariate logistic regression

analyses with the SAS PROBIT procedure. Finally, in paper X multiple linear regression analyses were used to test whether the results were the same when using the outcome measure as a continuous scale. The SAS PROC REG procedure was used.

RESULTS

The findings are described in detail in the separate papers. This chapter includes a subchapter for each main result. Every subchapter comprises a short description of the specific findings followed by a discussion.

4.1. CHANGES IN FUNCTIONAL ABILITY

The primary results presented in this chapter are that the analyses of change over time show both improvement and deterioration, and that the patterns of change vary by age and gender. As the results of these studies are based both on findings from paper I and from new analyses presented in the tables 10-13 in this thesis, the following sections will include a more detailed description and discussion of these results followed by a discussion.

Table 10 shows that the proportion of men and women who felt

tired and were in need of help in their daily activities increased with age. About half of the study population felt tired when they were 70 years old compared to more than 75% of the 85-year olds. Only 3%/4% of the 70-year old men/women needed help compared to 40%/60% of the 85-year olds. No gender differences were seen at age 70, but as the population grew older, significantly more women felt tired in their daily activities compared to the men.

Table 11 shows the individual changes in self-reported tiredness in daily activities in the different follow-up periods. In all three follow-up periods a large proportion of old people had sustained tiredness. Up until the age of 80 a rather large proportion reported sustained no tiredness in the follow-up periods, and some people also recovered from a period with tiredness. However, the proportion of persons with sustained no tiredness from age 80 to 85 was small and very few recovered from tiredness in that age group, while a substantial proportion declined. More women than men had sustained tiredness in all follow-up periods.

Table 12 demonstrates changes in need of help in the three follow-up periods. From age 70 to 75 a large proportion had sustained no need of help and a rather small proportion became in need of

Table 10. Proportion of 70-, 75-, 80-, and 85-year old men and women who felt tired in their daily activities or who needed help to perform their daily activities.

	70 years old			75 years old			80 years old			85 years old		
	men (n=364) %	women (n=367) %	p	men (n=337) %	women (n=411) %	p	men (n=184) %	women (n=248) %	p	men (n=77) %	women (n=119) %	p
Tired ¹	51	55	0.406	59	68	0.005	58	68	0.045	79	87	0.126
Need help ²	3	4	0.705	14	23	0.001	31	40	0.046	36	58	0.003

Tired 1): Measured by the Mob-T Scale

Need help 2): Measured by the Mob-H Scale

p describes differences between men and women by chi-square tests

Table 11. Changes in self-reported tiredness in daily activities (measured by the Mob-T Scale) among men and women from age 70 to 75, from age 75 to 80 and from age 80 to 85.

	From age 70 to 75			From age 75 to 80			From age 80 to 85		
	men (n=265) %	women (n=310) %	p	men (n=185) %	women (n=248) %	p	men (n=75) %	women (n=118) %	p
Not tired - not tired	33	25		29	20		19	8	
Not tired - tired	23	21		21	17		35	33	
Tired - not tired	8	7		13	12		0	4	
Tired - tired	35	47	0.034	37	50	0.033	47	54	0.056

p describes differences between men and women by chi-square tests

Table 12. Changes in need of help in daily activities (measured by the Mob-H Scale) among men and women from age 70 to 75, from age 75 to 80 and from age 80 to 85. The percentages are based on the survivors in each follow-up period.

	From age 70 to 75			From age 75 to 80			From age 80 to 85		
	men (n=265) %	women (n=310) %	p	men (n=184) %	women (n=248) %	p	men (n=74) %	women (n=118) %	p
No help - no help	87	77		67	57		61	35	
No help - help	12	20		26	29		24	36	
Help - no help	0	1		2	2		1	3	
Help - help	0.4	3	0.005	5	11	0.059	14	22	0.031

p describes differences between men and women by chi-square tests

Table 13. Changes in need of help in daily activities (measured by the Mob-H Scale) among men and women from age 70 to 75, from age 75 to 80 and from age 80 to 85. The percentages are based on all the persons who participated in the baseline study of each period.

	From age 70 to 75			From age 75 to 80			From age 80 to 85		
	men (n=364) %	women (n=367) %	p	men (n=337) %	women (n=411) %	p	men (n=184) %	women (n=248) %	p
No help - no help	63	65		37	35		25	19	
No help - help	9	16	0.015 ^a	14	18	0.226 ^a	10	17	0.017 ^a
No help - death	21	11	0.002 ^b	23	10	0.001 ^b	23	12	0.217 ^b
No help - non-participation	3	4		12	14		11	12	
Help - no help	0	0.5		1	1.5		0.5	2	
Help - help	0.3	2		3	7		5	11	
Help - death	3	1.4	-	8	10	0.125 ^c	20	21	0.154 ^c
Help - non-participation . .	0	0	0.001 ^d	2	5	0.001 ^d	5	6	0.009 ^d

a) describes p value for difference between men and women in onset of need of help among the survivors

b) describes p value for difference in death between men and women among those in no need of help

c) describes p value for difference in death between men and women among those in need of help

d) describes p value for total difference between men and women

help. Although this pattern changes over time it is still a rather large proportion of both men and women who had sustained no need of help from age 80 to 85, even though the proportion who became in need of help is substantial. In all follow-up periods the women were worse off: They had more sustained need of help and more functional decline than the men.

Table 13 summarizes the complete picture of the changes during the follow-up periods, as it includes the persons lost to follow-up during each of these follow-up periods. First of all this decreases the proportion with sustained no need of help in all the follow-up periods. Among the non-disabled participants significantly more women than men became disabled in the follow-up periods (though this was far from significant from age 75 to 80), while significantly more men than women died. Among those who were disabled (in need of help) at the various baselines no gender differences are seen with regard to death.

Paper I describes the changes in Physical and Instrumental Activities of Daily Living from age 75 to 80 among men and women in the NORA-study. The results are in the same direction as in table 12 and 13: A large proportion of men and women had sustained good functional ability from age 75 to 80, with both improvement and deterioration over time. The activities in which most people had sustained poor function and fewest people had sustained good function were the same with regard to tiredness and need of help, – and the same for men and women: PADL (measured by the Lower Limb-T Scale and the PADL-H Scale), vacuum cleaning and garden work. The activities that gave fewest problems to both men and women were managing money and preparing cold meals. Significantly more women than men had sustained poor functional ability from age 75 to 80 in many of the items, especially with regard to tiredness.

The finding of both improvement and deterioration over time is in agreement with several other studies (59, 136, 144, 176, 195, 262, 303, 346). The results indicate that functional ability is not a stable construct; functional ability may not only deteriorate by age, but also improve. It may thus be possible to postpone both tiredness in daily activities and need of help. More improvement was seen with regard to tiredness than with regard to need of help. This indicates that it is easier to recover from tiredness than from need of help and supports the results by Crimmins et al. (71) and Wolinsky et al. (347) that it is easier to recover from loss of function, if the impairment is not severe.

Another interesting finding about changes in functional ability is that women had both higher prevalence and higher incidence of disability than men, but that the men had higher risks of dying. This is in agreement with other studies, which found that women had consistently higher rates of prevalent and incident disability compared to men (135, 217, 225). One study did not find gender differences in incidence of disability (303). The lack of agreement between studies most likely reflects both the heterogeneity of disability in populations but also the hazards of using a variety of definitions of disability. In contrast to the findings on disability incidence other research findings are generally consistent in showing that men have higher mortality rates than women, in accordance with the present results. Crimmins et al. (72) found that older men had substantially higher mortality rates than women at the same age within each of four levels of functioning, ranging from no functional problems to inability to perform personal care. Similar gender differences in mortality rates among non-disabled and disabled populations were observed by Leveille et al. (184). In both non-disabled and disabled subsets of their study population women had one-third to one-half the risk of dying compared to men across 5-year age categories from age 65 to 95. In another analysis men had twice the risk of mortality from a non-disabled state, and a somewhat higher risk of dying from a disabled state compared to women (210). In the Glostrup Population Study we did not find the gender differences in deaths from disabled states (Tables 11-13). It is possible, however, that we would have had different results had the study population been larger.

These gender differences may have several explanations: It is possible that gender differences in the diseases underlying the disablement process play a role in explaining this paradox. It is known that, compared to men, women have higher rates of disabling, non-fatal chronic disease. This is particularly true for musculoskeletal diseases, such as arthritis and osteoporosis (183, 197, 225). Other chronic conditions that disproportionately affect women include depression, varicose veins, migraine (197), cataracts (183), and dementia (89). Each of these conditions may contribute to disability in old age. Also gender differences in systolic blood pressure may play a role. Recent studies showed relatively greater increase in isolated systolic blood pressure with aging in women compared to men, resulting in a higher pulse pressure in older women than in older men (260). It has also been demonstrated that women with peripheral arterial disease had a higher prevalence of leg pain on exertion and rest, poorer functioning, and greater walking impairment from leg symptoms than men with the same disease (208). Contrary to this, men have higher rates of common fatal diseases, such as heart disease and cancer (183) and thus are more likely to die from these diseases before disabling chronic conditions can progress to disability in old age.

Another explanation may be that men have a shorter duration of disability because they die from the conditions that cause their disability, such as heart disease and stroke. In addition, the number of chronic conditions also predicts incident mobility disability, suggesting a dose-like effect for these conditions on future occurrence of disability (52, 128). Recent American evidence has demonstrated that, in addition to having higher rates of the most common disabling conditions women also have higher co-morbidity, that is more co-occurring chronic conditions, another factor that may contribute to higher rates of disability in women (183, 225, 272). Schroll et al. (271) showed a step-wise increase in prevalence of disability with an increasing number of chronic diseases.

Constitutional factors related to body composition may predispose more women than men to becoming disabled. The higher risk of osteoporotic fracture in women compared to men is related to lower peak bone mass in women and accelerated bone loss beginning at menopause (204). Women have poorer pulmonary function and lower aerobic capacity than men (88, 277) and the age-related declines are larger for women compared to men (88). Women also have more loss of muscle mass and higher percentages of body fat than do men (114, 154, 225, 331). This relative difference in body composition may be a major contributor to the comparatively greater disability in older women. For example, a number of studies has suggested that muscle strength plays an important protective role in preventing disability (23, 244, 246, 273, 294). Lower initial muscle strength in women, compounded by further strength losses that occur with aging may place older women at greater risk of mobility problems in old age, and help explain gender differences in disability. Many common tasks that are critical for independence, such as walking and climbing stairs, require the same amount of strength across gender (243). Certain tasks including walking and rising from a chair require threshold levels of strength and aerobic capacity (244, 270) and women are typically closer to these threshold levels than men.

4.2 TIREDNESS AS DETERMINANT OF FUNCTIONAL DECLINE

The primary results summarized and discussed in this chapter are that tiredness in daily activities is an early indicator of 1) later disability and mortality at the individual level, 2) use of social and health services and 3) less use of dental services. The importance of tiredness as an early sign of disability has never been shown before.

More specifically the conclusions of the papers II-IV were that 1) tiredness in daily activities at age 75 was a strong independent determinant of onset of disability in mobility and daily activities at five-year follow-up (paper II), 2) that tiredness in daily activities in

two age groups (age 75 and 80) was a strong independent determinant of onset of mobility disability at 1-year follow-up (paper III), and 3) that sustained tiredness from age 75 to age 80 was significantly related to functional decline from age 80 to 85 (paper IV). These studies thus follow and expand on the results from a study in 1995, which demonstrated that self-reported tiredness in daily activities at age 70 was strongly related to dependence of help in daily activities at 5-year follow-up (26).

The conclusions of the studies with outcomes other than disability were 1) that tiredness in daily activities at age 70 was independently associated with mortality at 10-year follow-up (paper V), 2) that sustained tiredness in daily activities from age 75 to 80 was significantly related to mortality from age 80 to 85 (paper IV), 3) that tiredness in daily activities at age 75 was strongly related to hospitalization and use of home help at 80-year follow-up (paper VI), and 4) that sustained tiredness from age 75 to 80 was marginally related to not using regular dental services at age 80 (paper VII).

The findings demonstrate the significance of tiredness among the young-old (paper V, 26) and the old-old (paper IV), among men and women, and among older adults in different populations, i.e. in Glostrup (papers II, IV, V, VI, VII), in three other counties of Zealand (Denmark) (paper III), in Southern Jutland (Denmark) (paper III) and in Jyväskylä (Finland) (paper II).

Tiredness is an ambiguous concept, which especially relates to the reaction to physical and psychological work loads, but the concept may also include many different experiences and states of mind, e.g. the experience of exhaustion, impaired energy and vitality, and need for sleep. Further, tiredness is the normal physiological reaction in an organism, a part of the body or an organ, which has reached the limits of its capacity after heavy strain. Tiredness is a general reaction to any biological processes after intensive and/or long-lasting work, because the metabolic demands can not be met. This can occur outside the central nervous system, e.g. in the muscles after heavy and intensive stimulation. The centrally conditioned tiredness is more complex and entails both chemical and hormonal factors in nerve cells and their synapses, but also psychological factors such as endurance and motivation (257, 316). Tiredness which cannot be relieved by rest or sleep is a frequent sign of disease. Tiredness may in its chronic form be considered a disease in itself or it may be a personality trait throughout life (257, 316).

The measure of tiredness used in this thesis is based on the participants' own experiences. We asked whether the participant felt tired after performing each activity and/or whether he/she needed help to perform the activity. The questions were introduced by the following paragraph: "Many elderly people feel that they get tired when they have performed certain activities. We are going to ask the following questions in order to learn whether you are able to manage these daily activities without help and whether you get tired when you have performed the individual activities." This measure of tiredness thus has focus on tiredness in performing certain activities, and it is therefore likely that the measure reflects the physiologic and biologic consequences of doing these activities.

I want to focus on two potential explanations for the finding that tiredness in daily activities is related to functional decline. The first explanation may be that tiredness is a consequence of disease and other factors in the main pathway of the disablement process. Tiredness is closely related to many of these factors, suggesting that the pathway to disability goes from the factors in the main pathway via tiredness in daily activities to actual disability. Previous studies have shown that older adults with diseases (272, 276), impairments (23, 87, 269, 276), and functional limitations (23, 269) are more likely to experience tiredness in their daily activities. Nevertheless, when we adjusted the association between tiredness and functional decline by these factors they did attenuate the association, but not enough to explain the strong associations. In spite of this it is still possible that the associations between tiredness and functional decline could be due to other impairments or diseases not adjusted for in any of the

analyses and which may be related to tiredness, e.g. actual depression (337), or to health behaviors not adjusted for, e.g. inadequate nutrition (266), excessive drinking (216), or poor sleep patterns (100).

The other explanation for the finding may be that tiredness in daily activities is a consequence of age-related physiological and biological changes that are not disease-based. This explanation is based on the definition of tiredness in daily activities as a biologic syndrome of decreased reserve capacities and decreased resistance to stressors, resulting from cumulative declines across multiple physiologic systems, – declines that have not yet caused frank disability. I propose that the organs/systems, which may play the largest role for the findings are three main organs/systems of great importance in the disablement process: muscle function, cardiovascular/pulmonary function and cognitive function.

First, there are strong age-related declines in these three organs/systems. The age-related changes in muscle strength in older adults (247) are influenced by an age-related decrease in muscle mass caused by loss of motor neurons, lower levels of steroid hormones, a reduction in dietary protein, and a decreased level of physical activity (160, 190, 285). Loss of muscle mass will theoretically affect oxygen demand and perfusion (oxygen delivery) during muscle contractions at the same relative force levels. In addition to muscle mass, maximal voluntary muscle strength is determined by neural drive from motor cortex to muscles (86, 113). Maximal voluntary muscle strength is thus an indicator of the functioning of both the neural and the muscular system (247), and studies have shown strong correlations between tiredness in daily activities and muscle strength (23, 272).

Several studies have demonstrated age-related changes in cardiovascular (88) and pulmonary function (277). The biological age-related changes in the cardiovascular system are first of all manifested as a decrease in the heart minute volume (330). The age-related changes in the pulmonary system are caused by a decreased elasticity of the lungs, a reduction in lung volume and a decrease in the elasticity of the ribs, which cause a deterioration in vital capacity and forced expiratory volume. These changes in lung function combined with a reduction in the maximal heart volume result in a decreased aerobic capacity (330). Riley et al. (253) showed that fatigued individuals had a reduced aerobic work capacity compared to persons who were not fatigued. They had a significantly higher heart rate at submaximal levels of exertion and significantly higher blood lactate concentrations. Using a measure of tiredness which reflects feelings of exhaustion, Appels et al. (13, 14) found that tiredness was positively related to angina pectoris and unstable angina pectoris at screening as well as to future angina pectoris and non-fatal myocardial infarction. It is possible that tiredness in daily activities is a better indicator of aging of the cardiovascular system (271), while tiredness as measured by Appels et al. (13, 14) may be a more precise early sign of cardiovascular disease.

It is also well-documented that there is an aging-related loss in cognitive reserve capacities (218, 219, 312, 335). The normal aging process includes changes in the cognitive functions (intelligence, memory, learning, thinking), but many of these changes take place throughout life and are not necessarily linked to old age. This is the case for the so-called 'fluid intelligence', which refers to speed, mental span, and reserve capacities in adaptation of information and responses to new and complex stimuli. These tasks are linked to neurobiologic factors and normally show a gradual decline during the last part of adulthood. Contrary to this cognitive functions based on experience (crystallized intelligence) may improve throughout life under favorable circumstances. These functions include knowledge, strategical insight, expertise, and everyday problem solving (111, 301) and are considered to be more influenced by life history and social factors than by age (295). The declines with age are smaller for these tasks than for the tasks related to neurobiologic factors (218, 219).

A previous study (32) on the association between tiredness and cognitive function showed that participants with a poor self-reported memory indicated more tiredness/strain when they were engaged in more complex motor activities. Thus, it seems reasonable to assume that persons with self-reported memory problems are getting closer to the threshold levels of actual cognitive deficits. Many daily activities are characterized by relative complexity. It is possible that early signs of cognitive decline such as memory problems may complicate the ability to perform activities, which used to be easy to perform. This is likely to lead to tiredness.

Second, these three organs/systems are all related to functional ability (32, 36, 244, 270). More specifically, it is well-established that older adults are not able to perform daily activities, when they get below certain threshold levels of muscle strength (244, 270) and aerobic capacity (270). To the best of my knowledge there is no evidence for an exact threshold level of cognitive function for being able to manage daily activities. However, Agüero-Torres et al. (3) found that demented subjects had greater prevalence of disability in ADL than cognitively impaired subjects without actual dementia, who, in turn, had greater disability than subjects without cognitive impairment. Further, Avlund et al. (32, 36) showed that older persons with only memory problems were more likely to feel tired in their daily activities, whereas older adults with actual cognitive problems were more likely to be dependent on help from others.

Third, the gender differences in these three systems support the hypothesis that tiredness is an indicator of aging-related decline in these systems. Loss of muscle mass (154), muscle strength (23), aerobic capacity (88) are larger among women than men. Although there are few gender differences in changes in cognitive function (218, 219, 311), it has been shown that baseline performance in cognitive function was lower among women than men, both at age 50, 70, and 80 (219). Consequently, women may be closer to the threshold levels of not being able to manage the daily activities compared to men.

Tiredness in daily activities may thus capture initial dysregulations across a multiplicity of physiological and biological systems, first and foremost in the muscle, cardiovascular/pulmonary and cognitive systems. However, other age-related declines may also play a role, e.g. the age-related declines in the nerve system and the sensory system (330) and in the immunological system (42, 79, 340), or tiredness may reflect subclinical infections, which are regarded as biological responses of the immune system to a number of different stimuli (94, 251). In addition to that it may reflect the cumulative impact across multiple life domains such as a cumulative negative impact of low social position and/or stressful social relations or lack of social relations throughout the life span (283). Tiredness may then be seen as a kind of chronic reaction to the accumulated chronic strain of dealing with the effects of cumulated social stress throughout life in addition to the physiological and biologic decline that characterizes aging.

It is likely that the measure of tiredness used reflects both a certain kind of difficulties in doing daily activities plus, on top of that, a general perceived feeling of tiredness. When I investigated whether a global question about tiredness was predictive of functional decline, I found that the associations were in the same direction, but much weaker than when I used the measure of tiredness in daily activities (paper IV). Also Leveille et al. (185) found that women who reported tiredness in general were not more likely to become disabled than others.

It is possible that the new measure of tiredness is so strongly related to functional decline, because it captures the age-related declines in the various organs/systems directly related to the ability to perform basic mobility and ADL tasks plus, on top of that, a general feeling of tiredness that may catch the more psychosocial causes of tiredness. The measure of tiredness may then both be a valid measure of functional ability with a strong discriminatory power among the relatively healthy older adults and an early indicator of the aging process.

Recently, other indicators of later disability have been proposed. These indicators have focused on physical performance tests or self-report measures. It has been shown that objective measures of lower-extremity function are highly predictive of subsequent disability among non-disabled older persons living in the community (130, 230), that poor performance on tests of physical skills is strongly associated with onset of functional dependence among old adults (117, 118), and that hand grip strength is highly predictive of late life disability (246, 248). Other studies have shown that self-reported difficulty with ADL among independent old persons is predictive of onset of dependence later on (120, 140), that self-reported modification of doing daily tasks is an independent and strong risk factor of incident mobility disability (106, 107), and that self-reported slower walking speed is predictive of incidence of difficulty walking (240).

In my point of view these measures may all be good indicators of early decline as part of the disablement process, although the hand grip measure developed by Rantanen et al. (246, 248) may also be seen as an indicator of early loss of muscle mass. Apart from that none of these measures capture the early aging process to the same degree as the measure of tiredness in daily activities.

4.3 SOCIAL POSITION AND FUNCTIONAL DECLINE

In this chapter I summarize and discuss the results from the papers VIII and IX. There are two main results: First, two measures of material wealth were more strongly related to functional ability cross-sectionally and to onset of disability at 5-year follow-up than measures of education and occupation. Second, two indicators of social position were differently related to functional ability cross-sectionally, to onset of disability, and to mortality in men and women: housing tenure among men and income among women.

Even though several studies have shown that low social position is associated with functional decline (52, 61, 67, 162, 195, 233, 279) only few studies examined the strength of different measures in relation to functional decline. In agreement with the finding of this thesis the majority of those studies found that the relationship between measures of material wealth and functional decline was stronger than measures of education and occupation (147, 162, 200, 254). Only one study reported that income was not related to incidence of disability, while the odds ratios of education, occupation, and housing tenure on incident disability were of about the same size (125).

The same pattern has been shown with regard to other health outcomes. Thus, studies have shown that measures of material wealth were more strongly related to consultations with the general practitioner (62), self-rated health, longstanding illness, use of medications, high blood pressure (only among women), psychiatric morbidity (126) and mortality (40, 82, 115, 311) compared to measures of occupational and education levels.

In a life-course perspective level of education usually reflects a characteristic acquired early in life representing the transition from a social position largely received from parents to an achieved social position as an adult. Educational success also provides information about likelihood of future success, as higher levels of education generally are predictive of better jobs, lower unemployment, higher incomes, better housing and better working conditions (196, 293). Occupation influences living conditions in adult life and represents the major structural link between education and income. Educational experiences are important in determining what sorts of employment are available, and this employment then determines level of income (220). Income relates directly to the material conditions that may influence health no matter if a person is inside or outside the labor market. Adequate income has important implications for a range of material circumstances that have direct implications for health: quality, type and location of housing; food; clothing; transportation; medical care; opportunities for cultural recreational and physical activities; etc. In that way current material circumstances indicate the quality of life enjoyed and the extent to which auton-

omy and choice can be maintained (15). Level of income may reflect the situation at a certain point in time, but it may also reflect the cumulative influences of income levels through the life-course, if measured at different points in time (195).

I believe that income and housing tenure probably reflect the cumulative influence of income throughout the life-course. People who rent their housing in old age are likely to have done so during most of their lives and they do not have any financial resources in the housing. However, the observations of material wealth differences in old age may also be seen as the result of intertwining chains of biological and social factors throughout life which ultimately influence health in old age.

The second main finding was that two indicators of social position were differently related to functional ability cross-sectionally (paper VIII), to onset of disability (paper IX), and to mortality (paper IX) in men and women: housing tenure among men and income among women. This finding is in disagreement with Macintyre (198) who found that housing tenure had the same effect on symptoms, general health and depression among men and women, and with Arber & Lahelma (16) who found that housing tenure was related to limiting long-standing illness among British women but not among British men.

However, the findings are in agreement with an English study, which examined gender differences in lifetime exposure to a range of environmental hazards to health (poor housing, environmental risk at work, air pollution, and inadequate nutrition) (45, 48). They found that out of several measures of social position for men total hazard score was most strongly associated with current tenure status, while for women receipt of welfare benefits was most strongly associated with combined total hazard score. Other studies also showed that inequality in health among men and women may depend on the measure used. Two studies (39, 259) have compared the health effects of traditional measures of social position and a measure of general social and material advantage and lifestyle as indicated by the clustering of occupations into friendship groups (The Cambridge Scale). They found that the social gradients in mortality among women were larger when using this measure of social advantage than when using traditional measures of social position.

It is not known why housing tenure and income have different health effects among men and women. It is possible that housing tenure effects health in two ways: 1) As an indicator of the cumulative influence of income throughout the life-course, and 2) as an indicator of the meaning, prestige, and status, which is often ascribed to house ownership (83), and that both factors influence health. Maybe the importance of the status and prestige of home means more to men than to women, and that men that way have a double effect of owning their housing.

The cross-sectional design of paper VIII may give concerns about reverse causation, e.g. association between health and income due to ill-health leading to loss of income rather than loss of income leading to illness. Notably, the prospective design of paper IX guards against this possible bias. It is also plausible that individuals in poor health may be more likely to change housing, from living in their own house to a rented apartment prior to the baseline study. However, an analysis in a subsample of the study population who had participated in a study five years earlier showed that this was not the case.

4.4 SOCIAL RELATIONS AS DETERMINANT OF CHANGES IN FUNCTIONAL ABILITY

This chapter will include a summary and discussion of the results from paper I, X, and XI. The primary results of these papers are 1) that more poor-functioning women who lived alone or who became alone from age 70 to 75 had sustained poor functional ability from age 75 to 80 compared to women who lived with others, 2) that it reduces the risk of functional decline to have extensive social relations, 3) that more aspects of social relations are related to functional decline among women than men, and 4) that social relations had very

little influence on the association between musculoskeletal diseases and functional ability/decline. The more specific results will be described and discussed in the following sections.

4.4.1 Household composition as determinant of not recovering from disability

The most important finding from paper I is that more poor-functioning women who lived alone or who became alone from age 70 to 75 had sustained poor functional ability from age 75 to 80 compared to women who lived with others. This was especially seen among women who had sustained need of help from age 75 to 80.

The findings are in agreement with Lund et al. (191) who found an increased mortality among 75+ year old women who continuously lived alone compared to women who continuously lived with somebody, but in contradiction with Cerhan & Wallace (64) who found no associations between stability or changes in marital status over three years and survival. We have not been able to find any studies on changes in household composition as determinant of changes in functional ability. But the findings are in agreement with Sarwari et al. (262) who showed that the risk of further decline among severely disabled women was larger among those living alone compared to those living with others.

This may have several explanations. First, we can not exclude the possibility that the single women in need of help in daily activities may have had other health problems, which we did not adjust for in the analyses. Other studies have shown that disabled persons who live alone are at marginally higher risk of cognitive problems (46), and at significantly larger risk of dementia (101) and at larger risk of depression (57). However, it did not attenuate our results to adjust the analyses by cognitive function and depressive symptoms (not shown in tables).

Second, it is possible that single-living women actually get less physical exercise than cohabiting women, regardless of function. However, studies about this have produced conflicting results. Simonsick et al. (292) showed that single-living disabled women were nearly twice as likely to go for walks as women living with others, while other studies found that women who live alone are more likely than women who live with others to avoid physical exercise (263) and to spend less time doing housework, paying errands, etc. (170). In this age group it is strong tradition that the women take care of the usual daily chores such as cleaning and shopping. Thus, women who live with others may be encouraged by their husbands to go on with these activities. A qualitative study among older Danish women showed that for most of these the loss of spouse meant freedom from duties and many of the women enjoyed having a time on their own (80). These single-living women may not any more feel as obliged to perform the household chores. In addition, it is well-known that disabled persons are less likely to exercise (177). It is possible that poor-functioning single-living women simply do not get the personal support they need to be able to get outside the home and/or they may not get the motivation to do it. Glass et al. (122) and Wilcox et al. (343) showed that social supports for doing those tasks were essential for recovery after illness. Consequently, single-living women may be less active, especially if they have poor functional ability and therefore get less physical exercise in their daily life. The importance of physical activity for keeping up a good functional ability has been demonstrated in numerous studies (307), and studies have also shown that it can be regarded as part of an exercise pattern to do housework activities (10, 177, 206).

A third explanation may be that the poor-functioning single-living older women do not get adequate nutrition. Schroll et al. (266) showed that dietary quality is related to functional ability, and Sharkey et al. (284) demonstrated that homebound women were more vulnerable to low nutrient intakes compared to men. In addition, it is possible that older adults living alone eat less regularly scheduled meals, reduce the number of cooked meals and consume more foods easy to prepare. Conflicting data, however, have been reported

concerning dietary intake, nutritional status and household status. Some studies reported that older adults living alone have reduced food intake (58) and that single-living women tend to simplify cooking and eat fewer cooked meals (132). Schlettwein-Gsell & Barclay (264) showed that up to the age of 75 dietary intake and nutritional status of elderly women did not differ from women living with others.

4.4.2 Household composition as determinant for functional decline

Changes in household composition from age 70 to 75 had no influence on functional decline from age 75 to 80 among neither men nor women (paper I). The few studies, which examined these associations for men and women separately found that living alone (304) and being widowed (123) were risk factors of functional decline only among men. However, no studies examined whether actual changes in household composition had influence on functional decline.

The finding in paper I is in agreement with Lund et al. (191) who found that 70-74-year old men and women who continuously lived alone during four years did not have increased risk of dying during the next four years, but they also showed that women aged 75 or older who continuously lived alone did have a larger risk of dying. It is known from the literature that the total size of the network decreases with age, which may suggest an age dependent sequence of decrease in social relations, the more distant relations disappearing earlier than the closest. Therefore, Lund et al. (191) find that younger old women who still have close friends and relatives in addition to their cohabitation partner are less susceptible to the effect of losing these important persons, whereas among old-old women the cohabitation partner is the one most often lost, and losing him/her will make the most important person disappear.

4.4.3 Social relations outside the household as determinant of onset of disability

The overall finding of paper X is that having more extensive social relations reduces the risk of functional decline. More specifically we found less functional decline among men and women with more than weekly telephone contacts, among women with high levels of social participation and among women who help others.

These primary findings in paper X support other research of the protective effect of structural aspects of social relations and are generally consistent with findings from several previous studies of the role of social ties in disability (52, 61, 75, 202, 211-213, 305, 346).

The study presented in paper X is the first, which has shown more protective effects of weekly telephone contacts than of face-to-face contacts. One explanation for the finding may be derived from the socioemotional selectivity theory (174, 175). According to this theory, as people age they become more selective in their social relationships and seek to maintain relationships with people who enhance their emotional well-being. That may be the reason why older adults report less relational strain compared to younger persons (81, 226). One consequence of increasing social selectivity with age can be that older people are more likely than younger people to seek social support from sources not linked to stress and maybe these sources are easier to contact by telephone than face-to-face. This is in agreement with a qualitative study among individuals 85 years and older, which showed that friendships no longer required face-to-face contacts in order to sustain feelings of closeness (159). The content of telephone contact may thus vary from that of face-to-face contacts. Maybe the issues discussed over the telephone are different and/or cause less strain than those taken up face-to-face, and maybe the decrease in social participation has resulted in more telephone contact with the ones whom you really want to talk to.

It is also possible that face-to-face contacts, such as frequent visits by for example children could result in a decline in function, because these family members perform tasks for the old person instead of encouraging the person to do the activities themselves (281). This

could be associated with greater risk of reductions in actual physical ability, i.e. decreased fitness due to disuse. Seeman et al. (281) and Mutran (221) found that support from children had a negative effect on recovery and on sustaining a good functional ability, and Penning & Strain (236) showed that support from others may be associated with lowered feelings of autonomy, self-reliance, and subjective well-being, particularly among older men.

The second important finding in paper X is that it is protective against functional decline to sew for others as an indicator of help to others. This has never been shown before. Antonucci & Akiyama (11) showed that reciprocity of social relations was protective of morbidity. The importance of giving help to others has been supported by a few additional studies. Silverman (291) found that women who supported others with food or with preparation of meals enjoyed higher levels of life satisfaction and self-esteem. Ostir et al. (232) suggested that older women who were satisfied with the amount of support they gave to family and friends or to community organizations were significantly less disabled compared to those who reported less satisfaction with the amount of help they gave. There might be several potential mechanisms for this: First, high levels of giving support may be related to better emotional health and better emotional health may be related to better long-term physical health among older persons (237). Second, giving support may help older individuals remain connected to other people, providing purpose or meaning in life. Third, giving support may increase an older persons's level of physical or mental activity which is also related to functional ability (90). However, it cannot be ruled out that the explanation for the finding in paper X regarding sewing for others may be related to the significance of having an important activity (182).

The third important result in paper X is that an indicator of poor social participation (no membership of a retirement club) is associated with functional decline. This supports rather consistent findings from other studies (61, 162, 181, 217, 304, 345). Social participation implies social engagement and social integration, such as getting together with friends and attending social functions. This may perhaps enhance what has been called "host resistance" (146). It is possible that part of the reason why low social participation has such strong influence on functional decline is that social participation gives meaning to an individual's life by virtue of enabling him or her to participate in it fully, to be obligated and to feel attached to one's community (44). Thus, through opportunities for engagement, social networks define and reinforce meaningful social roles, which in turn provide a sense of value, belonging, and attachment. Recent research has actually begun to elucidate a number of cardiovascular, immune and neuroendocrine responses that provide a link between the quantity and quality of social relationships with specific physiological processes (47, 70, 161, 282, 283).

In addition, social participation provides opportunities for companionship and sociability. Evidence suggests that on-going participation in network activities is essential by promoting certain motivational characteristics or coping strategies, such as sense of control and self-efficacy (1, 69). Such characteristics have been shown to enable older persons to have more healthy behaviors with regard to exercise (69, 124), dietary fat intake, weight control, alcohol intake and smoking (124) and in this way to slow down the disabling consequences of declines in physical health (209). It is also possible that persons with strong social relations have support from others to facilitate strategies of adapting to aging losses in everyday life, e.g. by reducing the number of activities, goals, or domains in order to focus on those areas that are most important or salient in one's everyday life (175).

Maybe women who are club members and/or help others actually have a greater number of roles, thereby having a greater level of social anchorage. Moen et al. (215) explained this by the role enhancement perspective which points to the way in which multiple roles augment an individual's power, prestige, resources, and emotional

gratifications, including social recognition and a heightened sense of identity. Moen et al. (215) and Adelman (1) showed that loss of roles affected both physical and psychological well-being.

Along with Akiyama et al. (4) paper X showed that men's social relations in general were smaller than women's. Women are more involved and more oriented toward friendships than are men (97) and men rely more on their wives as confidants than women (286). Perhaps men perceive the investment in friends as less "worth it". Another possible explanation for the men's smaller networks may be that many friends are made at work, and the longer the time since retirement the less likely it is for a man to maintain such friendships (97). The larger networks among women also imply that they get more social support than men (31). Maybe it is easier for women to accept advice and help than for men.

Paper X also demonstrated that more aspects of social relations are related to functional decline among women than among men. This is in contradiction to the studies by Seeman et al. (281) and Unger et al. (320). However, it is difficult to compare these studies because different measures of social relations were used. The present findings may have several possible explanations: First women have larger networks than men and thus a larger pool of friends/family to help (31, 97, 336). Second, men's greater reliance on their wife may also make them more resistant to receive support from somebody else than the wife (31, 35). And that may be the reason why men do not benefit as much as women from the social relations.

There may a greater tendency for older men (as compared to older women) to interpret or internalize greater instrumental assistance as an indicator of reduced ability on their part, resulting in greater perceived disability (281). Older men may be more susceptible to such interpretations because of the relatively greater cultural emphasis on male self-reliance and independence, making "receipt of instrumental assistance" at older ages perhaps a particular threat to male self-efficacy beliefs. Indeed, several studies provide support for the idea that men may tend to react more "negatively" to others' attempt to provide support. In a community-based study of older adults, receipt of instrumental assistance was found to be associated with lower subjective well-being among men but not among women (236). A study of patients with rheumatoid arthritis found that men were more likely than women to report it as problematic when other people attempted to provide support (252).

4.4.4 The influence of social position and social relations on the association between musculoskeletal diseases and functional ability

The main results of paper XI are that persons with both musculoskeletal diseases and other diseases had a larger risk of experiencing tiredness and need of help at a given point in time and of onset of need of help in mobility as compared to persons with only other diseases and persons with no diseases. A further result was that social position and social relations had very little influence on the association between musculoskeletal diseases and functional ability/decline (cross-sectionally/ longitudinally).

As it might make a difference to reanalyze the data based on the knowledge from the papers VIII, IX, X, I repeated the analyses and: 1) included the measure of housing tenure in the analyses, 2) performed the analyses separately for men and women as income and tenure influenced functional ability in different ways among men and women, 3) included the measure of telephone contact in the analyses, and 4) included the dead in the analyses. This did not change the results (not shown in tables).

To my knowledge very few studies have examined whether social position and social relations influence the functional consequences of musculoskeletal diseases. In agreement with our findings Scudds & Robertson (278) showed that it did not change the association between musculoskeletal pain and functional ability to adjust the analyses by education, income, number of persons in household and marital status. In a study among chronically ill (including those with

low back pain) Mackenbach et al. (200) demonstrated that onset of disability was predicted by household income while social relations did not make any differences on changes in functional ability.

There may be several explanations why we did not find what we expected. First, the results might have been different had we used more detailed information about the severity of disease. We used a rather crude measure of musculoskeletal diseases. It may have been critical that we did not distinguish between different diagnoses, e.g. rheumatoid arthritis and osteoarthritis, because the two types of arthritis exhibit different behavior patterns, and the severity may well lead to differing outcomes (234). Neither did we distinguish between different severities of arthritis, including levels of pain, pain localization, radiation, duration, intensity, frequency of symptoms (49, 56). Eachus et al. (84) found that people with lower socioeconomic position experienced a greater severity of hip pain compared to other patients. Blank & Diderichsen (49) found social inequalities in both self-reported frequency and intensity of a variety of common symptoms.

Second, most musculoskeletal diseases develop slowly over many years. Social relations and social support are often hypothesized to represent important resources in coping with demands to adapt to new situations, e.g. the consequences of illness (349). It is possible that the social relations have more effect on functional ability if the determinant is musculoskeletal injury. Actually, several studies showed that social relations play an important role in recovery after hip fracture. Thus, the following factors were found to be related to recovery 6-12 months after hip fracture: telephone calls (202, 338), total number of people a person felt close to or with whom he or she had weekly contact (75), and affective support by intimates (221). Third, it is possible that patterns of recovery are different in studies on patient samples than in population based studies, as the present one. A fourth possible explanation could be the relatively well-functioning home service system in Denmark. Compared to many other countries home services in Denmark are free of charge and provided abundantly (143). Maybe the home helper gives the support, which older adults in other countries get from the social network.

Furthermore, it may be important to distinguish between decline in function and recovery from disability because different psychosocial processes may account for the possible salutary effects of social relations on disability outcomes.

A final result of paper XI was that being sedentary was a risk factor of functional decline among nondisabled persons with and without musculoskeletal diseases. Studies have shown that the social relations people have may be one factor of importance for being physically active (66). It is possible that one pathway goes from musculoskeletal diseases via poor social relations and sedentary activities to functional decline. However, the sample size was not sufficient to explore this further.

4.5 CONSEQUENCES OF DISABILITY

This chapter will summarize and discuss the results from paper V, VI, VII, and XII. The main findings are that the process leading to disability may also lead to mortality, to more use of social and health services, to less use of dental services, to poor oral health and to a decrease in social relations.

4.5.1 Mortality

Paper V shows that need of help in mobility activities at age 70 was strongly predictive of mortality during the next ten years. This is in line with numerous studies, which showed that disability is strongly associated with mortality (91, 135, 151, 217, 298). This makes sense because functional ability is strongly influenced by chronic diseases and other health problems.

4.5.2 Use of health and social services

Older adults who were not able to manage mobility activities without help were at higher risk of becoming users of hospitalization and

home help than non-disabled persons, and individuals who needed help in physical activities of daily living were at higher risk of becoming users of home help (paper VI). This is in agreement with other studies, which demonstrated that disability is a risk factor of use of home help (142, 187), hospitalization (135, 217, 345), and institutionalization (135, 151, 217, 298). The pattern went in the other direction with regard to use of dental services where disabled persons tended to go more seldom to the dentist than non-disabled persons (paper VII). These results are in accordance with earlier findings (12, 78) that persons with poor functional ability use dental services less often than others.

4.5.3 Oral health

Paper VII demonstrates that 80-year old persons who needed help in mobility activities and persons who had sustained need of help in mobility from age 75 to 80 were at larger risk of having few teeth and of having chewing difficulties than non-disabled persons. This is in agreement with a few cross-sectional studies, which showed that non-institutionalized old people with physical disability have more dental impairments (348), more untreated caries (155, 194) and edentulism (155). These findings have further implications as oral impairments may cause difficulty in eating and speech problems (241) as well as social and psychological problems (116, 189).

4.5.4 Social relations

The main result in paper XII was that women who felt tired in their daily activities had more sustained little diversity in social relations, and that both men and women in need of help had more sustained little diversity compared to the well-functioning persons. This indicates that the relationship between social relations and functional ability is complex and bidirectional: that people with poor social relations are more likely to have functional decline and that persons in poor functional ability are more likely to get weaker social relations. As suggested by Lund (192) this would mean that a vicious circle is developed resulting in continuous deterioration in functional ability and weaker contacts with other people.

The research on how functional ability influences social relations is limited. Cerhan & Wallace (63) found that physical disability predicted no longer attending church and that poor self-rated health was a predictor of no longer being a group member (among women). Bowling and colleagues demonstrated contradictory results: In one study of 85+ year old people they found that poor functional ability at baseline was associated with subsequent reduction in network size (53). In another study they found no association between functional ability and change in network size even among very old people (54). Lund (192) found that development of poor self-rated health was associated with development of less satisfaction with social relations.

Among a whole range of types of social relations among 75- and 80-year old persons it was children that they saw the most, and actually more than a third of the old population increased their contact frequency with children during the five year follow-up, whereas there was a decrease in social participation (paper XII). Also other studies have found a tendency of change towards the core of the network (97, 207, 321). A substudy on the Danish part of the NORA-study population showed increase in the social activities in the home and a decrease in social activities outside the home (314). However, close family ties such as ties with children are typically associated with both benefits and strains (211). Consequently, they may provide less unequivocal psychological reinforcement, compared with relationships with friends and more distant relatives (11). Tucker (319) actually showed that older adults were more likely to identify friends, not spouses and children, as persons who had a positive influence on their health behavior.

Most research on the disablement process has focus on disability as outcome. The present results indicate that the process leading to disability may also lead to mortality, to more use of social and health

services, to less use of dental services, to poor oral health and to a decrease in social relations. These factors are important for the society because of the financial costs, but also for the older adults themselves.

The most common wish of persons approaching old age is full autonomy for as long as possible. The ability to carry out common daily activities without needing the help of another person is essential for a good quality of life at least in the western part of the world. This has been shown in a questionnaire study in England (55), and in qualitative interview studies in Canada (199), Iceland (290) and Denmark (171, 313). A recent Swedish qualitative study demonstrated how important it was for old Swedish women to be independent and to manage daily activities, such as household work, as they had always done. One part of being independent was to be able to shop for food and to cook the well-known traditional dishes as they used to do it (289).

4.6 ANALYSES WITH AND WITHOUT THE DEAD

When we used social position, social relations and tiredness as determinant of functional decline we found that the associations between these variables and the outcomes were in the same direction for functional decline among the survivors and among the dead. This means that the association between the determinants and functional decline are attenuated when the dead are excluded. Consequently, we found it appropriate to combine the measure of functional decline among the survivors with mortality (papers IV, IX, X). Therefore, we performed the analyses with three separate outcomes: 1) functional decline among the survivors, 2) functional decline including the dead, and 3) death.

With regard to social position a few studies found the same effect of social position on onset of disability and mortality (148, 195), while others showed that social position was significantly related to onset of disability but not to mortality (52, 210). Beland & Zunzunegui (41) found that social position measured by education was related neither to functional decline nor death, and Amaducci et al. (7) reported that the associations between education and mortality at two-year follow-up disappeared, when adjusted by baseline disability.

With regard to social relations the results are in accordance with Lee (181) who found that persons with low social activity were at larger risk of both functional decline among the survivors over six years and mortality over seven years. In addition, only one study (145) has analyzed whether it made a difference for the associations between poor social relations and decline in functional ability to include or exclude the dead from the analyses. In that study no associations were seen between social relations and functional ability no matter whether the dead were included or not. However, this lack of association may be caused by a rather crude measurement of social relations.

This leads to the following assumptions: 1) In analyses of change in functional ability it is important not to disregard the dead, because this may result in either selection bias or in attenuation of the associations between the determinant and functional decline. 2) The first step in analyses of effects of various risk factors on functional decline should always be to perform analyses on functional decline and death as separate outcomes. 3) If these effects are in the same direction when the two outcome measures are used separately the next step could be to combine the two outcome measures in order not to lose all the dead in the analyses of decline. 4) If these effects are different regarding the two outcomes the solution must be to perform analyses separately with functional decline among the survivors and deaths as two separate outcomes.

5. DISCUSSION OF MATERIALS AND METHODS

5.1 MODELS OF DISABILITY

In this thesis Verbrugge & Jette's model of The Disablement Process (329) has been used as a theoretical frame of reference although the ICF-model (342) is newer and is increasingly used in rehabilitation

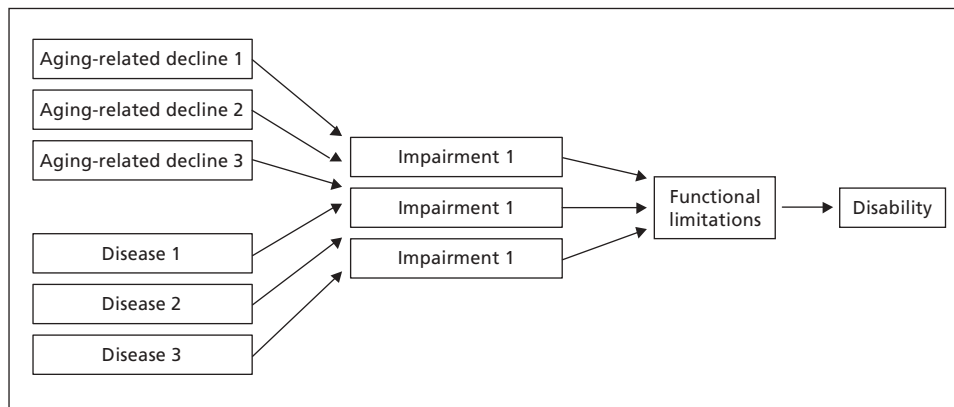


Figure 7. An expanded model of the Disablement Process.

research. Both models are premised on the notion that disability is not inherently a part of the person, but rather a function of the interaction between the person and the environment, and both models allow a rich assessment of age-related issues including work, family, social participation, asset accumulation and access to health care.

The International Classification of Functioning, Disability, and Health (ICF) is a health or health-related classification that incorporates the social and environmental aspects of disability and health (342). The ICF provides a list of environmental factors that influence individual activity and participation levels, some of which should be included in an enhanced conceptual framework.

Contrary to this, Verbrugge & Jette make clearer distinctions between pathology, impairments, functional limitations, and disability, distinctions which are very useful, especially in studies of older adults, where consequences of an aging body interact with consequences of diseases much more than is seen in studies among younger persons. It may be argued that the model by Verbrugge & Jette is also too rough, as it is based on the notion of one disease causing one impairment causing one functional limitation causing one kind of disability. Multiple co-occurring diseases and impairments are common and each has a synergistic effect that is difficult to unravel (129). Rantanen et al. (245) showed that the odds of severe walking disability was ten times greater among those who had both strength and balance impairments compared to those who had only one or the other. Tinetti et al. (318) examined how functional ability in older adults was influenced by four types of impairments (lower extremity impairment, upper extremity impairment, sensory impairment (vision, hearing) and affective impairment (anxiety or depression)). They found a significant increase in functional dependence as the number of these predisposing factors increased. Thus, it might be appropriate to expand the model of the disablement process as shown in Figure 7.

In my view the model of the Disablement Process is more precise when the need is to isolate the multiple, often intertwined biological, psychological, functional, social and environmental factors that contribute to the development of disability. Knowledge about the influence of the specific steps in the main pathway may be essential both when the aim is to get more knowledge about the aging process, and when the aim is to make interventions to prevent disability in old age.

5.2 THE STUDY POPULATIONS

5.2.1 Representativity

The socio-economic distribution among the participants was evaluated before the selection of the sample for the first study of the 1914-population in 1964 and again after the examinations were finished. This was done by comparing the corresponding distributions for the Copenhagen County and total Denmark. The participants were found to be representative of the inhabitants in the Copenhagen County as to sex distribution, housing, education, employment in the industries and type of occupation. In comparison with total

Denmark no differences were found as to gender and education, but employment in agriculture and fishing was underrepresented, resulting in the participants showing an underrepresentation of self-employed and an overrepresentation of salaried employees (133). It is likely that the 1914-population is also representative with regard to health, as the mortality rates were similar to rates for the whole country from 1964 to 1974 (267), from 1964 to 1984 (277) and from 1964 to 1994 (8).

The sample sizes in the NORA-study are considered representative of their localities (164). The total age cohort in Jyväskylä participated in the study whereas the study populations in Göteborg and Glostrup consisted of random samples. The success of random sampling has been verified by comparing the proportions of the frequency distributions obtained from the samples to the real distributions in the total population (164).

The study population which constituted the basis for the analyses in paper III included only nondisabled older adults from the control municipalities in an intervention project. It is considered representative of the general population, because participants in control and intervention municipalities were alike in most aspects, including disability.

5.2.2 Age selection

The study populations used have all been restricted by age: The Glostrup population and the NORA-population include only persons born in 1914, and the Danish Intervention Study on Preventive Home Visits is based on persons born in 1918 and 1923/24. The strength of this design is that age is supposed to be both the most important risk factor of functional decline and at the same time a confounding factor concealing the associations between other risk factors and functional decline (267). The design also allows a smaller sample size as subgrouping into age groups is avoided. The weakness of such a design is that we are not able to analyze for the importance of age as such.

5.2.3 Selection into the studies

The thesis deals with four baseline populations: The Glostrup 70-year population, the NORA baseline 75-year population, the combined Glostrup and NORA-populations and the baseline population in the Danish Intervention Study on Preventive Home Visits.

In the Glostrup study (paper V), which deals with the associations between tiredness and mortality we do not have information about tiredness among the non-participants; but analyses showed no differences in occurrence of diseases based on register data between non-participants and participants. However, we do not know whether the associations between tiredness and mortality would be different among the non-participants in the 70-year study than among the participants. In the NORA-study and in the Danish Intervention Study on Preventive Home Visits the participants had somewhat better functional ability than the non-participants. There is, however, no reason to believe that the associations between the various determinants used in the present studies and functional decline

would be different among the non-participants and the participants, and I do not think that this has led to a bias in the estimates.

A special problem turns up when a study is composed by several side studies as in the Glostrup studies, e.g. in the 75-year survey, where 748 persons received a home visit, while only 410 persons took part in the health survey. However, there is no reason to believe that this influences the results, as the two groups are similar with regard to functional ability and socio-demographic factors. A recent Dutch study examined the effect of differential inclusion in side studies and concluded that attrition through refusal associated with relatively low side study participation was not selective with respect to either socio-demographic characteristics or physical and mental health indicators. Thus, this did not severely damage the study's validity in terms of selective attrition (76).

5.2.4 Loss to follow-up

Eleven of the articles in the thesis are based on data from two or three points in time. In the analyses described in paper V, which has mortality as outcome there is no loss to follow-up as we have data about deaths in all baseline participants. With regard to the remaining 10 papers based on longitudinal data considerable attrition occurred, especially in the studies with 5- or 10-year follow-up (papers I, II, IV, VI, VII, IX, X, XI, XII).

Seven of the papers have functional decline as outcome measure (I, II, III, IV, IX, X, XI). This introduces risk of selection bias because functional ability is related to both mortality and non-participation (See Table 2), and because this may also be the case for the main determinants: tiredness (See Table 2), musculoskeletal diseases (See Table 3), social position (See Table 4) and social relations (See Tables 6-7).

In all three study populations the selection during follow-up due to deaths was largest among the men. This is described in detail for the Glostrup study in table 13, which shows that men are more likely to die during all follow-up periods while women are more likely to stay alive but to deteriorate in their functional ability. This could imply that the association between the determinants and functional decline would be more attenuated among the men than among the women when the dead are left out.

With regard to social position, social relations, and tiredness which are the main determinants in the present thesis we find that the associations between these factors are in the same direction with regard to functional decline among the survivors, mortality and non-participation for other reasons than death. This does suggest that the risk of selection bias is very little.

It also indicates that it might have increased the association between changes in household situation and changes in functional ability (paper I), the association between musculoskeletal diseases and functional decline (paper XI) and the association between tiredness and functional decline (paper II) if we had included the dead in the analyses. However, as the association between the determinants at baseline and non-participation at follow-up in most cases is in the same direction as for functional decline and mortality we do not think that this has caused any serious risk of selection bias.

In the study population in the Danish Intervention Study on Preventive Home Visits tiredness was not related to deaths, probably because of the short follow-up time. Consequently we excluded the dead from those analyses (paper III).

The remaining articles have other outcomes: use of health and social services (paper VI), oral health (paper VII) and changes in social relations (paper XII). Also with these outcomes there is a risk of selection bias. However, there is no reason to believe that the associations found would be systematically different among the non-participants than among the participants. But it is more plausible that the estimates would have been stronger without the attrition to follow-up.

5.3 FOLLOW-UP PERIODS

It is a strength that we have performed the analyses of tiredness and

functional decline in all three study populations and with different follow-up times. However, it may be regarded as a weakness of the analyses from the Glostrup- and NORA-studies that there are relatively long follow-up periods between the measurements. It is known that various patterns of functional change take place among elderly populations. Rudberg et al. (258) showed an extremely heterogeneous pattern of transitions between different levels of functional ability in a study using four waves of data over a 6 year period. Ferrucci et al. (92) described the onset of severe disability among old populations as being progressive (over a period of 2 or more years) or more abrupt or catastrophic. Wolinsky et al. (347) analyzed 35 possible trajectories in five functional limitation items among old participants in up to seven waves of data collection. They found that patterns of decline and recovery were not the same for all origin states. However, a study of self-reported difficulty in functioning among women with data obtained weekly over a 6-month period showed significant consistency between responses after 1 week and after 24 weeks (249).

The long five-year intervals in the studies introduce the possibility that we underestimate the actual occurrence of disability. Gill et al. (121) compared the rates of disability obtained from single follow-up assessments with those obtained from monthly assessment for intervals up to 24 months. They found that the rates of disability obtained from monthly assessments of function were considerably greater than those obtained from single follow-up assessment regardless of the underlying disability.

The present results indicate that tiredness, social relations and social position influenced functional decline over a period of five years, no matter what kinds of changes took place in between. And similar findings in the 1½ year follow-up-study with regard to tiredness support that the present results are not random.

It should be underlined that the results about functional decline or onset of disability are based on an outcome measure, which defines a person as having decline if she/he goes from being without help in six mobility activities to being in need of help in one or more of these activities. We chose this cut point because it is highly relevant both for the elderly persons to be independent in their basic daily activities and for those who provide health care to the elderly people. As a result, our findings only pertain to development of disability from a previously disability-free status and do not address other changes in disability status, e.g. from "some" to more severe disability. However, functional decline are measured in multiple ways in various studies, and it is open for future studies to examine whether the present findings will be the same, when other measures of functional decline are used.

In paper II and III tiredness in daily activities was measured at one point in time and functional decline was measured from that point of time to follow-up. This gives of course implications for the immediate benefits of not being tired. However, the persons who felt tired at one point in time include those who have felt tired for a long time and those who have become tired; and the group of persons who did not feel tired at a certain point in time is composed by persons who have not felt tired for a long time and persons who have recovered from a period with tiredness. Using that kind of design it is not possible to detect what is most important for functional decline: sustained tiredness for a long time or onset of tiredness over a period of time. Paper II and Avlund et al. (26) showed rather large changes in self-reported tiredness over two five year periods. It is possible that it is the changes from time 1 to 2, which make the difference for functional decline from time 2 to 3 rather than just tiredness measured at one point in time. Thus, I do think it gives more precise information to use a measure of changes in tiredness in daily activities as determinant as in paper IV instead of just using a measure of the determinant at one point. This has made it possible to detect that sustained tiredness for a long time has larger effect on functional decline than newly developed tiredness. As with the outcome measure I am aware of the various patterns of functional change in elderly populations

of difficulties doing daily activities (258) and in and out of feelings of tiredness (131). However, as with the outcome measure I want to underline, that the present results indicate that sustained tiredness in daily activities from age 75 to 80 influenced functional decline, no matter what kinds of changes took place in between.

5.4 PROBLEMS WITH MEASUREMENTS OF CHANGE

The assessment of change in functional ability at two or three points of time can also be fraught with technical problems of statistical analyses, the most important being regression toward the mean that may appear when the same phenomenon is measured several times. This may influence the results to some degree. However, I do think that the risk of regression to the mean is smaller when functional ability scales are formed of six to nine items as in this thesis than when a measure is based on one single question.

As in all studies of changes in functional ability the present studies encounter the common problem of floor and ceiling effects, in which large numbers of individuals who complete these instruments score at either the top or the bottom of the range, thereby reducing the measurement's precision (157). In other words: decrease in functional ability can be measured only among those who do not have the poorest baseline score on the scale used (floor effect), and improvement can only be measured among those who do not have the best score at baseline on the scale used (ceiling effect). This problem is to some degree minimized in this thesis, because we have measured changes in functional ability in two ways: by questions about tiredness and by questions about need of help. This means that there is a large variability in the scales: from managing completely without tiredness to being in need of help to all included activities. Thus, I do not think the problems with ceiling and floor effects are serious in this thesis.

5.5 AGE-PERIOD-COHORT EFFECTS

It is both a strength and a weakness that the used study populations consist of birth-cohorts. This means that the participants at the time of the surveys all had the same age. The strength is that we longitudinally can examine the effect of age in one single birth cohort. The weakness is that we do not know how the period or the fact of belonging to a certain birth cohort influences the findings.

It may be regarded as a weakness that all the studies included in this thesis are based on individuals that are old during the same time period of time. Eleven of the studies are based on persons born in 1914 and one study (paper III) is based on persons born in 1918 and 1923/24. It would have strengthened the results if we had performed the analyses in a study population who was born e.g. 20 years earlier or later. That way we would have been able to examine whether tiredness, social position and social relations would be related to onset of disability in two different birth cohorts or whether the results would differ. The older adults in the present studies are characterized not only by their age, but also by being members of certain birth cohorts, and sharing the collective life history of their generations. The 1914-population was born when World War I broke out, and experienced the reactions after the First World War during their childhood. They were teenagers during the Great Depression, and experienced the crisis in the thirties that caused unemployment and shortage of resources. In this period they established themselves as adults. They had small children during the Second World War. In the 1950s many of the study participants moved from the countryside to the suburbs of Copenhagen to get work in the factories there. During the 1960s and 1970s they experienced a time of prosperity and welfare. When they were in their 50s and 60s they were informed about risk factors for coronary heart diseases. And now, in old age, it is possible to get a hip-operation even when you are 90 years old, if you are fit, which was not possible 20 years earlier.

The late twentieth century has undergone substantial changes in actual and expected gender roles, especially for women. Women have entered the paid labor force in increasing numbers and fewer

women in developed societies remain in the role of full-time housewife. These profound structural changes in gender roles in the last quarter of a century across societies lead to the expectation that the pattern of inequalities in health among women and men will also have changed. The occupational roles of women have changed. The role of women in the family is under change, which means that the importance of marital status may change (17).

5.6 GENDER DIFFERENCES

Attitudes to elderly people and expectations of all elements in the disablement process may vary with gender (99) and be even more apparent when measuring how impairments and functional limitations influence activities of daily living, which are strongly influenced by expectations and value norms. Gender roles vary in different cultures and daily activities that are relevant, familiar and meaningful to elderly men and women in one culture may not be so in another culture (99).

These differences in expectations and norms may influence answers to questions about functional ability so that the weight/importance given to different activities and categories may be more influenced by gender than by actual function (99). If these answers are combined into a functional ability scale the result may be that items are related to the functional ability scale in different ways for men and women, thereby making the intergroup comparisons of functional ability in error and thus biased (315).

I feel confident that the functional ability scales used in this thesis are not biased by gender, because this was tested by the Rasch analyses on the Glostrup data (21, 28), and by item bias analyses on the NORA data (29), ensuring that the used functional ability scales measure the same construct among men and women and that the information about possible gender differences in functional ability by the individual items is correctly passed on by the index scores.

The findings of gender differences are discussed as part of the results (See page 16). However, I want to emphasize, that it does give new insight in the aging process to perform analyses separately for men and women. I showed that the women felt more tired in daily activities and had more sustained need of help and more decline than the men in all follow-up periods (Tables 10 and 12). This gender difference may add to our understanding of the importance of tiredness in relation to the aging process.

We also found that two indicators of social position were differently related to functional ability cross-sectionally (paper VIII), to onset of disability (paper IX), and to mortality (paper IX) in men and women: housing tenure among men and income among women. The knowledge that different indicators may have different impact on functional ability among men and women is important because analyses in combined study populations of men of women may be blurred by using a measure of social position, which is only usable among either men or women.

Finally, we found that men's social relations in general were smaller than women's and that more aspects of social relations are related to functional decline among women than men (paper X). Thus, it did give more information about aging and disability to stratify the analyses by gender when possible.

5.7 VALIDITY

The main variables are collected by structured interviews in the homes of the participants in the Glostrup- and the NORA-studies. This method has the advantage of being able to clarify any questions should need to arise resulting in a more precise response from the participants.

Likewise it is a strength that the same procedure for interviewing was carried out at all four studies in the Glostrup Survey. In the 70-year study, I (KA) carried out all the interviews, in the 75-year-survey I carried out about half of the interviews, and in the 80- and 85-year survey I trained the interviewers. In all studies the interviewers were female occupational therapists who had interest in and worked

with older people. In addition, they were familiar with education and interview skills. The inter-observer variation was minimized by having pilot interviews prior to the beginning of the investigation, a detailed code precept, and regular meetings where the coding of the answers was discussed and standardized.

With regard to the NORA-studies translations and back-translations were used for questionnaires and instructions, and pilot studies were conducted in the localities.

In Jyväskylä students of the health, social, behavioral and educational sciences at the University of Jyväskylä were used as interviewers (13 persons); in Glostrup, the interviews were made by occupational therapists. All interviewers were trained for their task. The duration of an interview session was approximately two hours. These differences in interviewers may have caused interviewer bias: 1) the interviewers in Glostrup and Jyväskylä had different educational and clinical backgrounds, 2) interviewer training programs may not have been sufficiently standardized, or 3) interviewers in one country may have interpreted rating instructions differently (315). Instrument error is also possible, as the questionnaire was developed in Glostrup, thus giving Glostrup a longer tradition of using the functional ability questions in their present form. Also an item may not mean the same thing in the three localities even though the wording is the same.

In Göteborg the questionnaires were left for the participants to complete on their own in contrast to Glostrup and Jyväskylä where the questionnaires were completed by the interviewers. This may have given biased estimates. A survey among 75-84-year old Swedes about home conditions, health and medical care has demonstrated some inconsistencies in answers obtained from mail questionnaires and personal interviews. The greatest inconsistencies in answers were on questions about vague, unclearly defined situations, whereas the inconsistency was much smaller with regard to concrete, everyday situations (317).

In the Danish Intervention Study on Preventive Home Visits the variables were collected via postal questionnaires. The advantage of this method compared to structured interviews is that it is less time-consuming, cheaper, and with no possibility of interviewer bias. It may be a weakness that 145 of initial non-responders were subsequently interviewed by telephone, because this resulted in using different modes of data collection. However, we accepted this risk in order to get a higher participation rate. The telephone interviews and the coding of the postal questionnaires were performed by two female occupational therapists who had interest in and worked with older people. The same procedures were used as in the NORA-study and the Glostrup study with a code precept and regular meetings where the coding of the questions was discussed and standardized.

5.7.1 The functional ability scales

It is a strength of the study that the analyses are based on well-validated measures of tiredness in daily activities (The Mob-T Scale) and of actual disability (The Mob-H Scale) (21, 28, 29). To our knowledge no other studies have included tiredness as a category in a measure of functional ability. This measure was originally developed in order to be able to show more variations in functional ability among the relatively well-functioning elderly people (28). As part of a pilot study in 1984 I interviewed about ten 70-year old persons about their daily activities. I asked the question: "Do you in any way experience that you are getting older when you perform the daily activities?" A majority of the participants answered that "Yes, I feel more tired than earlier when I do the activities I used to do". That is the reason why the questions about tiredness were included as part of the functional ability measure.

The scales have been tested for construct validity and criterion-related validity and they have a strong capacity for discriminating between elderly people in general. The scales are able to distinguish between the elderly with poor function and elderly with good function and to describe different levels of disability, where the tiredness

scales are more suitable for measuring change among the well-functioning elderly and the dependency scales are more suitable to measure change among the less well elderly. Thus, these scales are more sensitive than other measures with regard to early declines in functional ability among healthy elderly people.

Although we tried to avoid it there is still the risk of misclassification, especially with regard to tiredness, where some participants may be in doubt how to answer. However, there is no reason to believe that any such misclassification is not random. Consequently, I do not think this has influenced the results.

5.7.2 THE MEASURE OF SOCIAL POSITION

In paper VIII we used several measures of social position: Education, occupation, social class, income and tenure.

There is a risk of misclassification with regard to some of the social position questions, especially the answers to the questions about vocational training, because of the long time-span between the time of education and the time of the interview. It might have been better to ask more precisely about school exams or degrees.

The problem with measures of occupation is that these measures cannot readily be used for social groups outside of the recognized paid labor force. These groups include homemakers and retired adults. That is why we used three measures of social position based on occupation: longest held occupation, last held occupation, and social class. The coding into the different classes of occupation was performed according to the standards of the Danish National Institute of Social Research (134) using a long list of very specified occupations. In some cases, a very special job may have been coded erroneously into the wrong occupation group. According to recent recommendations the occupation based measures were coded both as a household measure and as an individual measure of social class (172).

Collecting and analyzing individual and family or household income data can be subject to problems. Non-response to questions about income is often high, and income tends to be poorly reported, especially by individuals with high income (115, 172). In the present study (especially paper VIII and IX) income was defined very roughly: low income as having only compulsory old age pension and high income as having both compulsory old age pension and other income sources. This way the number with missing answers was reduced, but the consequence was that the proportion categorized as having high income is combined by persons with just very few interest rates yearly and persons with high pensions. However, there is no reason to believe that the possible misclassifications with regard to education, occupation and income are not random.

The measure of housing tenure has many advantages in that it is easily collected and allows identification of some reasonably sized groups. The measure is frequently used, especially in Great Britain, and has been advocated as a sensible way of classifying groups, such as married women and older people, not themselves in the labor market (125). It is important, however, to be aware of, that this variable may not be useful under all circumstances. E.g. policies designed to promote owner occupation such as the sale of council housing has led to sharp reductions in the proportions of local authority tenants during the 1980s and mean that the predominance of owner occupation is higher and increasing among those who are now middle aged. Such changes may change the meaning of housing tenure as a measure of social position.

5.7.3 The measure of social relations

It is a strength that the measures of social relations have been validated. However, it is a weakness of the study that we do not have information about the quality of social relations, e.g. about emotional support and whether the social exchanges with key relationships were positive or negative. It is possible that these variables would exert additive effects on functional decline or that negative social exchange with some persons is buffered by positive social interactions

with other persons (226). It is a strength of the study that we included a measure of change in household composition (paper 1); but then a weakness that we do not have information about changes in social relations as determinant of functional decline. Other studies have shown that changes in social relations are associated with mortality (64, 85, 191) and Asakawa et al. (18) showed that older adults who experienced functional decline over a two-year period at the same time had a decrease in the frequency of contacts with relatives, friends and neighbors.

In some cases it was difficult for the participant to answer whether they had weekly or monthly contact with their social relations, if they saw them twice a month. This suggests a risk for misclassification. But there is no need to believe that this possible misclassification is not random.

Most of the persons who live with others live with their spouse; however, some of the non-married participants live with a friend or with their children, and an increasing proportion of persons, also in the older population, lives with their partner without being married (193). Consequently, we have found it appropriate to use the variable "live alone" as a measure of cohabitation status in stead of marital status.

5.7.4 Considerations about measures based on self-reports

I consider it a strength of the study that most of the measures are based on the experiences of the old people themselves. The Mob-H and the PADL-H Scales which are used as outcome measures in most of the analyses are strongly correlated to functional limitations assessed by tests, to postural balance, to muscle strength and to cognitive function. Thus, there is no reason to believe that the results have been affected by some third factor, – such as a general negativistic attitude (153). Furthermore, measures of self-rated health used in other studies seem to guarantee an acceptable validity in that it predicts future health surprisingly accurately (150).

6. ETHICAL CONSIDERATIONS

The Ethical Committees of the regions involved approved the studies. The participants were invited by personal letter with an enclosed stamped addressed envelope, and a date for the first phase of the examinations was proposed. Requests for a change of date were always met. In the 70- and 75-year study renewed invitation was made by letter or by telephone. All participants and non-participants were thoroughly informed of the purpose and course of the study. According to new rules by the ethical committees we were allowed only to ask for response once in the 80- and 85- year study and the Danish Intervention Study on Preventive Home Visits. In these studies written informed consent was obtained. All the relevant community social offices were informed prior to the investigations. The home visits did not incur any risk to the participants, nor any noticeable discomfort. In the Glostrup studies advice was offered regarding aids and equipment or modifications in the home.

7. CONCLUSIONS

The thesis has had focus on the aging process with special attention to changes in functional ability. The thesis has contributed with new knowledge about factors, which accelerate these processes in old age. There are several conclusions of the thesis.

– First, there were large variations in changes in functional ability in old age, and both deterioration and improvement of functional ability were rather common. The proportion of older adults with functional decline was larger among women than men, and among older than younger old adults. Knowledge about the large variations in changes in functional ability is important for the study of the aging processes. Furthermore, functional ability is not stable, which suggests that it is possible to postpone disability.

- Second, tiredness in daily activities is an early indicator of functional decline, increased use of social and health services, less use of dental services, and mortality. Tiredness may capture initial dysregulations across a multiplicity of physiological and biological systems and may thus be an early sign of the aging process.
- Third, present material wealth was strongly related to functional decline, but the effects were different for men and women. It is suggested that material wealth reflects the consequences of living conditions throughout the life-course.
- Fourth, having more extensive social relations reduces the risk of functional decline and of not recovering from disability. More aspects of social relations were related to changes in functional ability among women than men.
- Fifth, older disabled adults are at larger risk of dying, of using more social and health services, of not using dental services regularly, of poor oral health and of decrease in social relations compared to nondisabled older persons.
- Sixth, the results showed gender differences in changes in functional ability, and in the way social position and social relations were related to these changes.
- Finally, the thesis showed that it is possible to perform analysis of change in functional ability both with and without the dead. Most of the problems of loss to follow-up in longitudinal studies of older adults are avoided when the dead are included in the study of functional decline.

8. PERSPECTIVES FOR FURTHER RESEARCH

The results in the thesis suggest the following themes for future research.

There is a large need to perform further studies of changes in functional ability in several areas: 1) to use other measures of functional changes, e.g. measures that include changes from "some" to more severe disability, and from tiredness in few activities to tiredness in more activities, 2) to study patterns of changes in tiredness and need of help in daily activities with shorter time periods between measurements, 3) to study patterns and determinants of recovery from disability. It is important to examine whether functional changes, including both decline and recovery, are related to changes in social relations, to oral health, to use of social and health services and to use of dental services.

There are three main questions with regard to tiredness that need to be pursued. First, to examine whether early signs of impaired muscle function, cardiovascular function and cognitive function explain the association between tiredness in daily activities and functional decline. Second, to examine whether the measure of tiredness is an indicator of the aging process when measured in younger groups, e.g. among 50-60-year old individuals. Third, to examine whether it is possible to use the questions about tiredness as a trigger in the primary prevention of disability in older populations. This is one of the research questions addressed in the Danish Intervention Study on Preventive Home Visits, which has the main aim to investigate whether education of preventive home visitors in the municipalities improves functional ability in the older adults. The design was a prospective controlled follow-up study over three years (1999-2001) with randomisation and intervention at community level, and outcomes measured at individual level (322). During three years home visitors in the intervention communities received regular education about the importance of early signs of disability, especially tiredness in daily activities. Control communities did not receive any education but conducted the traditional preventive program completely in their own way. Preliminary analyses of the data have shown that the education was well accepted and feasible (322). The first main results of the study are under publication (323).

I recommend that future studies of social position and functional decline use theoretically founded indicators of social position in their analyses and that analyses always are stratified by gender, if

possible. Also, there is need for further research on how social position/social mobility in a life-course perspective influences functional ability in old age.

The present data did not include information about possible changes in social relations preceding the baseline study, neither did we have data about the quality of the social relations. Thus, there is a need to examine whether changes in social relations over time accompany changes in functional ability and to study how both negative and positive social exchanges influence these changes.

Finally, it would be highly relevant to study the influence of social position and social relations during the life-course on functional decline in old age, and also to examine whether these factors explain some of the associations between tiredness and functional decline.

The findings reported in the thesis are based on data from individuals born from 1914-1924 and living in Denmark, Göteborg (Sweden) and Jyväskylä (Finland). It is important to examine whether the results would be replicable among older study populations in later birth cohorts and in cultures different from the Nordic countries.

9. CLINICAL IMPLICATIONS

The results of the thesis point at the following clinical implications: First, health professionals should be aware of the fact that disability is not necessarily a stable condition and that it may be possible to intervene in order to improve the shown patterns of functional decline. Second, it should be taken seriously, when older adults complain about tiredness when they perform their daily activities as these people are at a higher risk of becoming dependent of help than others. In the preventive work among older people it is recommended to include the measure of tiredness as a "trigger", which may prompt referral to further geriatric assessment, effective intervention and adequate follow-up. Such interventions might be directed towards identifying the underlying causes, justifying rehabilitation, physical exercise, and treatment of a possible underlying disease. Third, health professionals should be aware of the circumstance that older adults with poor material wealth and with lack of social relations may be more susceptible to decline than others, and that older disabled single-living women may be at special risk of not recovering from disability. Fourth, health professionals should be aware of the negative consequences of disability, by supporting an intact social network and by encouraging or supporting older people to take care of their teeth and to keep up regular visits to the dentist.

10. SUMMARY

The thesis is composed by a summarizing synopsis and 12 papers. The thesis has focused on the aging process with special attention to changes in functional ability. The purposes of the thesis are 1) to analyze changes in functional ability over time in old age, 2) to examine whether tiredness, social position and social relations are related to changes in functional ability in older adults and 3) to analyze consequences of disability in old age on mortality, utilization of social and health services, oral health and social relations.

The thesis is based on data (1) from the longitudinal studies of the 1914-population at the Center of Preventive Medicine in Glostrup from 1984 to 1999/2000 (from age 70 to 85), (2) from the longitudinal NORA-study of the 1914-populations in Glostrup, Göteborg and Jyväskylä from 1989 to 1994 (from age 75 to 80), and (3) from the 1½ year follow-up survey in the Danish Intervention Study on Preventive Home Visits from 1999 to 2001.

There are several main results: 1) There are large variations in changes in functional ability in old age, and both deterioration and improvement of functional ability are rather common. The proportion of older adults with functional decline is larger among women than men, and among older than younger old adults. Furthermore, functional ability is not stable, which suggests that it is possible to

postpone disability. 2) Tiredness in daily activities is an early indicator of functional decline, increased use of social and health services, less use of dental services, and mortality. Tiredness may capture initial dysregulations across a multiplicity of physiological and biological systems and may thus be an early sign of the aging process. 3) Present material wealth is strongly related to functional decline, but the effects are different for men and women. It is suggested that material wealth reflects the consequences of living conditions throughout the life-course. 4) Having more extensive social relations reduces the risk of functional decline and of not recovering from disability. More aspects of social relations are related to changes in functional ability among women than men. 5) Older disabled adults are at larger risk of dying, of using more social and health services, of not using dental services regularly, of poor oral health and of decrease in social relations compared to non-disabled older persons. 6) The results showed gender differences in changes in functional ability, and in the way social position and social relations were related to these changes. 7) It is possible to perform analysis of change in functional ability both with and without the dead. Most of the problems of loss to follow-up in longitudinal studies of older adults are avoided when the dead are included in the study of functional decline.

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