

Successful ageing with a focus on fitness and physical activity

Population-based studies of
75-year-olds

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”Hur smått blir allting som fått ett svar, det stora är det som står olöst kvar, när tanken svindlande stannat”

Tomas Tranströmer

ABSTRACT

Background: Life expectancy increased dramatically during the 20th century and is still increasing in many parts of the world. In view of population ageing, the health and functioning of older persons and factors that could promote a good life in old age have become of vital importance. The aim of this thesis was to further the knowledge about successful ageing, focusing particularly on fitness and physical activity.

Method: This thesis is part of the repeated cross-sectional and longitudinal Gerontological and Geriatric Population Studies in Gothenburg, initiated in 1971. Samples comprised 75-year-olds born in 1930 and examined in 2005, 75-year-olds born in 1911-12 and examined in 1987, and also 75-year-olds living in Teheran, Iran. Fitness was assessed with standardised tests of gait speed, chair stand, stair climbing, one-leg stance and grip strength. Questions on physical activity and health-related quality of life (HRQL), assessed with Short Form 36 (SF-36), were also included. Further, open interviews were conducted with 22 persons aged 75-90 years regarding their views of successful ageing.

Main findings: Seventy-five-year-olds in Sweden had better physical functioning, both in tests of fitness and in self-reported measures, compared to those in Iran. They also had a higher level of physical activity (about 85 % versus 10 % reported any physical activity). However, no difference was found regarding the proportion of fallers. In both countries, there was a gender gap with men having better physical functioning and reporting more physical activity, compared to women.

In Sweden, about 60 % of 75-year-olds attained recommended levels of walking (≥ 150 min/week). Regular walking was positively related to HRQL, and fitness was identified as a partial mediator in this relation, mainly among women.

Seventy-five-year-olds examined in 2005 had better fitness and a higher level of physical activity compared to 75-year-olds examined in 1987, but this positive trend was not observed in women with a low level of education.

Further, when persons aged above 75 years were asked about their views of successful ageing, an overarching theme was formulated as “self-respect through ability to keep fear of frailty at a distance”.

Conclusion: This thesis suggests that the level of fitness and the frequency of physical activities are higher among 75-year-olds in Sweden examined in 2005 compared to those examined in 1987 and compared to those living in Iran. Although older persons seem to have improved their physical functioning, worries about future frailty may threaten the possibility for successful ageing.

Keywords: Age well, quality of life, healthy ageing, older persons, cross-national, walking, exercise, qualitative research, content analysis, secular trends

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SAMMANFATTNING PÅ SVENSKA

Bakgrund: Medellivslängden och andelen äldre personer ökade dramatiskt under 1900-talet och fortsätter öka i stora delar av världen. Detta innebär ett behov av kunskap om äldre personers hälsa och funktion, samt faktorer som kan främja ett gott åldrande. Syftet med denna avhandling var att öka kunskapen om ett gott åldrande med fokus på fysisk kapacitet och fysisk aktivitet.

Metod: Studierna bygger på de Geriatriska och Gerontologiska populationsstudierna i Göteborg, vilka startade 1971. Ingående i denna avhandling är 75-åringar födda 1930 och undersökta 2005, 75-åringar födda 1911-12 och undersökta 1987, och även 75-åringar i Teheran, Iran. Alla undersöktes med likvärdiga och standardiserade metoder gällande fysisk kapacitet i form av gånghastighet, uppresning från stol, palltest, enbensstående och greppstyrka. De besvarade även frågor gällande fysisk aktivitet och hälso-relaterad livskvalitet (HRQL) i form av Short Form 36 (SF-36). Dessutom har öppna intervjuer genomförts med 22 personer i åldern 75-90 år gällande deras tankar kring ett gott åldrande.

Resultat: Sjuttiofemåringar i Sverige hade bättre fysiskt funktionstillstånd, både i tester av kapacitet och självskattad funktionsförmåga, jämfört med dem i Iran. De var även mer fysiskt aktiva (cirka 85 % mot 10 % ägnade sig åt någon form av fysisk aktivitet). Ingen skillnad kunde påvisas gällande förekomst av fall. Män hade bättre fysisk funktionsförmåga och en högre fysisk aktivitetsnivå än kvinnor i båda länderna.

Cirka 60 % av 75-åringar i Sverige uppnådde rekommenderade nivåer för fysisk aktivitet med måttlig intensitet (≥ 150 min/vecka) i form av promenader. Promenadvanor var positivt relaterat till HRQL, och fysisk kapacitet var en delvis bakomliggande faktor i detta samband, främst bland kvinnor.

Sjuttiofemåringar i Sverige undersökta 2005 hade bättre fysisk kapacitet och högre fysisk aktivitetsnivå jämfört med 75-åringar undersökta 1987, men kvinnor med låg utbildningsnivå hade inte samma positiva trend.

Ett gott åldrande kan enligt äldre personer själva ses som en bevarad självrespekt genom förmåga att hålla oro för ökad skörhet på avstånd.

Konklusion Sjuttiofemåringar i Sverige undersökta 2005 har en bättre fysisk kapacitet och är mer fysiskt aktiva jämfört med 75-åringar i Sverige undersökta 1987 och jämfört med dem i Iran. Trots detta, kan oro för ökad skörhet vara ett hot för ett gott åldrande.

LIST OF PAPERS

This thesis is based on the following papers, referred to in the text by their Roman numerals (I-IV).

- I. Mosallanezhad Z, **Hörder H**, Salavati M, Nilsson-Wikmar L, Frändin K. Physical activity and physical functioning in Swedish and Iranian 75-year-olds: a comparison. *Arch Gerontol Geriatr*. 2012; 55(2):422-30.
- II. **Hörder H**, Skoog I, Frändin K. Health-related quality of life in relation to walking habits and fitness: a population-based study of 75-year-olds. *Quality of Life Research*, 2013;22(6):1213-1223.
- III. **Hörder H**, Frändin K, Larsson M. Self-respect through ability to keep fear of frailty at a distance: successful ageing from the perspective of community-dwelling older people. *Int J Qual Stud Health Well-being* 2013. Mar 18;8:20194.
- IV. **Hörder H**, Skoog I, Johansson L, Falk H, Frändin K. Birth cohort differences in fitness, physical activity and falls: a population-based study of 75-year-olds examined in 1987 and 2005. Manuscript submitted.

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ABBREVIATIONS

ADL	Activities of Daily Living
CI	Confidence Interval
DSM-III-R	Diagnostic and Statistical Manual of Mental Disorder, third edition, Revised
HRQL	Health-Related Quality of Life
OR	Odds Ratio
QoL	Quality of Life
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organisation

DEFINITIONS IN SHORT

Capacity	What a person can do in a standard environment (1).
Cohort	A group of people who share a common characteristic or experience within a defined period.
Confounding	A variable that distorts the association between exposure (x) and outcome (y).
Disability	A complex phenomenon often defined as an umbrella term for impairments, activity limitations and participation restrictions (1). Also defined as the gap between a person's intrinsic capabilities and the demands created by the environment (2).
Exercise	“A physical activity that is planned, structured, repetitive and purposeful” in the sense that improved or maintained physical fitness is the objective (3).
Fourth age	The period in life where one is dependent on another person (4).
Function	Functioning at the level of body or body part. physiological functions of body systems (1).
Functioning	All body functions, activities and participation (1).
Health-related quality of life	Multiple outcomes of health-status, conceptualised as two broad categories, function (physical, mental and social) and well-being (5).
Interaction	A situation where two or more factors modify their separate effect on a given outcome
Mediation	A third variable (mediator) carries the influence of a given independent variable (x) to a given dependent variable (y).
Moderation	The effect of one independent variable(s) on the dependent variable is modified by the value of another independent variable(s).

Older people	The age of 65 is commonly used in developed countries as a definition of elderly person. The age of 60 is more common in developing countries.
Performance	What a person actually does in their usual environment (1).
Physical activity	“Any bodily movement produced by skeletal muscles that results in energy expenditure” (3).
Physical fitness	“A set of attributes that people have or achieve” that relate to the ability to perform physical activity. These attributes can be divided into health-related: cardio-respiratory fitness, muscle strength, body composition and flexibility; and skill-related: agility, balance, coordination, speed, power and reaction time (3).
Third age	A period after working life where one is still healthy and able to fulfill personal goals (4).

1 INTRODUCTION

1.1 Population ageing

There are numerous definitions of ageing and approaches from the cellular to the population level. At the individual level, ageing may in a biological perspective be defined as: the deteriorative changes with time during post-maturational life that underlie an increasing vulnerability to challenges, thereby decreasing the ability to survive (6). There are multiple theories of ageing, which may be divided into two major groups: ageing as genetically determined (the biological clock) and ageing as a response to random events over time (7).

At the population level, ageing is often described with mortality statistics. Life expectancy has increased by about 30 years in many developed countries during the twentieth century, and in many countries it is above 80 years. Japan is at the top on the list with 83 years and Sweden is in the top ten (8) (Figure 1). It has been estimated that many children in developed countries today will reach an age of 100 years (9). In developing areas, e.g. Africa, life expectancy is below 40 years in many countries. However, the most rapid increases are seen in less developed countries, and the twenty-first century will probably witness even more rapid ageing in many developing countries.

Population ageing (i.e. the process by which the proportion of older persons in the total population increases more and more) during the twentieth century is regarded as a triumph, one not previously seen in human history. The key drivers to this continuing phenomenon are increased life expectancy and decreased fertility rate, due to medical, economic and social progress. It is a global phenomenon, but different countries are at different stages (10). The proportion of the world's population over the age of 60 was about 11 % in the year 2000 and is expected to double, to 22 %, by 2050 (11). This could be seen as a success story, but it also challenges society to adapt in order to promote a good life in old age.

This demographic transition, from high mortality and high birth rate to decreasing mortality, followed by decreasing birth rate, has been accompanied by an epidemiological transition. This transition means a gradual shift in the burden of disease from infectious diseases towards chronic, non-communicable diseases (12). This transition used to be a slow process, but today it is more rapid in developing countries. However, the transition speed is unique to every country (13). Moreover, there are health inequalities within countries, with low socioeconomic groups having a life expectancy that is up to 20 years shorter than that in higher socioeconomic groups (9).

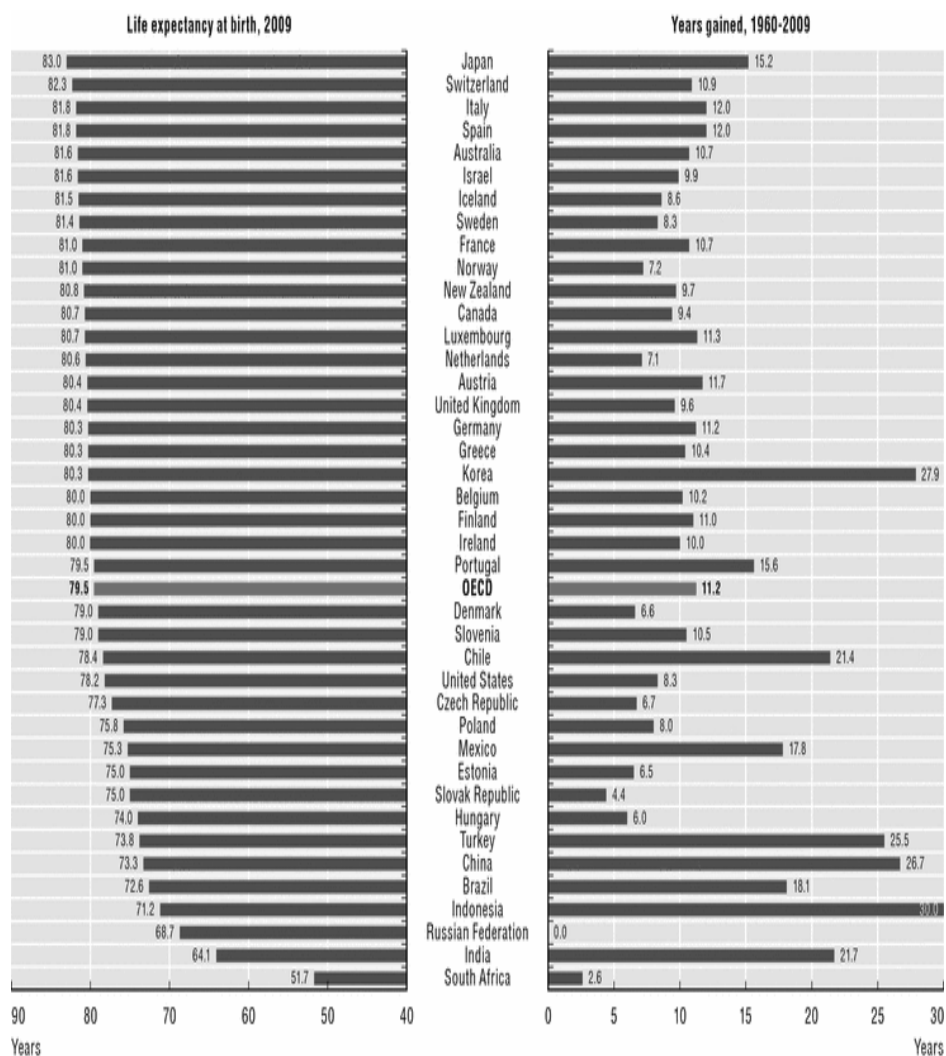


Figure 1. Life expectancy at birth (in 2009) and years gained since 1960.

Source: OECD Health Data 2011; World Bank and national sources for non-OECD countries.
Health at a glance

1.1.1 Ageing in Sweden

Sweden has one of the world's oldest populations. The life expectancy for women was 84 years and for men 80 years in year 2011 (8). Compare this with the situation in year 1900, when the life expectancy for women was 54 years and for men 51 years (14). By the year 2060, it is estimated to be 89 and 87, respectively (15).

At present, more than 17 %, or 1.6 million people, are ≥ 65 years and 5 % are ≥ 80 years, which represents one of the highest proportions of persons above 80 years in the world. In 2030, the proportion of persons aged 65 years or older is estimated to reach 20 % (16) (Figure 2). The increased number of older persons and the epidemiological transition towards chronic diseases puts demands on society and highlights the importance of identifying factors that could promote a good old age.

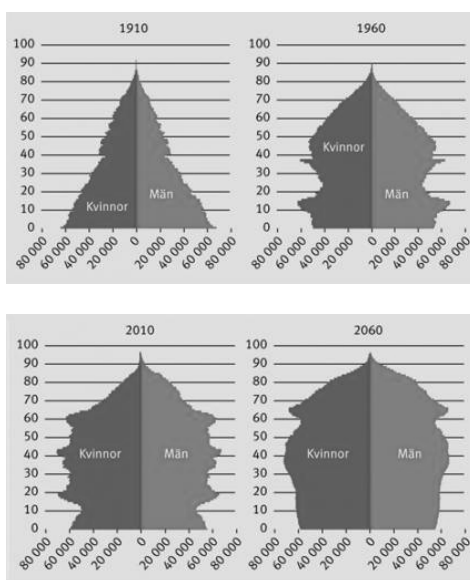


Figure 2. Population ageing from 1910 to 2060 in Sweden (17)

Source: Sweden Statistics

1.2 Successful ageing

What is regarded as a good old age may be traced back to the Greek philosophers. In an essay from Cicero 44 BC, the main debate concerned the hedonic way: the maximum amount of pleasure for happiness, and the eudaimonic way (daimon=true self): arguing that true happiness is doing what is worth doing, emphasising the importance of morale for happiness (18).

This approach to achieving most well-being in life has been replaced in recent decades with the concept Quality of Life (QoL). One reason for this was that QoL (quality according to the Oxford English dictionary: “the standard of something as measured against other things of a similar kind; the degree of excellence of something”) seemed more medically and scientifically correct and it was also supposed to include more objective aspects that could be assessed by others (19). It was also suggested that it could be influenced to a higher degree in contrast to hedonic happiness or eudaimonic well-being which seem to be more related to personality and more biologically determined (20). QoL measures have supplemented health assessment such as morbidity and mortality (21). There is no consensus definition of QoL, but it has been described as a global construct that is derived from social science and describes subjective well-being in terms of overall life satisfaction (22). It refers to a comparison process and includes weighting the importance of particular areas within a person’s life (22). The World Health Organisation (WHO) defines QoL as “an individual’s perception of his/her position in life, in the context of the culture and value systems in which he/she lives and in relation to his/her goals, expectations, standards and concerns” (23). Lawton (24) suggested one of the first conceptualisations of QoL in old age: objective environment (physical attributes of one’s own environment), perceived QoL (subjective life satisfaction, psychological well-being (emotional state) and behavioural competence (physical health, functional competence, cognition, time use and social behaviour).

Successful ageing is one of the most commonly used terms in discussions dealing with a good life in old age (success according to the Oxford English Dictionary: “the accomplishment of an aim or purpose”). Like QoL, the concept of successful ageing emerged from social science in the 1960s and 70s, and in its original meaning it implies life satisfaction (“adding life to years”) as the most salient indicator (25). During the 1980s and 90s, psychologists and behavioural scientists started to address successful ageing, and in the last two decades, biomedical and health scientists have shown greater interest. The term “successful” in this context is a North American construct (26) and related concepts such as “healthy ageing”, “active ageing”, “positive ageing”, “effective ageing”, “productive ageing”, “optimal ageing” and “ageing well” are also used. Two main approaches to successful ageing can be described: 1) sociological and psychological theories focusing on processes of development and adaptation and 2) biomedical models, often with suggested outcome measures.

In social science, two major theories of human development during ageing were presented during the early 1960s. One was the *activity theory*, which was presented as

a form of successful ageing where maintained activity and roles are supposed to be related to life satisfaction (25). This also includes the role as a contributor to society. At about the same time the *disengagement theory* was introduced. It views ageing as a gradual withdrawal between society and the older person. This is seen as a natural and acceptable process, encountered by both society and the individual. This freedom from societal roles is suggested to promote self-reflection and a good old age (27). These two could be called “first generation” theories. Later on, “second generation” theories were presented. The *continuity theory*, which was derived from the activity theory, emphasises adaptation, flexibility and an interaction of the past, present and future. This theory focuses on personality and maintained coping strategies, which allow psychological and social/behavioral continuity (28). Another theory of relevance to successful ageing is Eriksson’s (29) developmental stages of identity throughout the life span, which suggests that personality is determined by an interaction of body, mind and culture. The eighth and final stage is integrity versus despair, where wisdom has to be acquired for a positive development of identity in the latest stage of life. From a psychological perspective, these developmental theories are supposed to promote life satisfaction. Ryff (30) has suggested an integrated model of successful ageing with psychological criteria beyond life satisfaction; self-acceptance, positive relations with others, autonomy, environmental mastery, purpose in life and personal growth. During the same period, Thornstam (31) introduced the gerotranscendence theory. This theory may be seen as a new view of ageing, i.e. ageing as a shift of perspective from a materialistic to a more reflective one. A dominant theory today is that of Baltes and Baltes (32, 33), who suggest a strategy for successful ageing; the selective, optimisation with compensation model (SOC), focusing on behavioural and psychological adaptation to age-related changes. This is a life-course model that emphasises a process of adaptation to handle the balance between gains and losses in life, by a strategy of *optimising* situations by *compensating* losses by *selecting* things that one can do. Recently, the psychological term resilience which may be described as an individual’s capacity to cope with stressors and adverse events has been acknowledged as an important predictor of successful ageing (34).

From a biomedical perspective, Fries (35) suggested that a long life and being vibrant until shortly before death is the best way to describe successful ageing. In an attempt to broaden the concept and differentiate between normal and successful ageing, Rowe and Kahn (36) introduced a model characterised by: a) absence or avoidance of disease and risk factors for disease, b) maintenance of high physical and cognitive functioning and c) engagement with life. This is the most widely used conceptualisation of successful ageing in medical and health science. However, researchers use different indicators and criteria for successful ageing. One review identified life satisfaction, longevity, freedom from disability, mastery/growth, active engagement with life, high/independent functioning and adaptation as the major elements included in researchers’ definition of successful ageing (37). Another review, including 28 studies, identified 29 different definitions of successful ageing, among which disability/physical functioning was the most common criterion (38).

Recent models of successful ageing emphasise multidimensionality and an expanded definition of successful ageing that includes both objective and subjective indicators

(37, 39-42). A multidimensional framework with screening tools for assessment of physiological, psychological and social components has recently been proposed. This assessment tool contains three dimensions: physiological (disease and impairment), psychological (emotional vitality) and sociological (engaging with life and spirituality). This model implies a continuous approach to successful ageing and stresses that individuals with limitations in one dimension could still be ageing successfully due to compensation by components in other dimensions (43). This model has not yet been tested in research or for face validity by older persons.

The definition of successful ageing differs between researchers and older people, in that older people assess themselves as successful agers more often than the researchers do (41). The concept is criticised because it does not include the perspective of the older people themselves and could contribute to discrimination and ageism in categorising too many persons as not ageing successfully (44). If a positivistic research perspective is allowed to dominate, there is a risk that a confidence crisis will occur, in that results are too far removed from the things themselves, the meaning to the persons involved. Studies with a qualitative approach have therefore been carried out to explore older persons' views of successful ageing. Just recently, a systematic review of studies focusing on lay views of successful ageing was conducted. This concluded that psychosocial components (e.g. social engagement) and personal resources (attitudes) were essential for the older people themselves. It also concluded that most studies had been carried out in the US and that minority groups need to be included (45).

As has been pointed out, an integrated model of successful ageing is required. Biomedical and psychosocial models do not need to be in conflict, but could complement each other. The Rowe-Kahn model emphasises what individuals themselves can do to use, maintain, and perhaps even improve their physical and cognitive capacities, while the psychosocial theories emphasise an acceptance of age-related changes and doing the best you can with what you have. As the conceptualisation of successful ageing is developed in a certain socio-political context in North America, a wider inclusion of cultural and structural factors for successful ageing is also needed (26). Today, one of the most important questions is who should define successful aging. To enhance the face validity of the concept, it seems essential to include the perspective of diverse groups of older persons.

1.3 Health

Health is considered to be one of the most important aspects of a good old age. The word *health* is related to *whole*, which means happiness. Health is defined as: “A state of complete physical, social and mental well-being, and not merely the absence of disease or infirmity” (46). On the other hand, Gadamer (47) has argued that it is not health but illness that objectifies itself, “health does not actually present itself to us”.

Traditionally, health outcomes have focused on “the five D’s”: death, disease, disability, discomfort and dissatisfaction (48). Within the context of health promotion, health has been seen less as an abstract state and more as a means to an end, which can be expressed in functional terms as a resource which permits people to lead an individually, socially and economically productive life (49). “The five D’s” have recently been supplemented with self-rated aspects. A single item of self-rated health (“In general, how do you rate your overall health?”) is perhaps the most widely used health-status assessment. Among the reasons for its popularity is that it has been shown to be a predictor of morbidity and mortality (50). The global question is effective and easy, but more comprehensive measures of self-rated health status also exist, often referred to as Health-Related Quality of Life (HRQL). HRQL has been used to describe multiple outcome of health-status, conceptualised as two broad categories: functioning (physical, mental and social) and well-being (5). Several generic and disease-specific instruments exist. The Short-Form-36 (SF-36) is the most widely used instrument for measuring HRQL, also in older persons. A proximal/distal relation has been identified between HRQL and QoL, where constructs of HRQL predict life satisfaction (51).

With chronic diseases as the main threat to health, there is an increased interest in the transition from health to disability. Impaired physical functioning is a strong predictor of clinically more meaningful outcomes such as disabilities, nursing-home admission and death (52, 53). There is no uniform language for classification in the field of functioning. There are, however, two major conceptual frameworks to guide how to think and describe health and disability outcomes and their consequences: *Nagi’s disablement model* (2, 54) as elaborated by Verbrugge and Jette and referred to as the disablement process (55) and *The International Classification of Functioning, Disability and Health (ICF)* (1).

1.3.1 The disablement process

Nagi's (2) disablement model has its origin in the early 1960s. Nagi viewed the concept of disability as representing the gap between a person's intrinsic physical and mental capabilities and the demands created by the social and physical environment. The model includes pathology, impairment, functional limitation and disability. Pathology can be caused by disease or age-related decline. Impairment refers to dysfunctions in specific body systems and reflects the consequences and degree of pathology. Functional limitations are situation-free restrictions in individual capability and include central physical, cognitive and emotional functions, while disability refers to experienced difficulty in doing activities in any situational life-domain.

The original model has been extended and elaborated to include personal (i.e. lifestyle behaviours and attitudes) and societal (i.e. social and physical environment) factors that speed up or slow down the disability process (55). Also, the concept of QoL has been included in the disablement model (56). According to this model, QoL deals with the personal and societal level (Figure 3).

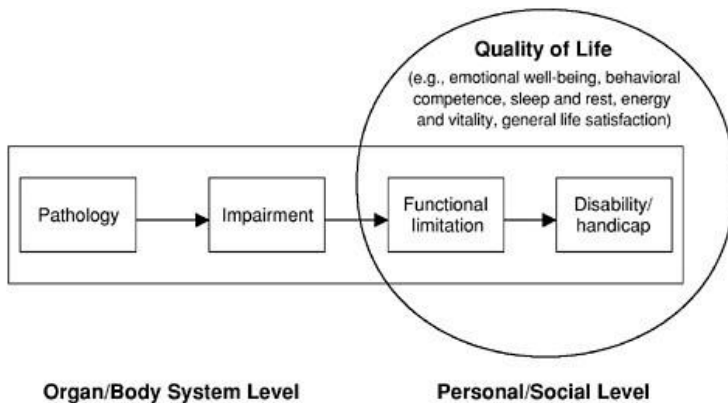


Figure 3. The disablement model with inclusion of a quality of life concept (56).

1.3.2 The International Classification of Functioning, Disability and Health (ICF)

The ICF is a more recently developed model and provides a description of situations with regard to human functioning and its restrictions, and serves as a framework for organising this information (1). In contrast to the disablement process, the ICF focuses on health and does not provide a single way to determine disability status. The term *functioning* is an umbrella term referring to all body functions (physiology) and structures (anatomy), activities (individual functioning) and participation (societal functioning). Similarly, *disability* is an umbrella term for impairments (physiology and anatomy), activity limitations (individual) and participation restrictions (societal). Classifications of activity and participation are further divided into capacity (can do in standardised environment) and performance (actually do in usual environment). ICF also lists contextual factors, which interact with all these components (Figure 4).

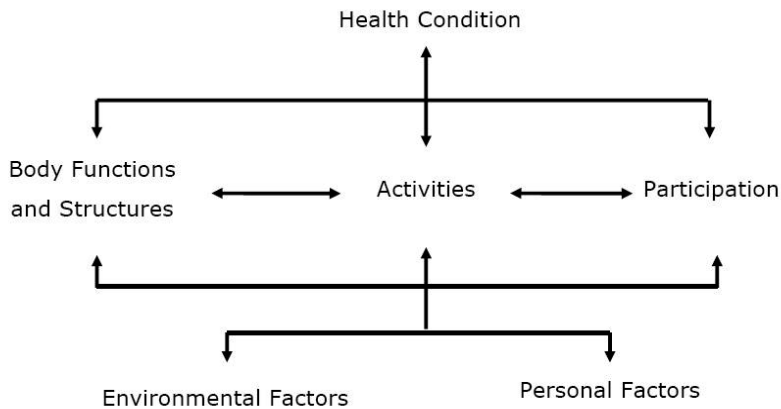


Figure 4. Basic elements of the World Health Organisation’s International Classification of Functioning, Disability and Health (ICF).

Despite the overall aim of ICF, a unified standard international language and framework for the description of functioning and disability are still lacking (57-59). The Disablement process is still the most commonly used framework in gerontological research. According to this framework, the term physical or functional *ability* is often used as the positive term for both absence of functional limitations (individual level) and disability (societal level), while ICF suggests *capacity* (individual level) and performance (societal level). Because of the standardised procedure connected with it and the lack of environmental influence, capacity is more sensitive to change compared to more distal outcomes such as performance (environmental level) and participation/disability (societal level) (Table 1).

Table 1. Terminology and definitions according to the Disablement model and the International Classification of Functioning (ICF)

The disablement model, according to Nagi	The International Classification of Functioning (ICF)
<i>Pathology</i> - interruption or interference with normal processes, and effort of the organism to regain normal state	<i>Health condition</i> - diseases, disorders, and injuries
<i>Impairment</i> - anatomical, physiological, mental, or emotional abnormalities	<i>Body function</i> - physiological functions of body systems
<i>Functional limitation</i> —limitation in performance at the level of the whole organism or person	<i>Body structures</i> —anatomical parts of the body
<i>Functional limitation</i> —limitation in performance at the level of the whole organism or person	<i>Activity</i> —the execution of a task or action by an individual
<i>Disability</i> —limitation in performance of socially defined roles and tasks within a socio-cultural and physical environment	<ul style="list-style-type: none"> • <i>Capacity</i> • <i>Performance</i>
<i>Disability</i> —limitation in performance of socially defined roles and tasks within a socio-cultural and physical environment	<i>Participation</i> —involvement in a life situation

Source: Jette 2006 (57)

1.3.3 Assessment of physical functioning

Another term to describe physical capacity/ability is *fitness* (e.g. cardio-respiratory endurance, muscular strength, flexibility and balance), which is a primary concept in the field of physical activity (3) and the term used in this thesis. Among older persons, fitness is often measured by means of functional tests. The Short Physical Performance Battery (SPPB) is one of the most widely used. SPPB includes walking speed (also known as gait speed), timed chair stand and standing balance. Gait speed alone is a marker of physiological reserve and is suggested to be included in routine clinical practice as a “sixth vital sign” (60, 61). Reduced gait speed is characterised by shorter step length and increased double support time (62). It is associated with clinical comorbidities and subclinical conditions such as arteriosclerosis and inflammation, and is a predictor of several adverse health-related events: disability, falls, cognition, hospitalisation, institutionalisation and mortality (53). It is a simple and accessible summary indicator of vitality as it puts demands on heart, lung, circulatory, nervous and musculoskeletal systems and indicates known and unrecognised disturbances in multiple organ systems (63). It may be tested as self-selected or maximal speed. A self-selected gait speed below 1 m/s has been suggested as a threshold for risks of adverse outcomes (64). A small meaningful change has been suggested to be near 0.05 m/s, and a substantial meaningful change to be near 0.1 m/s (65, 66). Another commonly used measure is grip strength. It has been suggested as a marker for physical performance (67) and has shown predictive value for mortality, morbidity and other adverse outcomes (68). For grip strength, a lower limit for risk of dependence and a cut-off value for frailty are set to 17-21 kg for women and 29-32 kg for men, based upon the level of BMI (69-71). Both gait speed and grip strength are included as two out of five criteria in a physiological frailty phenotype, which also includes low physical activity, self-reported exhaustion and unintentional weight loss.

Disability is most commonly assessed with dependence in Activities of Daily Living (ADL). It is generally self-reported. Two main types of ADL exist: personal ADL (P-ADL or ADL) and instrumental ADL (I-ADL). P-ADL refers to tasks of everyday life such as eating, bathing, dressing, toileting and transferring—the basic functions needed to maintain independent living within the community, while I-ADL refers to individuals’ functioning in the community—activities such as getting around in the community, cooking, housekeeping, and managing money. Several instruments exist, most of which may be traced back to the Katz ADL Index (72) or the Barthel Index (73).

Another adverse outcome among older persons, and a consequence of a decline in physical functioning, is falls and their related injuries. A fall may be defined as “an unexpected event in which the participant comes to rest on the ground, floor, or lower level” (74). About 30 % of persons above 60 years (75) and 50 % of persons above 80 years fall each year (76). Falls are one of the ten most common causes of “years lived with disability” globally (3rd in Western Europe) (77). The number of falls is expected to increase due to population ageing. An important aspect in relation to falls and functional decline is fear of falling, which may be conceptualised as fall-related self-efficacy (78).

1.4 A life course perspective

To understand the process of ageing, a life course perspective has been suggested. Life course epidemiology has been defined as “the study of long term effects on later health or disease risk, of physical or social exposures during gestation, childhood, adolescence, young adulthood and later adult life” (79). In a life course model of ageing, both intrinsic and extrinsic exposures across the life course are suggested to influence the response of maintenance, repair and the capacity to carry it out. Differences in both exposures and individual response might underlie variations in ageing between individuals and between systems in the individual (80).

Decline in physical functioning is strongly associated with ageing and also a consequence of many chronic conditions (Figure 5). However, there are great differences between individuals and between various organs and systems within individuals (81). For example, self-selected gait speed has been suggested to be relatively stable up to age 60 with a decline of about 1-2 % per decade, but with an accelerated decline of about 10 % per decade after age 60 (82). For grip strength, a yearly decline of 0.6 kg for men and 0.3 kg for women in an almost linear way from ages 50 to 85 years has been reported (83). Self-rated physical functioning also declines with age, while mental health declines at a slower rate (84). As regards life satisfaction, ageing is not associated with a decline, and it is suggested to be a more stable construct (85). In fact, some researchers have even reported a slight increase (86). However, recent studies have shown that life satisfaction may not be as persistent as suggested among persons above 80 years (87).

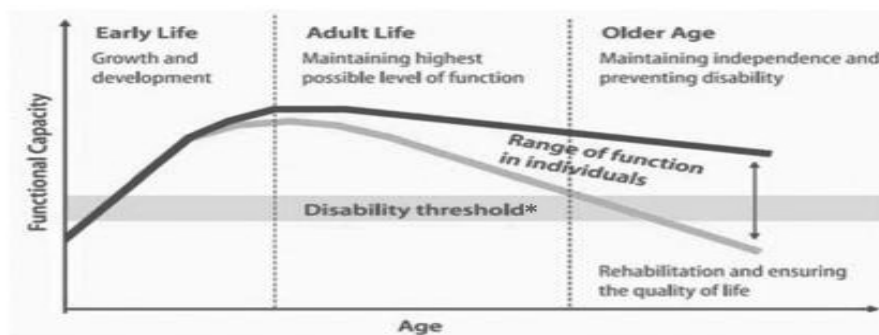


Figure 5. A life course perspective to physical functioning

Source: Kalache and Kickbusch, 1997

Old age is sometimes divided into a *third age*, which is described as a period after working life where one is still healthy and able to fulfill personal goals and a *fourth age*, the period in life where one is dependent on another person (4). Women generally live longer with disabilities than men do (88). A Norwegian study has shown that, on average, women become dependent in ADL, 3.2 years before death and men 1.8 years before death (89). However, the ageing process is very individual, and it is impossible to know how much of the decline in capacity is due to ageing, disease or lifestyle factors such as physical inactivity.

1.4.1 Birth cohort

One of many concepts about the timing of causal actions in life course epidemiology is *birth cohort*, referring to the location of an individual in historical time as indexed by their year of birth. Birth cohort differences in health may be seen at old age in relation to e.g. childbearing characteristics, habits during childhood and adolescence, baby boomer generations and living standards etc. (90).

There is no consensus on whether the gain in life expectancy entails more years of good health or more years of disease or disabilities (9) (Figure 6). Three main hypotheses are:

- 1) Compression of morbidity
- 2) Expansion of morbidity
- 3) Postponement of morbidity

The compression of morbidity theory hypothesises that morbidity is being squeezed into a shorter period of life with less lifetime disability (35, 91). On the other hand, the expansion of morbidity theory hypothesises that more years of disabilities are added with the same amount of healthy years (92). The postponement theory hypothesises that the years that are added to life are mainly healthy, while the period with disabilities remains the same but is postponed to a higher age (93).

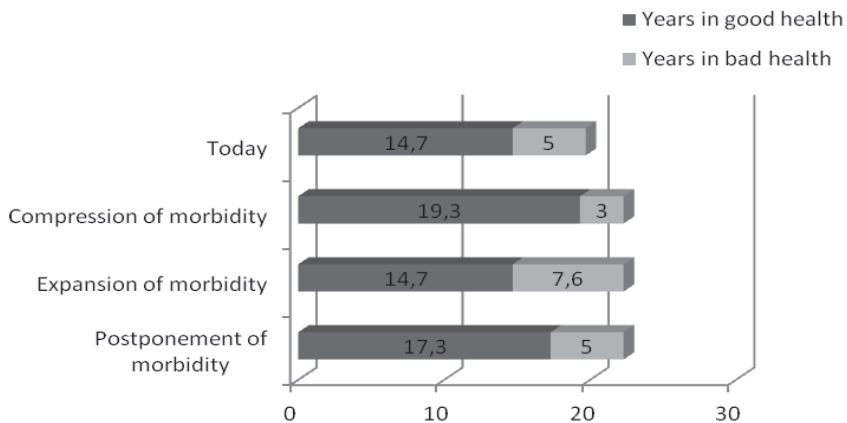


Figure 6. Life expectancy at age 65 years in 2010 and 2050, divided into years in good and bad health according to three different theories (94).

1.4.2 Mediation and moderation

In a life course perspective, mediating and moderating factors are two concepts referring to different types of mechanisms underlying causal pathways to health outcomes (90). Generally speaking, mediators and moderators are third variables, whose purpose is to enhance a deeper and more refined understanding of a causal relationship between an independent variable and a dependent variable (95).

Mediation

A mediation effect occurs when a third variable (mediator) carries the influence of a given independent variable (X) to a given dependent variable (Y). Mediation models answer hypotheses of how/why an effect occurs by hypothesising a causal sequence (95, 96) (Figure 7).

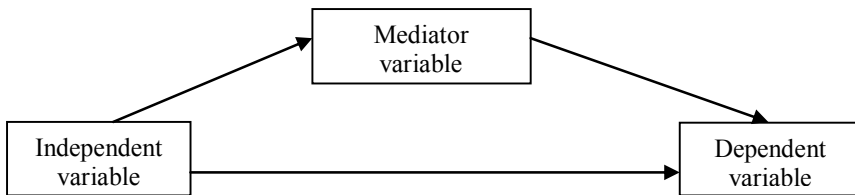


Figure 7. The mediation process

Mediating factors are by definition post exposure of interest and differ from confounding factors, which are conceptualised as prior to and/or tangential to understanding the effects of the exposure of interest (90). A confounder is not the causal pathway between exposure and outcome, but is instead related to both the independent (X) and the dependent variable (Y), and distorts this association ((97) (Figure 8).

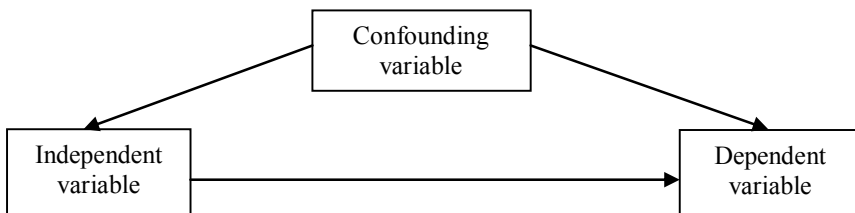


Figure 8. Confounding

Moderation

Moderation answers the hypothesis of *when* and *for whom* in pre-established relationships. Moderation is a situation where the effect of one independent variable(s) on the dependent variable is modified by the value of another independent variable(s). It modifies the strength or direction of a causal relation (95) (Figure 9).

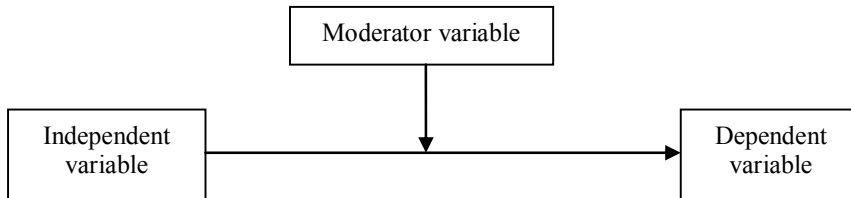


Figure 9. Conceptual path for moderation effect

Moderation can be traced back to statistical interaction. The term interaction is used to describe a situation where two or more factors modify their separate effect on a given outcome. Interaction is a bidirectional (non-causal) hypothesis, which implies that two or more concepts “work together” or have a combined effect in eliciting a third, while moderation is a more restrictive version of interaction where the hypothesis is unidirectional and could be referred to as “causal interaction”. In other words, a moderation effect is certainly an interaction effect, but an interaction effect is not necessarily a moderation effect (95). Also, statistical interaction should be distinguished from biological interactions of behaviour, psychological factors and gene-environment.

1.5 Physical activity

With population ageing, a major objective for public health is to identify modifiable determinants of a good life in old age. Lifestyle factors (smoking, alcohol consumption, diet and physical inactivity) are at the top of risk factors for mortality and morbidity and account for over one third of the global burden of disease (98). Inadequate physical activity has been identified as the fourth leading risk factor for global mortality, accounting for 6 % of deaths globally, after high blood pressure (13 %), tobacco use (9 %) and high blood glucose (6 %) (99). There is a correlation between ageing and inactivity and the proportion of those meeting the public health recommendations of physical activity declines with age (100).

The health benefits from physical activity are extensive and well-known; i.e. decreased risk of cardio-vascular disease, diabetes type 2, hypertension, colon and breast cancer, osteoporosis, anxiety, depression and all-cause mortality (101). The Global Recommendations on Physical Activity for Health (102) provide guidance on the dose-response (i.e. the frequency, duration, intensity, type) relationship between physical activity and health benefits for persons aged ≥ 65 years:

- At least 150 minutes of moderate-intensity aerobic physical activity throughout the week or at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous intensity activity.
- Aerobic activity should be performed in bouts of at least 10 minutes duration.
- For additional health benefits, increase the moderate intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous intensity aerobic physical activity per week, or an equivalent combination of moderate-and vigorous-intensity activity.
- If poor mobility is evident, perform physical activity to enhance balance and prevent falls on 3 or more days per week.
- Muscle-strengthening activities, involving major muscle groups, should be done on 2 or more days a week.
- When older persons cannot do the recommended amounts of physical activity due to health conditions, they should be as physically active as their abilities and conditions allow.

Walking is the main example of recommended moderate physical activity. It started to receive attention in the 1990s as a behaviour with substantial health benefits as a complement to the earlier focus on vigorous activities (103). Walking is by far the most prevalent physical activity among older adults (104) and it is feasible, cost-effective, relatively safe and may be performed regardless of socioeconomic status (105).

The goals of physical activity for older people differ from those for younger people, and one important issue for older people is to minimise the biological changes of ageing. The health benefits might even be larger in older persons than in younger ones as physical activity could influence factors that are more prevalent at older ages: promoting a higher level of functional health, a lower risk of falling, healthier body mass and composition, the enhancement of bone health and better cognitive function. There is evidence that regular physical activity reduces the risk of moderate and severe functional limitations. Also, in older persons with functional limitations, there is fairly consistent evidence that regular physical activity is safe and has a beneficial effect on functional ability (102). The evidence for the effects on disabilities is not that clear (106), but the number of years without disability seems to be greater in persons who remain active (107) and physical activity is considered to be a key factor in predicting non-disability before death.

Rejeski et al (108) have suggested a relation between physical activity and several domains of QoL in older persons. Physical activity has been shown to be generally positively related to several aspects of HRQL, both in cross-sectional studies and randomised controlled trials (RCTs) (109). The evidence is less conclusive for global QoL (51). A review by Taylor et al (110) suggests that physical activity seems to have a small to moderate positive effect on cognitive health, psychological well-being and social functioning. However, the results are inconclusive with regard to the type, frequency, duration and intensity of physical activity in relation to HRQL (108, 109).

It has been suggested that a deeper understanding of the relation between physical activity and QoL is required, and that the focus should be on mediating and moderating variables, rather than on dose-response relations (108). Regular exercise is hypothesised to improve health and overall well-being through mechanisms including direct neurophysiological responses, expanded social networks and improved self-efficacy (5). Psychological constructs, such as self-efficacy (i.e. “a person's belief in his or her capability to perform a particular task successfully (111)) has been identified as an especially important mediator both in the relation between physical activity and QoL and the relation between physical activity and functional limitations (51). Another possible mediator in this relation is fitness. Improved fitness is traditionally a main focus in exercise interventions. Fitness has recently been shown to be positively associated with several aspects of HRQL (112-116), but the role of fitness as a mediator in the relation between physical activity and HRQL is not clear. It has been suggested that a person must be aware of a capacity to have an improved quality (108). To identify pathways or mediators in the relation between physical activity and QoL could help us to understand the underlying mechanisms, and thereby increase the possibility of promoting QoL with physical activity interventions.

1.5.1 Assessment of physical activity

Physical activity is a complex behaviour and there is no internationally agreed measure. It can be assessed either as energy expenditure or as behavioural habits. Behavioural habits (in terms of type, intensity, frequency and duration) are assessed either by subjective or objective ratings. Self-reported questionnaires are common in epidemiological studies with large populations, as they are cheap and easy to administer. Self-reported questionnaires generally show moderate validity, and more high quality validity studies are necessary (117). In an attempt to objectify the behaviour, assessments with pedometers or accelerometers are increasingly used. However, these measures have limitations since they are dependent on the season of the year, and correlations between self-assessed and objective physical activity are quite low (118). When interpreting the results of questionnaires on physical activity it is important to consider recall bias. While total physical activity is often overestimated in self-reported measures (119), walking is often underestimated (120).

2 AIMS

The overall aim of this thesis was to further the knowledge of successful ageing, with a focus on fitness and physical activity among older persons.

Specific aims were:

- To report physical functioning and physical activity habits in 75-year-olds living in Sweden and to compare the results with those of a similar investigation of 75-year-olds living in Iran.
- To assess HRQL in relation to walking habits and fitness in older persons. A secondary aim here was to examine fitness as a mediator in a hypothetical relation between walking habits and HRQL.
- To explore successful ageing from the perspective of community-dwelling older persons in Sweden.
- To report fitness status, physical activity level and proportion of fallers in two different birth cohorts of 75-year-olds examined in 1987 and 2005, respectively

3 METHODS

This thesis is based on three population-based studies with quantitative approaches and one study with a qualitative approach. Research designs are summarised in Table 2.

Table 2. Research design overview

Study	Design	Setting	Participants	Data collection
I	Cross-sectional cohort, explorative, cultural comparison	Population-based, Gothenburg, Sweden and Teheran, Iran	75-year-olds born 1930, living in Sweden (n=637), 75-year-olds living in Teheran, Iran (n=851)	Performance-based and questionnaires
II	Cross-sectional cohort	Population-based, Gothenburg, Sweden 2005	75-year-olds born 1930 (n=698). Included in regression analysis: n=545	Performance-based and questionnaires
III	Qualitative inductive approach	A smaller Western community in Sweden, rural area	9 women and 15 men aged 76-92 years	Open individual interviews
IV	Repeated cross-sectional, cohort	Population-based, Gothenburg, Sweden 1987 and 2005	75-year-olds born 1911-12 (n= 591) and 1930 (n= 637)	Performance-based and questionnaires

3.1 The Gerontological and Geriatric Population Studies in Gothenburg, H70 (paper I, II and IV)

Paper I, II and IV are part of the Gerontological and Geriatric Population Studies in Gothenburg, Sweden, H70. The H70-studies are repeated cross-sectional and longitudinal population studies of older persons started in 1971 in order to examine medical and social conditions in older populations. The initial purpose was to increase the understanding of normal ageing, identify risk factors and to plan the care of older persons. Systematic samples of birth cohorts are obtained from the Swedish Population Register according to certain birth dates. The design, procedures and methods of data collection for the initial H70 cohort have been reported elsewhere (121). Up to now, six cohorts have been examined and re-examined and a seventh cohort born in 1944 is planned to be examined at the age of 70 years in 2014.

3.1.1 Samples (papers I, II and IV)

Swedish cohort born in 1930, examined in 2005 (paper I, II and IV)

In 2005, 75-year-olds born in 1930 living in Gothenburg, Sweden on September 1, 2005, were invited to participate in a health examination. The sample was obtained, based on birth date (3rd, 6th, 12th, 18th, 21st, 24th, or 30th in each month), and included persons living both in private households and in institutions. Most persons were examined at a research clinic but some only had a visit in their home or institution and took part only in certain examinations. Among those selected (N=1250), 10 died before they could be examined, 2 had emigrated outside Sweden, and 32 could not speak Swedish, leaving an effective sample of 1206 persons. Among these, 18 could not be traced, 430 refused, and 758 (323 men, 435 women) accepted to take part in the examination (response rate 63 %). Papers I and IV include those examined at the research clinic (n=637) and paper II also includes those with a home visit who answered questions on walking habits and HRQL (n=698).

Swedish cohort born in 1911-12, examined in 1987 (paper IV)

Paper IV was a comparison of the 1930 cohort and a cohort born in 1911-12, at the age of 75. The design and procedure with systematic sampling were generally the same for the 1911-12 cohort as for the other cohorts. However, one third of this sample was part of a medical-social intervention at ages 70-73, called the InterVention of Elderly people in Gothenburg (IVEG). The intervention sample consisted of 400 persons randomly drawn from 10 target areas according to type of housing, degree of service, age structure and marital status. The medical controls consisted of 406 persons born on the 5th, 15th or 25th of each month. The register control sample consisted of 400 persons born 6th, 16th or 26th of each month. The IVEG is described in detail elsewhere (122).

At the age of 75, the 1911-12 cohort comprised a sample of 1245 persons, living in Gothenburg, selected at the age of 70 and still alive in 198-88 (n=844). Among those, 649 accepted to take part (response rate 77 %) and 591 (327 women and 264 men) were involved in tests of fitness at the research clinic. Out of these, 182 had participated in the IVEG study. As the intervention and control groups did not differ in fitness, and differed only to a small extent in physical activity at the age of 75 (123), the groups were analysed together.

Iranian cohort (paper I)

A replication of the H70-studies, with focus on physical functioning, was addressed with a representative cross-sectional sample of 75-year-olds living in Teheran, Iran, born 1932-33 and examined in 2007-08. A total number of 1100 persons were randomly selected, according to strategic areas in Teheran, from the last Iranian census records by the Centre of Statistics in Iran using computerized methods. The sample obtained included people living in private households. Among those selected, 37 died before they could be examined, leaving an effective sample of 1063 individuals. Out of these, 204 refused and 8 were excluded due to severe disability or communication deficits and 851 accepted to take part in examinations (response rate 80 %).

3.1.2 The variables assessed

Similar methods were used in all three cohorts in papers I, II and IV (Table 3).

Table 3. Main measures and interviews assessed in cohorts of 75-year-olds

	Swedish cohort born 1930	Swedish cohort born 1911-12	Iranian cohort
Self-selected gait speed	x	x	x
Maximal gait speed	x	x	x
Timed chair stand	x		x
Stair climbing capacity	x	x	x
One-leg stance	x	x ¹	x
Grip strength using Jamar	x		x
Physical activity scale	x	x	x
Number of physical activities	x	x	x
Walking habits	x	x ²	x
Short Form-36	x		
Activities of Daily Living (ADL)	x	x ²	x
Falls-related self-efficacy	x		x
Feeling healthy	x	x ²	x
Feeling generally tired	x	x ²	x
Self-rated fitness	x	x	x
Falls	x	x	x

¹ A subsample only (n=173), ² Not used for analytic purpose in this thesis

Fitness

- Self-selected and maximal gait speed for 30 metres (20 metres for 1930 cohort) indoors with standing start (124). Type of walking aids was recorded. The walking test has shown good intra- and inter rater reliability (125).
- Timed chair stand, i.e. the ability to stand up from a chair, was tested (124). Each subject was asked to stand up from a chair with a seat height of 43 cm and arm rests, with or without support of his/her arms. The subject was asked to stand up and sit down five times in a row, as quickly as possible. The total time was used as outcome. The timed chair stand test has been shown to have high test-retest reliability and is considered to be a sensitive test for evaluating effects of exercise (126). It also displays discriminative and concurrent validity properties (127).
- Stair climbing, i.e. the ability to climb onto boxes of varying heights (10, 20, 30, 40 and 50 cm) without support (124). The result from the best leg was used for analytical purposes.
- Static balance was tested by ability to stand on one leg without shoes, for a maximum of 30 seconds (128). The hip joint of the non-weight bearing leg was in a neutral position and the knee flexed to approximately 90 degrees, hands behind their back and looking straight ahead. The test was interrupted if the person moved from the standardised position. Three trials for each leg were allowed and the best result from the best leg was used for analytical purposes.
- Grip strength was tested with a Jamar dynamometer at an elbow angle of 90 degrees and the shoulder joint in a neutral position. The test was repeated three times for each hand, and the highest value of the best hand was used in the analyses. The method has been shown to have high intra- and inter-test reliability (129) and validity (130).

Physical activity

The total level of physical activity was estimated in interviews, conducted by a physiotherapist, for summer and winter separately according to a scale comprising 6 levels, including household activities (Table 4). The activity scale is described in detail elsewhere (124). For analytical purposes the activity scale was reduced to four groups, by combining the lowest level of activity with level 2 and the highest level with level 5, due to very few persons reporting levels 1 and 6.

Table 4. Physical activity scale

1	Hardly any physical activity.
2	Mostly sitting, sometimes a walk, light gardening or similar tasks, sometimes light household activities such as heating up food, dusting or cleaning up.
3	Light physical exercise around 2-4 h a week, e.g. walks, fishing, dancing, ordinary gardening etc including walks to and from shops. Main responsibility for light domestic work such as cooking, dusting, cleaning up and making beds. Performs or takes part in weekly cleaning.
4	Moderate exercise 1-2 h a week, e.g. jogging, swimming, gymnastics, heavy gardening, home-repairing or light physical activities 4 h a week. Responsible for all domestic activities, light as well as heavy. Weekly cleaning with vacuum cleaning, washing floors and window-cleaning.
5	Moderate exercise at least 3 h a week, e.g. tennis, swimming and jogging.
6	Hard or very hard exercise regularly and several times a week, where the physical exertion is great, e.g. jogging, skiing.

In addition, the number of physical activities was assessed using the question: What activities have you taken part in during the last year? There were 24 response alternatives, e.g. cycling, gardening and swimming, of which four could be selected (124).

Walking habits

Data concerning walking habits were collected in interviews conducted by a physiotherapist. The questions used were: “Do you take a daily walk?” “If not, how many days a week do you walk?” and “How long does your walk generally last?”(131). For analytical purposes, participants were divided into four groups: <75 min/week, 75-<150 min/week, 150-<300 min/week and ≥ 300 min/week. This is in line with the global recommendations on physical activity with moderate intensity (102).

Health-related quality of life (HRQL)

The 36-Item Short-Form Health Survey (SF-36) was used to assess HRQL. It is the most widely used instrument in the world for measuring physical, mental and social functioning and well-being (132). It has been translated into Swedish and validated in a representative sample of the population and has normative Swedish data for different age groups (84). It includes 36 items and generates a health-profile of eight subscales (Physical Function, Role Physical, Bodily Pain, General Health, Vitality, Social Function, Role Emotional and Mental Health) (132). Each domain is transformed to a scale ranging from 0 (worst score) to 100 (best score). The subscales are also organised to form summary measures for physical and mental health. When tested on older people, the questionnaire showed comparable reliability to the one for younger people (133). The SF-36 was sent by mail to the subject and he/she was asked to fill it in at home and bring the form to the examination. A difference of 5-10 points is suggested as a clinically relevant difference (134).

Activities of Daily Living (ADL)

Disability was tested with the instrument referred to as the ADL Staircase, which covers five personal activities of daily living (P-ADL): i.e. feeding, transferring, going to the toilet, dressing, and bathing and four instrumental activities of daily living (I-ADL): i.e. cooking, shopping, cleaning, and transportation, referred to as the ADL Staircase (135, 136). This instrument is an extension of Katz' ADL Index (72). The ADL Staircase is administered using a combination of interview and observation. Dependence was defined as dependence on another person in ≥ 1 activity.

Falls-related self-efficacy

The Falls-Efficacy Scale (FES) was developed to evaluate fear of falling (78). The aim of the questionnaire is to determine how confident a person feels about undertaking thirteen different activities. The responses are recorded on a scale from 0 (not confident at all) to 10 (completely confident). The maximal score 130, indicates no fear of falling. Fall-related self-efficacy was evaluated by means of the Falls Efficacy Scale (FES-S) (78, 137) and an Iranian version (138).

Single questions

“Do you generally feel healthy?” (yes/no), “Do you feel generally tired?” (yes/no). Self-rated fitness was assessed by “How would you judge your current physical fitness?”. Response alternatives ranged from very poor to very good on a 5-point Likert scale (124).

Prevalence of falls was assessed with the following questions: “Have you fallen during the last year?” (yes/no), “How many times have you fallen?” and “Did your fall lead to a fracture” (yes/no).

Background variables used in this thesis were living alone (yes/no), education level (basic/higher), body mass index (BMI), self-reported medical condition: ischemic heart disease, diabetes mellitus, cerebrovascular disease, bronchitis, osteoarthritis and diagnosed dementia, and major depression according to DSM III criteria, and number of medications. Data on mortality were obtained from the Swedish Population Register. Seven-year mortality was defined as not being alive 7 years after the date of examination.

3.1.3 Statistical analyses

Statistical tests used in this thesis are summarized in Table 5. All data in papers with a quantitative approach (papers I, II and IV) were analysed using the SPSS (Statistical Package for the Social Sciences, Chicago IL) version 16.0. For mediation analysis, SAS procedure LOGISTIC (version 9.2 for Windows) was used. As SAS is relatively inefficient for drawing a large number of repeated bootstrap samples, an external program was written for fast generation of a large number of randomly drawn samples with replacement. Two-tailed p-values ≥ 0.05 were considered statistically significant.

Table 5. Overview of statistical tests used in this thesis

	Paper I	Paper II	Paper IV
Chi 2 (Fisher exact test)	x	x	x
Mann Whitney U	x	x	
Logistic regression	x	x	x
Cochrane Armitage: trend ordinal data	x		
Spearman rank correlation		x	
Kruskal Wallis test		x	
Students t-test	x	x	
One-way ANOVA with Tukeys post-hoc adjustment for multiple comparisons		x	
Tests of interaction	x		x
Sobels test of mediation		x	
Effect size		x	

3.2 Paper III

In order to “go to the things themselves”, a qualitative approach was adopted to explore what successful ageing means to older persons.

3.2.1 Participants

Participants invited to qualitative interviews comprised 24 community-living persons in a smaller community/rural area in western Sweden, who were recruited from a health promotion intervention based on the concept of physical activity, which took place during 2009-10. Inclusion criteria were >75 years and low physical activity level (1-2 on a 6-level scale (139)). Exclusion criteria were living in institutions, severe health problems, homecare with the exception of a safety alarm and help with food purchase. A total of 60 persons were included in the original intervention study and they were randomised into one control group and one intervention group. After the three-month intervention was completed, a strategic sample, with regard to gender, civil status, living in the community or in the countryside, respectively, were invited to participate in interviews by a letter and a follow-up phone call from the first author. Most interviewees were participants from the intervention group (n=18). The reason for this was a second aim to also capture experiences from the intervention, which is not a part of this thesis. During the study we decided to include a strategic sample from the control group (n=6) as well, to handle potential bias from participation in a health-promoting intervention. The mean age was 81 with a range of 77-90.

3.2.2 Qualitative content analysis

Qualitative content analysis was used to analyse the data in paper III. It is a method with the purpose of providing knowledge, new insights and a practical guide to action (140). It was chosen as it is a method well-suited to analysing data on multifaceted phenomena and to producing conceptual models to increase understanding (141). The approach as described by Graneheim and Lundman (142) was used. The unit of analysis was the transcribed individual interviews. The computer program NVivo 9 (QSR international Pty Ltd) was used to help organise the lists of codes developed by generating a structure of individual categories (“nodes”) and connecting codes and meaning units to these category groups. It was also a help in communication between authors.

4 ETHICAL CONSIDERATIONS

Studies I, II and IV were approved by the Regional Ethical Review Board (diary number T453-04). The study in Iran was also approved by the Ethics Committees of the Ministry of Health, Treatment and Medical Education and University of Social Welfare and Rehabilitation Sciences, Teheran, Iran. The IVEG study in 1987 was approved by the Ethical Committee of the Faculty of Medicine at Gothenburg University. For paper III, approval was granted following a supplementary application to an ongoing research project (diary number 761-08).

All staff working with H 70-studies and database followed the ethical principles of the World Medical Association's Declaration of Helsinki, for medical research involving human subjects established in 1964 and last updated in 2008 (143) and the ethical guidelines of the Swedish Council for Research in the Humanities and Social Sciences: the principles of autonomy and integrity, the rules of consent and the demand for research.

Participants were contacted by a letter explaining the nature of the study, which was followed by a telephone call. The Iranian sample was contacted exclusively by telephone. Before examinations and interviews, all participants were given the opportunity to ask further questions and they gave their written informed consent to participate. If the participant had indications for cognitive impairment, consent was (also) given by a proxy. Everyone interested in participating was orally informed of the procedure, that they could withdraw from the study at any time, and that all data would be treated with confidentiality.

5 RESULTS

5.1 Missing data

External missing data

In Gothenburg, a somewhat lower proportion of the population is aged ≥ 65 years, and the level of education is higher compared to the total Swedish population (Table 6).

Table 6. Overview of demographics in Sweden and in the city of Gothenburg

	Sweden	Gothenburg
Persons aged ≥ 65 , % ¹	19.1	14.9
Tertiary school, % ²	40	50
Yearly income, ssk (mean) ³	262 479	261 381

¹Statistics Sweden 2012, ²University or college, persons aged 25-64 years, Statistics Sweden 2012,

³Persons aged ≥ 20 years, Statistics Sweden 2011

The response rate was 63 % for the Swedish 1930 cohort, 77 % for the 1911-12 cohort and 80 % for the Iranian cohort.

In the 1930 cohort in 2005, responders and non-responders did not differ significantly regarding gender, civil status in women, in-patient hospitalisation during a four-year-period preceding the examinations, or prevalence of depression and dementia according to the Swedish Hospital Discharge Register. However, among non-responders, the seven-year mortality was higher, and among men fewer of the non-responders were married (Table 7).

In the Swedish 1911-12 cohort in 1987, responders and non-responders followed a similar pattern to that of the 1930 cohort. They did not differ regarding gender and number of hospitalisations during a four-year-period preceding the examinations, non-responders had a higher seven-year mortality, and among men, fewer of the non-responders were married (Table 7). In the 1911-12 cohort, responders and non-responders have also been compared at age 70 years. This showed a lower annual income among non-responders (144). Further, responders at age 75 had better fitness, were more physically active and were less often dependent in ADL at the age of 70, compared to non-responders.

No data on non-responders are available for the Iranian cohort.

Table 7. Data on responders and non-responders in the 1930 and 1911-12 cohorts

	1930 cohort			1911-12 cohort		
	Re- sponders	Non- responders	p-value	Re- sponders	Non- responders	p-value
Women, %	57	57	0.99	55	53	0.73
Married, %						
-women	42	43	0.72	41	45	0.44
-men	72	55	<0.001	72	61	0.05
7-year-mortality, %						
-women	17	27	0.001	24	42	<0.001
-men	29	44	<0.001	42	61	<0.001
In-patient hospitalisation, % ¹						
-women	42	42	0.97	41	38	0.82
-men	49	48	0.89	45	50	0.47
Dementia, %	2.7	4.1	0.17	-	-	-
Major depression, %	2.0	3.2	0.24	-	-	-

¹ ≥1 in-patient hospitalisation during the four years before year of examination

Internal missing data

Among responders in the 1930 cohort, missing data in tests of fitness ranged from 9.7 % (n=61) for grip strength to 12.2 % (n=85) for the one-leg stance. For walking habits, missing data comprised 2.1% (n=15). In SF-36, missing data ranged from 6.6 % (n=47) in Physical Functioning to 9.7 % (n=69) in Role Emotional.

The higher number of missing values for fitness in comparison with other measures is due to the fact that persons with a home-visit only were not asked to participate in these tests. Only individuals investigated at the out-patient clinic (637 out of 698) were asked to perform the tests of fitness. Among these, missing data ranged from 0.6 % (n=4) for grip strength to 4.7 % (n=30) for stairclimbing capacity.

When those who were examined at a home-visit were compared to those who were examined at the research clinic, it was found that the group with a home-visit had worse results in almost all subscales of SF-36.

If a person's data were missing for any variable, the individual concerned was excluded from analyses dealing with that specific variable, except for SF-36, where missing data in single questions were computed according to the manual (134).

5.2 Physical functioning

Among 75-year-olds examined in 2005, men had better results than women in all tests of fitness, particularly with regard to stair-climbing and grip strength (Table 8 and Figure 10).

Table 8. Results in tests of fitness in 75-year-olds born 1930 and examined in 2005 (n=637)

	Women		Men	
	n		n	
Self-selected gait speed; m/s, mean (sd)	369	1.16 (0.2)	240	1.21 (0.2)***
Maximal gait speed; m/s, mean (sd)	368	1.56 (0.30)	240	1.78 (0.32)***
Timed chair-stand; sec, mean (sd)	367	13.6 (5.2)	244	12.5 (3.7)
Stair climbing; 50 cm, %	373	25	246	72***
One-leg stance; sec, median (iq range)	373	20 (22)	246	30 (18)
Grip strength; kg, mean (sd)	372	22.9 (5.1)	245	38.6 (7.1)***

*p<0.05, **p<0.01, *** p<0.001 for gender difference

Seventy-five year-olds in Sweden had better results in all tests of fitness compared to those in Iran, with the exception of grip strength, for which the Iranian cohort had better results. Further, Swedes were less often dependent in ADL (9 % versus 55 %). Swedes had a higher fall-related self-efficacy, and the FES had ceiling effects in Sweden, where 85 % had 130 (maximal score=completely safe). However, no difference was found regarding falls. In both countries, men had better results than women both in tests of fitness and in self-rated physical functioning.

In Sweden, 75- year-olds examined in 2005 performed better in the maximal gait speed test than 75-year-olds examined in 1987, and among women also in self-selected gait speed, stair-climbing and one-leg stance. The proportion of persons who had fallen the in last year was higher in those examined in 2005 compared to those examined in 1987, but no difference was found in fall-related fractures (3.6 % versus 4.7 %). In both cohorts, men had better results than women. Among women in 2005 and men in 1987, those with only basic education had worse results in tests of fitness than those with a higher education. Thus, the gap between educational levels increased among women, while there was a trend towards a decreased gap among men between cohorts.

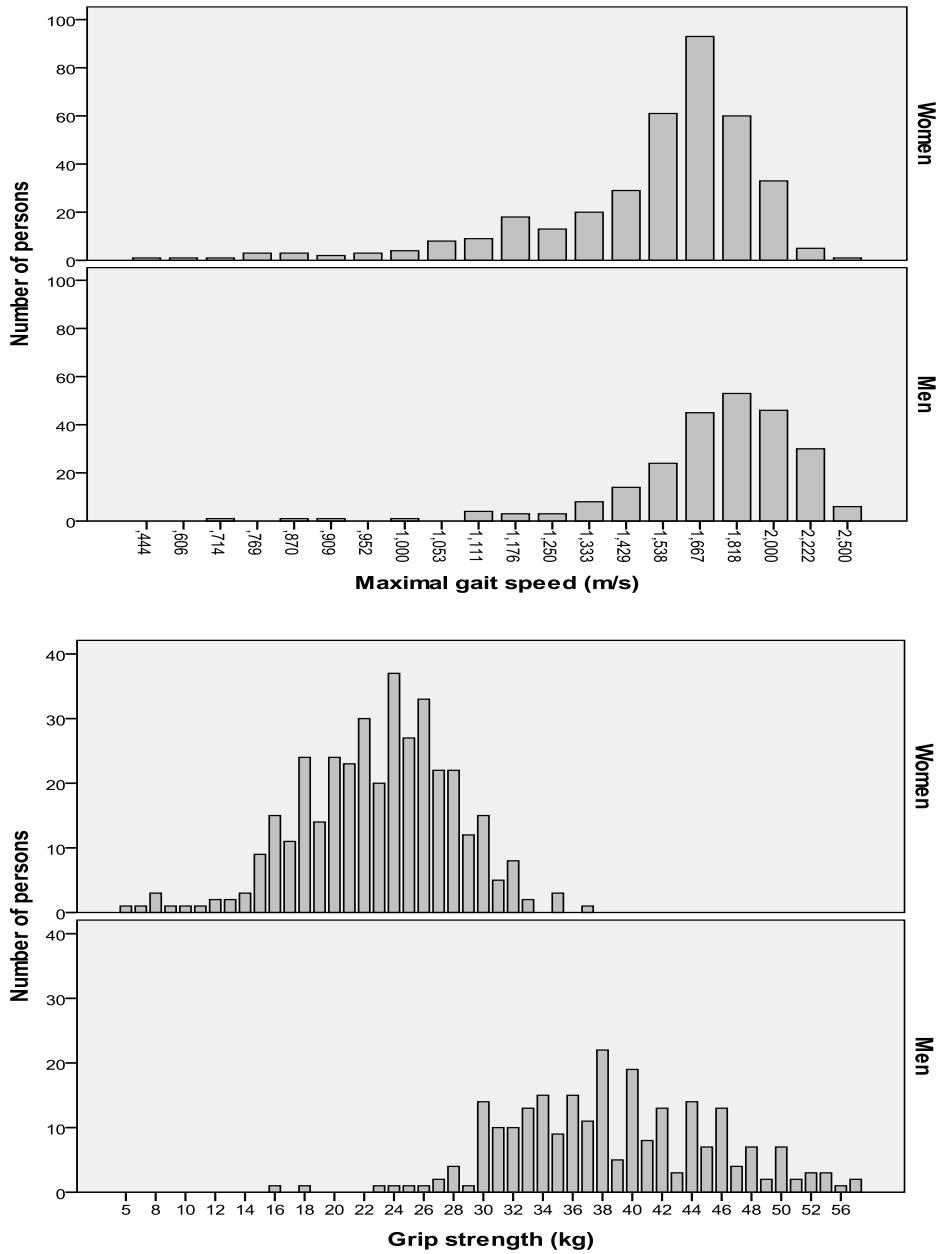


Figure 10. Distribution of results in maximal gait speed and grip strength in the 1930 cohort in Sweden

5.3 Physical activity

Among 75-year-olds examined in 2005, there were gender differences regarding moderate/hard exercise several times a week (level 5-6) according to the activity scale and the number of physical activities. No difference was found for walking habits, about 60 % of both genders reported regular walking (≥ 150 min/week) (Table 9).

Table 9. Physical activity habits in 75-year-olds born in 1930 and examined in 2005

	Women	Men
Physical activity scale, % (women: n=373; men: n=246)		
• Levels 1-2	2	2
• Level 3	27	19
• Level 4	70	72
• Levels 5-6	3	7**
Number of physical activities, % (women: n=373; men: n=246)		
• 0	22	9***
• ≥ 3	45	65***
Regular walker (≥ 150 min/week), % (women: n=427; men: n=271)	59.5	59.1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ for significant gender difference

Those in Sweden had a higher level of physical activity compared to those in Iran: 2 % versus 32 % mostly inactive according to activity scale (level 1-2), 85 % versus 7 % participating in ≥ 1 physical activity or sport (walking not included), and they were more often regular walkers (about 60 % versus 32 %). Gender differences to the disadvantage of women were generally about the same in both countries.

In Sweden, 75-year-olds examined in 2005 had a higher frequency of physical activities compared to 75-year-olds examined in 1987. In both cohorts, men had a higher frequency of physical activities than woman, but the relative gender gap was smaller at examinations in 2005 compared to in 1987. Among women in both 2005 and 1987 and men in 1987, those with only basic education reported fewer physical activities than those with higher education. Thus, the gap between educational levels decreased among men between cohorts.

5.4 Health-related quality of life

Among 75-year-olds examined in 2005, men had higher scores on all subscales of SF-36 compared to women. The variability in all subscales of SF-36 was high, both among women and men. The highest variability was seen in Role Physical and Role Emotional (Table 10).

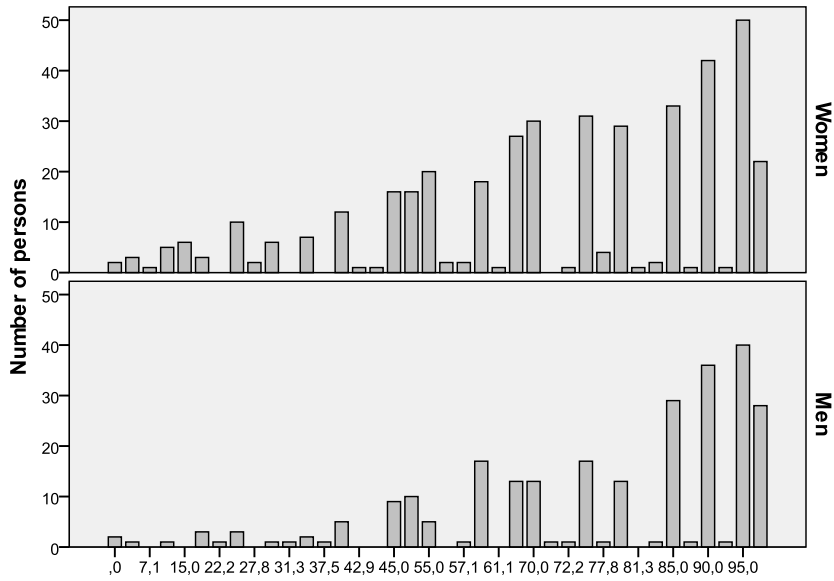
Table 10. Results in SF-36 in 75-year-olds born in 1930 and examined in 2005 (n=698)

SF-36 subscales ¹	Women (n=427)		Men (n=271)	
	n	Mean (sd)	n	Mean (sd)
Physical Functioning	408	69 (24)	258	76 (22)***
Role Physical	401	66 (40)	253	73 (38)*
Body Pain	406	64 (26)	259	76 (24)***
General Health	397	64 (20)	252	70 (19)***
Vitality	397	65 (22)	252	70 (20)***
Social Functioning	407	84 (22)	257	91 (18)***
Role Emotional	396	77 (36)	248	84 (32)*
Mental Health	401	78 (19)	254	83 (18)**

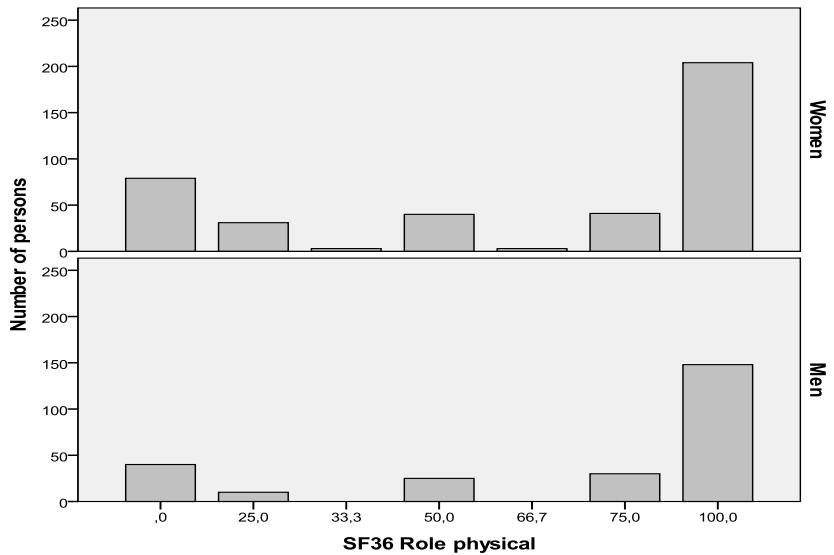
*p<0.05, **p<0.01, *** p<0.001 for significant gender difference

¹ SF-36 = Short Form-36: scale score 0 (worst possible) to 100 (no limitations)

There were ceiling effects in Role Physical, Social Functioning and Role Emotional, where the median was 100 (maximal score=no limitations). The distribution of scores in SF-36 subscales of Physical Functioning and Role Physical is shown in Figure 11.



SF36 Physical functioning



SF36 Role physical

Figure 11. Distribution of scores in SF-36 subscales Physical Functioning and Role Physical

5.5 Associations between variables

Those who attained recommended levels of walking had better results in all tests of lower extremity fitness, but not in grip strength. Walking habits were related to HRQL in a dose-response manner. Compared to those who walked <75 min/week, no differences could be confirmed for those who walked 75-<150 min/week, but those who reported ≥ 150 min/week of walking had better results in all dimensions of SF-36, except Role Emotional in men. Even better results were seen in some physical subscales of SF-36 in women who walked ≥ 300 min/week. In adjusted analyses, associations remained between walking habits and SF-36 subscales of Role Physical, General Health and Role Emotional in women only.

Maximal gait speed was the test of fitness with the highest correlation to SF-36 subscales, while grip strength was the test with lowest correlation. Fitness, assessed as maximal gait speed was related to all eight subscales of SF-36 among women, and to Physical Functioning, Role Physical, Vitality and Social Functioning among men. Fitness was confirmed as a total mediator in the relation between walking habits and SF-36 subscale Social Functioning and as a partial mediator in most other SF-36 subscales in women (effect change in OR -0.2- -0.6). Among men, fitness was identified as a partial mediator between walking habits and SF-36 subscales of Role Emotional and Role Physical (effect change in OR -0.1- -0.3). For both walking habits and fitness, there appeared to be more and stronger associations with SF-36 subscales among women than in men.

5.6 Older persons' views of successful ageing

An inductive approach was adopted concerning what constitutes successful ageing from the perspective of older people. An overarching theme was formulated as “self-respect through ability to keep fear of frailty at a distance”. This embraced the content of four categories: “having sufficient bodily resources for security and opportunities”, “structures that promote security and opportunities”, “feeling valuable in relation to the outside world”, and “choosing gratitude instead of worries” (Figure 12). Ageing seems to be a dynamic process rather than a static structure and might therefore be susceptible to actions. Paying attention to attitudes and treating the older person with respect, particularly with regard to worries about increasing vulnerability, can lead to better ways of promoting successful ageing. Quotations are presented in Table 11.



Figure 12. A model of successful ageing from the perspective of community-dwelling older persons

Table 11. Categories, subcategories and example of quotations in theme: self-respect through ability to keep fear of frailty at a distance

Category	Subcategory	Example of quotation
Having sufficient bodily resources for security and opportunities		<i>"I look after myself quite well, avoid being a hanger-on to the children, hi, hi, hi. I'm helping them in fact. I don't think it would be fun to be like an extra to them, they have quite a lot to cope with themselves you see".</i>
Structures that promote security and opportunities	Satisfaction with one's financial situation	<i>"Yes, it means there are no worries, no worry about money or anything".</i>
	Security and opportunities in the closest context	<i>"As long as you drive a car you're not so isolated either...".</i>
	The health and well-being of close relatives and friends	<i>"I wish, of course that both of us will be allowed to remain healthy. It's the be-all and end-all".</i>
Feeling valuable in relation to the outside world	Feeling noticed and appreciated in social relations	<i>"Then I've been pleased to give to others when I was a leader on the painting course – I keep an eye on everybody and show interest. Then.. they think I'm good and then I'm pleased".</i>
	Engagement in activities that provide pleasure or benefit	<i>"Then I get going and work, you know, then I don't think about that thing, then I don't feel it in the feet, but if I were to lie down and only stay at home with the wife, then I would be sick, I believe that. Yes, then you feel this thing, you know, oy, today I can't walk . . . and then you just sit there".</i>
Choosing gratitude instead of worries	Choosing gratitude for not being as bad as others who are in a worse situation	<i>"Being sufficiently in order every morning you have to get up that you can get up out of bed. You see an awful lot of people who come in their wheel-chairs and with assistive devices".</i>
	Denying difficulties	<i>"Yes, but then it's a question of shutting out those thoughts, quick as hell. You must do that, because you can't go around fretting all the time that you can't and can't do that. That would be awful (laughs). Think of something else. It works well. And then, make a fresh start and try, and do what you can".</i>
	Accepting things you cannot change	<i>"What you cannot do anything about you have to go through. One should keep spirits up yet somehow...but if you can argue that it is what belongs to life so it may take its course".</i>

6 DISCUSSION

6.1 Methodological considerations

The main strengths of this thesis are the population-based design, that tests and interviews were conducted by trained physiotherapists and research nurses, and that similar methods were used in examinations performed 18 years apart and also in two different countries, and that both objective and self-assessed health indicators were included. Compared with RCTs, observational studies, such as the Gerontological and Geriatric Population Studies in Gothenburg, have an opportunity to achieve higher external validity (studying “real life”), are cheaper and provide openings for discovering new issues and testing mediating and interaction effects. Several limitations and challenges are discussed below.

6.1.1 Reliability

Critical aspects in repeated cross-sectional and longitudinal studies are the reliability and validity of the outcome measures when tests and interviews are performed with many years in between. Strategies for high reliability should have a careful explanation of the test, which should preferably have been already tested for reliability, and a detailed description of procedures. It is also essential that the person who carries out the measures on one occasion trains the next generation of examiners. Repeated check-ups during the study and careful education of new research staff need to be considered. In paper II, with only one research centre included, it was probably easier to maintain high reliability than in paper I with research centres in two different countries, and in paper IV with a gap of almost 20 years between examinations. However, a strength of these studies is that the one who did the examinations in 1987 trained the one who did the examinations in 2005.

Cross-national comparisons are associated with even more difficulty keeping the reliability at an acceptable level, due to distances between research centres and the high cost of arranging meetings between investigators. In this thesis, the physiotherapist who examined the Iranian cohort visited Sweden and was trained by the physiotherapist responsible for examinations of the Swedish cohorts in 1987 and 2005. Pictures and notes of procedures were taken. The intention was also for the researcher in Sweden to visit Iran during the study period, but this could not be arranged. Procedures for achieving high reliability will be a challenge in future epidemiological research with increasing focus on longitudinal follow-ups.

6.1.2 External validity - generalisability

It is important to consider the underlying population (who's the reference) when estimating risk and preventive factors. A demographic report from Gothenburg in 1981 suggested that the results from H70 could be generalised mainly to other urban areas as the demographic, economic and social environment of older people in larger cities differs from that experienced by older people in other parts of the country (145). Further, persons who were institutionalised and persons with dementia were not included in this thesis, implying that the results could not be generalised to these populations.

One major issue for population-based studies concerns sample bias, i.e. the representativeness of the responders in the sample. The response rate declined in the Gerontological and Geriatric Population Studies during the study period. The 1930 cohort (currently the latest cohort examined) had a response rate of 63 % at the age of 75. The initial cohort in the H70-studies was examined in 1971 at the age of 70. At that time the response rate was 85 % (121). This decline in response rates could lead to a healthy population bias, and an overestimate of improvements in health over time in repeated cross-sectional analysis. The decline in response rates is not unique to this study, and it is continuing according to some views (146). In our studies, participants not able to visit the research centre had a home-visit instead. In such cases, assessment of fitness was limited or not carried out at all, and these persons were not included in analyses dealing with fitness. We found that those with a home-visit had lower scores in SF-36 than those examined at the research clinic. Further, those with a home-visit had worse results for physiological measures than those who were examined at the research clinic, and they seemed more similar to non-responders than to responders, according to a report on population bias in the population study of women in Gothenburg (147). This implies an even larger healthy population bias in tests of fitness. Also, when older persons are studied, there is always a healthy survival bias, as the most seriously ill persons have died or dropped out or are incapable of performing certain tests or of visiting the research centre.

In the case of the 75-year-olds examined in 1987, it has to be borne in mind that 30 % of the sample participated in an intervention at ages 70-73. This could mean better results in fitness and a higher level of physical activity for the intervention group. On the other hand, the mean age for "75-year-olds" at examination in 2005 was 75.7 (range 75.0-76.9) years compared to 76.1 (range 75.2-77.9) years in 1987, making the 1911-12 cohort chronologically slightly older and at a higher risk of functional decline.

The cross-national comparison presented in this thesis is unique in that similar tests and interviews were performed in two different countries. This is a strength when wanting comparable data, but one could also ask if a certain measure used in one (developed) country has the same relevance in another (developing) country. Also, in the Iranian cohort, compared to the Swedish, persons with impaired cognitive and physical functioning could have been included to a higher degree. The contact procedure (exclusively telephone in Iran versus letter and telephone in Sweden) and availability might have influenced sample bias between countries. The Iranian cohort

also had a higher response rate than the Swedish cohort (80 % versus 63 %) leading to the risk that the results for the Swedish cohort could be confounded by a healthy-population bias.

Regarding qualitative studies, the external validity is up to the reader, but it is based on the author's information on the participants. The participants in the qualitative interviews were limited as regards strategic sampling as they were recruited from an RCT with specified inclusion and exclusion criteria. This could have resulted in a more homogeneous group than desirable. Furthermore, all participants in paper III lived in a rural area as opposed to the urban population in papers I, II, and IV.

6.1.3 Internal validity - measures

One of the main purposes of repeated cross-sectional and longitudinal studies is to allow comparisons over time. This inevitably leads to problems with adding new gold standards for measurements. This is the reason why e.g. physical activity was not assessed with more recently established tests. On the other hand, fitness and HRQL were assessed with measures tested for validity and reliability. As SF-36 was not established at the time of examinations in 1987, HRQL could not be compared for secular trends.

The internal validity is probably higher in cross-sectional analysis, but analysis of change over time could give a deeper understanding. The possibility of different procedures and wordings over time could jeopardise the validity. Therefore changes in definitions of concepts, diagnostic criteria and the meaning of wordings have to be considered. Regarding self-assessed measures, a longitudinal response shift and social desirability have to be taken into account. Response shift is a change in the meaning of a respondent's self-evaluation as a result of changes in the internal standards, valuation, and conceptualisation of the construct. Here, coping strategies such as social comparison play a role (148). Social comparison was also a common strategy for successful ageing in the study described in paper III. This could make it hard to draw conclusions from differences in e.g. self-rated health in repeated cross-sectional or longitudinal studies. For example the concepts of health and QoL, and the comparison object, probably change in a society over time, e.g. from 1987 to 2005 for paper IV. Of special relevance in birth cohort comparisons, response shift may also occur at the population-level, when a large proportion of the population experiences the shift simultaneously, as a unit, and when the cause of the response shift is a socially significant event or trend (149). This might be of even more relevance in comparisons between countries.

The level of physical activity was measured with a global self-report questionnaire, which provides a general impression of behaviour and does not provide detailed information about the type and patterns of physical activity (150). The assessment of walking habits used in this study has not been tested for reliability or validity, which is a weakness. However, walking habits have been compared with an activity diary in an H-70 subsample (n=43). This showed that the walking time declared in the interviews

did not seem to have been overestimated. Further, the walking question includes information about walking frequency and duration but not about intensity, which is a third critical aspect of physical activity. Comparison with heart-rate recordings showed that the average heart-rate during walking was below 100 beats/min (151). This represents a “light” intensity (152), which is a lower intensity than the recommended moderate intensity for health promotion. However, older persons differ widely in this respect. For some a moderate-intensity walk is a slow walk, while for others it is a brisk walk.

Finally, education was used as a proxy for socioeconomic status in paper IV. Income or manual/non-manual worker might also have been preferable. However, education has been reported to be the most important indicator of socioeconomic status in relation to trends in physical functioning among older persons (153).

6.1.4 Multivariate analyses – confounding, mediation and interaction

In cross-sectional analysis of associations, the question of causality always occurs. One major problem is to interpret whether an independent variable is truly associated with the dependent outcome, or if it is just associated with another variable, which is the true cause. This is especially true in elderly populations, where multiple conditions and risk factors frequently co-exist and there is potential circularity in the relationships (154). When interpreting the direction of cause and effect, there could also be several confounding and mediating factors. In observational (non-RCT) studies, confounding could bias the estimate of effects and widen the confidence intervals (CI). Hypothesised confounding variables have to be included in analyses based on philosophical and theoretical knowledge. A more detailed method is to present actual results stratified by the potential confounder. For example, in paper II it is not possible to ascertain if a high physical activity level and fitness cause the higher HRQL, or if the high HRQL leads to improved physical activity and fitness or, more likely, both.

Mechanisms in a relation between physical activity and HRQL are probably a combination of many psychosocial and biological factors. Another variable that could have been examined as a potential mediator is falls-related self-efficacy, which has been identified by others as one mediator in this relation. Most of these studies are based on women (51). However, in the 75-year-old H70 population, there were ceiling effects in the falls-efficacy scale. Falls-related self-efficacy could be a mediator in even older populations and in populations with worse functioning and larger variability in self-efficacy. Mediators could also differ by gender, as in our findings where fitness was more frequently a partial mediator among women than among men. However, one has to consider that the power to detect differences in analyses among men was lower. Further, some variables included as confounders could be mediators. In a life-course perspective some chronic conditions and also BMI could be influenced by physical activity, and in turn influence HRQL. More sophisticated analyses of mediation effects, such as factor analysis or structural equation modelling, are possible with a longitudinal design, which would have been preferable. Another way to

examine mediators and moderators could be to perform qualitative interviews with two subgroups from a physical activity intervention, i.e. those who improved their QoL and those who did not. Both multilevel modelling and qualitative analysis aim to achieve a deeper understanding of mechanisms underlying associations.

The statistical power to test significant interactions is 5 times lower than when testing the main effect. So the level chosen in paper IV ($p \leq 0.10$) could be considered significant if we do not want to miss any important interaction (155). It is recommended that stratified estimates should be reported if interactions are found to be significant, but limitations in the length of papers when presenting results often prevent this from happening.

Another issue is whether adjustment is needed for multiple comparisons in explorative observational studies with large bodies of data. This could have been relevant in some of the papers in this thesis. The argument is to reduce type I error and not reject the null hypothesis too easily. It has been argued, however, that it is better not to adjust for multiple comparison, in order not to miss any important findings by increasing type II errors (156). In our cross-national comparison by gender and also in paper II with descriptive data on fitness and the eight subscales of SF-36, adjustments could have been made, but we found that the clinical relevance of the absolute differences was of more importance than a significant p-value.

6.1.5 Trustworthiness in qualitative methods

Qualitative content analysis, the method chosen in paper III, aims to provide knowledge, new insights, and a practical guide to action (140). It is well suited to analysing data on multi-faceted phenomena and to producing conceptual models to increase understanding (141). The fact that the constituents of successful ageing probably vary from person to person, but also might be ones that are held in common or are comprehensive, made qualitative content analysis a suitable method for this study. It is a method without any specific philosophical background. Advantages of adopting a phenomenological or hermeneutic approach would have been clearer methods for handling pre-understanding.

To validate the study findings for trustworthiness, attention has to be paid to credibility, transferability, dependability, and confirmability (140, 142, 157) (Table 12). Credibility, (157) that is, the confidence in the “truth” of the findings, was addressed by including a strategic sample according to gender and living conditions, and including persons from both the intervention and the control group from the original RCT, and choosing a number of interviewees to ensure variation. Further, the first and the last authors compared codes, sub-categories, and categories throughout the analysis. With reference to professional experience, all authors were physiotherapists. The first author had previously worked for ten years in hospital care, the second author for 20 years in hospital care, and the third author for ten years in primary care. However, the interviewees were only informed about the occupation of the interviewer when they asked for it. Peer debriefing by persons with different backgrounds and experience was used as a way to explore new aspects of the

phenomenon of successful ageing. Furthermore, links between the data and results are illustrated in quotes.

Table 12. Criteria for trustworthiness in quantitative and qualitative research

Traditional criteria for judging quantitative research	Alternative criteria for judging qualitative research
Internal validity (face validity)	Credibility
External validity	Transferability
Reliability	Dependability
Objectivity	Confirmability

Source: Lincoln YS, Guba Naturalistic Inquiry Newbury Park, CA: Sage Publications 1985

For evaluation of transferability, that is, the possibility of transferring the results to other contexts, a clear description of the interviewees and their contexts, data collection, and process of analysis has been given. Dependability and confirmability, that is, the extent to which the same findings will appear under similar circumstances and how well the results can be confirmed by others, were addressed by following the same procedure in every interview and by including dialogue among co-researchers with different professional backgrounds.

A reflexive attitude, i.e. attending systematically to the effect of the researcher, at every step of the research process, was adopted and the first author's pre-understanding was recorded before starting the interviews and was continuously reflected upon (158).

Main limitations in paper III were the reduced possibility for strategic sampling as the persons were recruited from an RCT, and that the researchers who analysed the transcribed text all had the same profession, namely physiotherapists, which limited the perspective from e.g. psychological and social science.

6.2 General discussion of results

Regarding fitness, the results in this thesis could be compared to results from the Nordic Research on Ageing (NORA) where 75-year-olds in Finland and Denmark were examined in 1989-90. Residents in Finland had a maximal gait speed of 1.54 m/s among women and 1.84 m/s among men (159), and residents in Denmark had a maximal gait speed of 1.49 m/s among women and 1.69 m/s among men (160). This is similar to results for the Swedish 1930 cohort (women: 1.56 m/s; men: 1.78 m/s) and higher than for the 1911-12 cohort (women: 1.43 m/s; men 1.66 m/s). For stair climbing, 26 % of the women in the same Finnish cohort managed 40 cm (159). This is a worse result than for all cohorts in this thesis (1930 cohort: 55 %; 1911-12 cohort: 47 %; and Iranian cohort: 45 %). Further, in a population-based sample of 75-year old men in Sweden reported in 1999, the results of the chair stand test was 14.7 sec and grip strength 41 kg (161). This is a somewhat worse result for chair stand and a similar but somewhat better result for grip strength than for men in the Swedish 1930 cohort (12.5 sec and 39 kg, respectively). A non gender-specific population in the US with a mean age of 73.6 years had a chair stand time of 14.3 sec, which is somewhat worse than for both women and men in the Swedish 1930 cohort. The same US population had a self-selected gait speed of 1.18 m/sec (162), which is similar to the self-selected gait speed of 1.16 m/s for women and 1.21 m/s for men in the Swedish 1930 cohort.

Regarding physical activity, we found that approximately 60 % of 75-year-olds in Sweden attained the recommended levels of walking (150 min/week). This is in line with reports from Sweden in 2010 where 57 % of the women and 63 % of the men aged 65-84 years attained the recommended levels of physical activity >30 minutes/day (163). In the US, 34 % of older persons reported regular walking (164), which is a lower prevalence than among Swedish 75-year-olds but comparable to the one in Iran. The Swedish cohort had better results regarding physical activity levels than 75-year-olds in Finland in 1989-90, where 25 % of the women and 29 % of the men reported being mostly inactive (levels 1-2 according to the activity scale) (165), compared to 2 % among both genders in Sweden. Physical inactivity levels for the Finnish cohort are similar to those in Iran (32 %).

Further, results in SF-36 were similar but somewhat higher on all subscales, except for Body Pain in women, compared to non-gender specific norms for Swedish persons aged >75 established in 1991-92 (84). Compared to residents in Iran with a mean age of 72 years (SD 6.3), the mean scores in all the SF-36 subscales were about 10 points lower than those for Swedes reported in paper II (166). Age-specific data in SF-36 are also published for Wales. Here the scores are about 5-10 points lower in most subscales compared to the results for those in Sweden (167).

The proportion of persons above 65 years who fall each year is about 30 % (75). This is close to the proportion of persons who had fallen during the last year in the 1930 cohort (29 %), while it was somewhat lower in the 1911-12 cohort (23 %).

6.2.1 A cross-national perspective

It is to be expected that the health of the inhabitants in different countries will vary according to the demographic and epidemiological transition taking place there. Large global differences are seen in mortality and morbidity (13, 77, 168). Targeted health promotion interventions and the exchange of best practices have been suggested to overcome health inequalities (169), but this calls for more research into the nature of these inequalities. However, there is a lack of knowledge regarding physical functioning and physical activity due to differences between countries in operationalisation and outcome measures (170). Therefore, we aimed to compare health with focus on physical functioning in two countries at different stages in their demographic transition; Iran with one of the youngest populations in the world with a life expectancy of 73 years, and Sweden with one of the oldest populations in the world and a life expectancy of 82 years (171).

As expected, we found that 75-year-olds in Iran had worse results in most health indicators than their counterparts in Sweden. Surprisingly, they had better results for grip strength, which might be due to this measure being more sensitive to body composition, life style demands (industrialisation, for instance, would lead to more use of technical instruments), nutrition, occupational demands and access to medical care (172, 173). Grip strength is, together with functional tests of lower extremity capacity, a common measure of general health and functioning in older persons. The direction of cultural differences in paper I might indicate that grip strength is not relevant as the only measure when comparing health indicators between countries. This direction of differences has not been found in other studies. Comparison of older persons in America and India showed worse results in grip strength for the Indian population (172). Our results have to be replicated in other cross-national comparisons to be able to draw further conclusions. The fact that we could not find any difference between Sweden and Iran regarding the proportion of fallers might indicate that older persons in developing countries are not particularly exposed to risks due to a more inactive lifestyle. Falls account for a larger cause of disability-adjusted life-years (168) and years lived with disability (77) in Western Europe than in other regions such as Eastern Europe and Asia. Further, hip fractures do not constitute such a large burden of disease in Iran as in Sweden (174). Falls prevention might not be the main issue of priority for improving health among older persons in Iran.

Data on successful ageing for persons aged above 65 years in Europe have shown cross-national variation with a north-south gradient, with Danes and Swedes most often meeting the successful ageing criteria of Rowe and Kahn, and persons in Poland and Spain least often (175). We found a high percentage of ADL-dependence in Iran compared to Sweden (55 % versus 9 %). Dependence in ADL in Europe ranges from 6-35 % (176) with a North-South gradient (9). This highlights the importance of structural factors (175). Some of the differences could probably be explained by cultural and socioeconomic aspects, but also what is meant by dependence and the availability of help within families. I-ADL have been suggested to be sensitive to cultural bias, while P-ADL are more related to socioeconomic circumstances (176). The differences between the Swedish and the Iranian cohorts in fitness suggest that there are also physiological differences.

6.2.2 A gender perspective

Within every country, differences in health are observed in relation to gender and socioeconomic status (177). In a WHO (178) report on policy actions for social equalities in health, it is suggested that women and men should always be analysed separately.

As expected, we found that women had worse results than men in tests of fitness, ADL, HRQL and most other health indicators. This is in line with the paradox of women having a higher life expectancy but more diseases and disabilities (179). In Sweden, women have more chronic diseases, medications, fractures, diagnosed depression and dementia and are more dependent in ADL than men, while men more often exercise (180). We could not find any difference between genders in walking habits, but men more often participated in vigorous physical activity and reported a higher number of physical activities (≥ 3 activities: women 45 %; men 65 %, $p < 0.001$). The relative gender difference was of about the same magnitude in Sweden and Iran. It was however larger in Iran with regard to the lower extremity function, indicating that the gender differences might be larger in countries at an earlier stage in their epidemiological transition. Further, our studies suggest that the gap in relation to educational level increased among women but decreased among men from 1987 to 2005, indicating that health inequalities in relation to socioeconomic status might follow different trends among women and men.

The higher life expectancy in women with the subsequent “feminization of the world” (181) and the higher proportion of morbidity and disabilities in women (gender paradox) highlight that it is important to consider older women when targeting physical functioning. As a consequence of lower fitness in women than in men, women are closer to physiological thresholds for risk of dependence in ADL. We found that women might benefit more from physical activity if its duration is extended, and that fitness might play a larger role in relations between physical activity and HRQL. Policymakers, health care workers, and researchers need to consider the perspective of gender when implementing and evaluating effective interventions (181).

In most, but not all countries, women also have a lower self-rated health (182). It has been suggested that there are gender differences regarding older people’s experience of successful ageing, as men are more likely to remain in a healthy state and these differences are thought to increase at higher ages (183). In view of this, the fact that the qualitative interviews in paper III were not analysed separately for women and men could be seen as a limitation.

6.2.3 A life-course perspective

Besides the longitudinal changes within individuals during ageing, birth cohort differences in health are to be expected due to societal changes over the years. Secular trends are the product of birth cohort effect (i.e. relating to year of birth, irrespective of age and calendar time), period effect (i.e. a factor affecting an entire population at the some point of time, irrespective of age and birth cohort) and age effects (i.e. factors related to age, irrespective of birth cohort and calendar time) (184).

Our results suggest that fitness and the number of physical activities improved among 75-year-olds between 1987 and 2005. This is in line with reports on improvements in self-reported physical functioning among older persons below the age of 85 years in developed countries in recent decades (9), with a yearly improvement of about 1 % in disability rates in the US (185). In Sweden, there are indications that physical functioning improved during the 1970s and 1980s (186, 187), but this improvement might have levelled off in the 1990s (188, 189). There are also indications that persons aged 70 have improved (187), while there has been stagnation or even deterioration in persons above age 77 (188). Studying certain birth cohorts has the advantage and disadvantage of having persons sharing the same life history. Findings for a certain birth cohort might not be of relevance to future generations. For example, the 1911-12 and 1930 cohorts were affected differently by the large decline in fertility rates during the 1930s (190), the Second World War, health campaigns, access to medical interventions such as hip/knee replacement etc. Also, predictors of status and change in fitness might be found during the whole life course: birth weight, growth during childhood, socioeconomic status, chronic conditions, environmental and health behaviours such as physical activity, diet, smoking and stress. Regarding trajectories in HRQL, two recent studies have shown that physical activity is one of the most important lifestyle factors in promoting a slower decline (191, 192). Further, early environmental factors such as birth weight seem to influence grip strength in middle age (193). Here, biological interactions of genes, environment and behaviour are of crucial interest as the effects of life style factors such as physical activity are shown to differ by gene profiles (194). This is of particular relevance to older persons in a life course perspective.

Childhood conditions are associated with odds for successful ageing according to Rowe and Kahn's criteria, and interventions to promote successful ageing should be considered throughout the entire life course (195). In line with longitudinal data, it seems important to target potentially vulnerable groups early on, as variables assessed in middle age could predict outcomes at older ages (196). Similar data also show that adaptation to old age is dependent on social class and stressful events earlier in life (197). The capacity to cope and adapt to age-related change, by keeping fear of frailty at a distance, was identified in paper III as a strategy/personal resource that one had or had not. This might indicate that successful ageing already has its origin during childhood or should be regarded as an early personal characteristic. According to the Erikssons' developmental theory (29), a life course perspective on identity seems necessary to reach an ability to adapt to losses and stressors in old age. If there is a successful development of personality during different stages of life, wisdom rather than predominantly regrets or despair could be the result.

6.2.4 A lay perspective

The perspective of health-care organisations and society might differ from that of the older persons themselves. While economic and effectiveness indicators are of interest to society, there are increasing demands for participation and influence on the part of individual members of society. Here, older persons form a priority group (198). At an individual level, participation in society is strongly related to health (199).

In paper III, an existential perspective including self-respect was identified as important for successful ageing. Self-respect is a concept closely connected to dignity (200). Another concept related to these two is identity. A maintained identity despite changes that come with ageing has been found to be an important aspect of growing old by people aged 85 years in Sweden (201). Attitudes, communication and social inclusion are important for dignity (202). It is in everyday conversations and attitudes a person's value and status can be highlighted (203). Attitudes towards older persons in society at large could influence the possibility for successful ageing. In many Western countries such as Sweden and the US, independence, activity and productivity are norms. These norms are also reflected in older person's views of themselves, and restrictions in these aspects could threaten the possibilities for maintained self-respect. Violations of dignity are linked to poor health (204). According to paper III, some persons were worried about being inactive and maybe becoming dependent later on. This might be an expression of the cultural and political climate that influences older persons' views of themselves. Ageing involves a combination of structural, biological, psychological, social and existential aspects which all have to be considered. If a final goal for the person is self-respect, then positive attitudes in others, despite the older person's declining health and QoL, have to be encouraged. It should not be a duty to age well with no disabilities (205). The worries about increased frailty, as identified in paper III, suggest that attention has to be paid to offering respect and dignity despite increasing frailty. This is to avoid isolation and feelings of being a burden to relatives and society.

Both the societal and person-centred perspective need to be acknowledged in goals and outcome measures. For example, fitness and physical activity might have one role from a societal perspective and another role from a person-centered perspective. If there is a focus on the existential perspective of successful ageing, older persons could age with dignity, despite limitations in physiological, psychological or sociological dimensions of health.

6.2.5 Synthesis from a physiotherapy perspective

Within the context of physiotherapy, the human being is considered to be a physiological, psychological, social and existential whole (206). The World Confederation for Physical Therapy (WCPT) describes the nature of physical therapy as providing “services to individuals and populations to develop, maintain and restore maximum movement and functional ability throughout the lifespan. This includes providing services in circumstances where movement and function are threatened by ageing, injury, diseases, disorders, conditions or environmental factors. Functional movement is central to what it means to be healthy” (207).

With population ageing, physiotherapists have an important role in many of the key areas as pointed out in a life-course perspective on successful ageing: e.g. promoting healthy behaviours at all ages, minimising consequences of chronic diseases, creating physical and social environments that foster the health and participation of older people, and reinventing ageing – changing social attitudes to encourage the participation of older people (208).

Regarding physical activity, society and older persons are shown to prioritise different things when motivating people to perform physical activity: i.e. health benefits versus confirmation and social reward (209). Health-care providers and health-promotion specialists might have more success in facilitating a long-term physically active lifestyle and maintaining physical functioning if they emphasise physical activity as a means to enhance their QoL instead of the culturally mandated “exercise as medicine” (210). Further, physiotherapists have been shown to focus on physical function and performance of daily tasks, while patients mainly focused on activities that gave identity and control (211). For older persons, this could include a focus on self-respect by putting emphasis on feelings of value, confirmation of capacities and supporting coping strategies when fitness declines. Physiotherapists have an opportunity for a positive confirmation of the body and its resources. The body could still be a source of pleasure in older persons (212).

Further, there is a need to identify and treat pre-frail persons before frailty sets in and the risk of adverse outcomes such as disabilities and falls is high (213). This also seems to be important to the older people themselves, as a main threat to successful ageing could be described as a fear of frailty. On a population-level, older women with a low level of education seem to be an important group when targeting physical functioning and physical activity. On an individual level, physical activity interventions need to focus on more than a high level of fitness, if successful ageing is the goal. It appears essential to make a multidimensional assessment of both frailty indicators (e.g. according to Fried criteria) *and* successful ageing resources (e.g. bodily resources, societal structures, possibilities for feeling valuable in relation to the outside world and ability to choose gratitude instead of worries). The challenge is to choose the right intervention at the right time for the right person.

7 CONCLUSIONS

Seventy-five years olds in Sweden have better physical functioning and a higher level of physical activity compared to those in Iran. Attaining recommended levels of walking and also fitness are positively associated with HRQL. Among 75-year-olds in Sweden, those examined in 2005 have better fitness and a higher frequency of physical activities compared to those examined in 1987. However, although the physical functioning of older persons seems to have improved, worries about future frailty could threaten the possibility for successful ageing.

Specific conclusions

- Seventy-five-year-olds in Sweden had better physical functioning, with the exception of grip strength, and a higher physical activity level than their counterparts in Iran. No differences could be found in the prevalence of falls. Women generally had worse results than men in both countries, but there was a somewhat larger gender gap in Iran.
- About 60 % of 75-year-olds attained recommended levels of walking. Walking habits as well as fitness were positively associated with several aspects of HRQL. Fitness, described with maximal gait speed, seems to play a partial role in the relation between walking habits and HRQL, mainly among women. This suggests that other mechanisms are also involved in this relation.
- Successful ageing, from the perspective of older persons, may be seen as “self-respect through ability to keep fear of frailty at a distance”. Paying attention to attitudes and treating the older person with respect, particularly with regard to worries about increasing frailty, can lead to better ways of promoting successful ageing.
- From 1987 to 2005, there has been a trend towards better fitness and higher physical activity levels among 75-year-olds. However, the same positive trend has not been recorded in women with a low level of education

8 FUTURE DIRECTIONS

8.1 Clinical implications

- There are large cross-national differences in physical functioning and physical activity among older persons. Particular attention should be paid to improving physical functioning and physical activity among older persons in developing countries.
- In addition to their known association with morbidity and mortality, both self-selected and maximal gait speed seem to be tests of relevance to self-rated outcomes such as HRQL and could be included in geriatric assessments of older person.
- In societal attitudes and everyday meetings with older persons, it seems important to focus on making the older person feel valuable and needed. A preserved dignity, despite increasing frailty, could prevent worries about future frailty and thereby promote successful ageing.
- An existential perspective, focusing on self-respect and dignity should be considered in interventions that aim to promote a good old age
- To decrease health inequalities, it seems necessary to target older women with a low level of education to improve their fitness and increase their physical activity level.

8.2 Research implications

- Further cross-cultural comparisons of frailty and successful ageing indicators need to be made. In cross-national comparisons of fitness, both lower (e.g. gait speed) and upper extremity capacity (grip strength) need to be assessed.
- Longitudinal trajectories and their secular trends in both frailty indicators (e.g. according to Fried's criteria) and successful ageing resources need to be explored. Special attention should be paid to persons above age 85.
- There is a need to further explore mediators in the relation between different types of physical activity and QoL, with a longitudinal and/or qualitative design.
- It is necessary to identify moderators (=for whom) in relations between physical activity and QoL, e.g. personality, attitudes towards physical activity etc. This could be done by multilevel analysis to identify subgroups with different health trajectories. In-depth interviews could then be done with persons in the different subgroups. Moderators could also be explored by separate interviews with persons that have been participating in physical activity interventions, i.e. by examining 1) those who did improve their outcomes and 2) those who did not.
- Moderation/Interaction genes and behaviour (e.g. physical activity) during the life course for outcomes such as physiological frailty.
- Coping strategies in older persons with increasing frailty could be further explored.
- Person-centred interventions for groups in most need and with most potential for improvement (moderators) could be carried out.
- In studies/intervention in (frail) older persons, outcomes and strategies to promote dignity should be obligatory.

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