

REDUCING
the **IMPACT** of
GERIATRIC
CONDITIONS by
PHYSICAL
ACTIVITY

ERWIN TAK

Reducing the impact of geriatric conditions by physical activity

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The 6 studies presented in this thesis were conducted at the Netherlands Organisation for Applied Scientific Research TNO in Leiden and partly at Body@Work, Research Center on Physical Activity, Work and Health, the EMGO institute for Health and Care Research, VU University Amsterdam and The Erasmus Medical Center, Department of Epidemiology, Rotterdam.

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Reducing the impact of geriatric conditions by physical activity

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General Introduction

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CHAPTER

1

The aging society

Over the coming decades most Western societies will be facing demographic and epidemiologic challenges. Between 2010 and 2050 the number of persons aged 65 or older in the Netherlands, will increase from 2.4 to 4.5 million ¹. Due to this increase and the fact that diseases that used to be fatal are now better treated and managed, the number of older adults with chronic diseases will rise. In primary care, the prevalence of those with one chronic disease in the general Dutch population is 33.7%, and this rises with age from 30.0% for 25-54 years-old to 83.5% for 75 years and older ². Multimorbidity, i.e. having two or more chronic diseases, rises from 8.1% in 25-54 year-olds, to 59.2% for those aged 75 and older. It is estimated that the number of older adults (over the age of 65) with multimorbidity will rise from one million in 2008 to 1.5 million in 2020 ³. This increase in older adults with multiple chronic diseases will lead to a higher demand for care ⁴, which will have to be met by a shrinking work force ⁵.

The consequences of old age and chronic conditions

One important consequence of chronic disease in older adults is the increased risk of becoming disabled ^{6,7}. Disability is defined as difficulty or dependency in carrying out activities essential to independent living including essential roles needed for self-care and activities important to one's life. Compared with having no disease, suffering from a chronic disease increases the risk of developing disability 3.5 fold. If co-morbidity is present, this figure rises to 4.7 ⁸⁻¹⁰. This is especially true if a second disease has impact on another bodily system, for instance when knee osteoarthritis (musculoskeletal system) occurs together with heart disease (cardio-respiratory system) ¹¹. As well as diagnosed diseases, the so-called geriatric conditions are known to have a strong negative impact on daily life ¹². These conditions can be described as a collection of signs and symptoms common in older and particularly vulnerable adults which are not necessarily related to a specific disease ¹³. They are multi-factorial in cause, may be triggered by a variety of acute insults, are typically episodic in nature and are often followed by functional decline ¹⁴. Although there is a lack of consensus on the exact definition, there seems to be a consensus that cognitive impairment, falls, incontinence, immobility and vision and hearing problems belong to these geriatric conditions.

As a result a large proportion of older persons experience difficulties in performing activities necessary for independent living. The prevalence of disability in older age groups (55+) is reported to vary between 13% (severe) to 29% (mild) depending on level of disability ¹⁰. Over a 6-year period the incidence of disability is around 45% for older adults (55-88 years) increasing to 68% in older age groups (75-88 years). Recovery from disability is reported in up to 20% of these persons within a 6-year period, this percentage being lower in the older

age groups. Several sub-types of disability are reported, including instrumental, locomotor, mobility, and activities of daily living (ADL) ¹⁵. Disability in ADL activities in particular limits an older person's autonomy and is directly related to loss of independence, an increased risk of requiring outpatient care, hospitalization, institutionalization and death ¹⁶⁻¹⁹.

As well as increasing the demand for and cost of care, difficulty in performing everyday activities also has a negative impact on quality of life ²⁰ and threatens the participation in society such as volunteer work and social contacts by older adults ²¹. Supporting participation and independent living are key Dutch governmental policy targets in elderly care ²². Successful aging is no longer restricted to postponing death or curing disease, but is focusing more and more on preventing the negative effects of disease and increasing the participation of older adults in society. According to the Dutch Health Council this means that as well as the prevention of disease, prevention should also be function-oriented and focus on identifying which determinants can be positively influenced ²³. The goal should be to prevent the onset of disability, minimize its progression and to enable older adults to recover from disabilities. Recent studies show that disability is a dynamic process with individuals moving in and out of states of disability ²⁴⁻²⁶. It is therefore necessary to identify modifiable factors associated with this process. This leads to the question - what are the factors that cause diseases and aging to result in disability?

The disablement process

The Disablement Process Model (DPM) ²⁷ can help us to understand the pathway from disease to disability. According to this model, pathology (presence of disease, trauma) leads to impairment (anatomical and structural abnormalities) which in turn lead to functional limitations (restrictions in basic and mental actions) that eventually result in disability (difficulty carrying out activities of daily life). Figure 1 shows a model of the main pathway and a number of other factors that can speed up and slow down the journey along the pathway ²⁷, or affect the direction of the process. Next to risk factors, these include extra and intra-individual factors such as interventions (introduced to slow down and reverse disablement) and accelerators (factors that have the harmful effect of speeding up disablement) ²⁸.

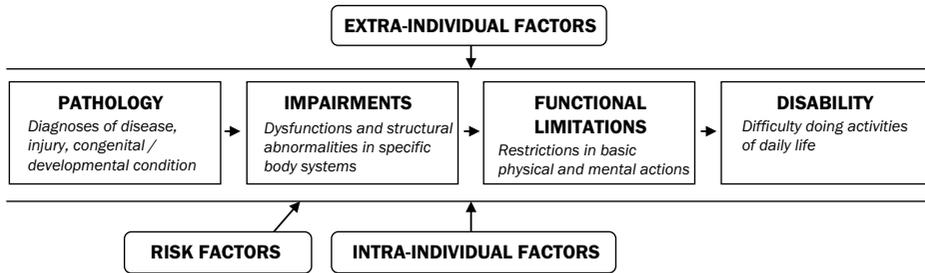


Figure 1: *The Disablement Process Model*²⁷

The model is best illustrated by an example. If an older person develops osteoarthritis (pathological condition), the cartilage in their joints will decrease in quality and cause deformation of the bone (impairments) which will lead to pain and limitations in joint flexibility (functional limitation), and which in the end may result in problems riding a bicycle, carrying groceries or opening tins (disability). Although, not everyone who is diagnosed with osteoarthritis (OA) will develop disability, OA is known to have a substantial impact with 80% of patients having some limitation of movement, and 25% not being able to perform the main activities of daily living²⁹. Factors associated with a high risk of incident disability in patients with OA include pain, muscle weakness, poor aerobic capacity, and severity of disease³⁰. Higher weight, increased varus-valgus laxity, higher proprioceptive inaccuracy, older age, and more intense knee pain are associated with progression of disability in OA. In contrast, greater muscle strength, better mental health, higher self-efficacy, more social support, and higher level of physical activity seem to be protective³¹⁻³³.

The DPM elaborates the work of the Nagi scheme³⁴ and closely reflects the International Classification of Functioning, Disability and Health (ICF model) developed by the WHO³⁵. Currently there is debate on which model serves best in research and clinical practice³⁶⁻³⁸. The advantage of the DPM is that it was originally developed in the field of disability research and is therefore equipped for scientific and clinical research^{27,28}. For instance, most concepts of the DPM have been operationalized in the form of valid and reliable instruments³⁹ that can be used in research and clinical practice⁴⁰. When used for research, the following propositions of the DPM should be taken into account²⁸:

1. Causal effects between proximate concepts are stronger than those between distant ones. Limitations in mobility have direct implications for cleaning the house and shopping; the pathology of having arthritis in itself is less predictive of these difficulties.
2. Disablement is a highly multivariate phenomenon with many factors affecting the presence and level of disability at any given time. The measured effect of a risk factor or intervention is likely to be modest at best; tiny statistical effects will be far more common than enormous ones (this is especially true for effects of interventions because they are numerous, often multiple and changeable in a person's life).

3. Any of these concepts (impairments, functional limitations, disability) can be measured in several legitimate ways, but the main distinction between functional limitations and disability is the context: functional limitations refer to the individual capacity without reference to situation requirements, while disability refers to the manifestation of a functional limitation in a situational context.

In order to synthesize the evidence on risk factors for functional decline in older adults (defined as either functional limitations or disability) Stuck et al.⁴¹ reported that, as well as disease burden, the functional impairment of vision, the lower extremities and cognition, intra-individual factors such as lifestyle (smoking and alcohol intake, physical activity) and environmental factors such as social contacts influenced the level of functional decline. Tas et al.⁴² systematically reviewed prognostic factors on the course of prevalent disability and on transition rates to different outcome categories in community-dwelling older people. They found moderate to strong evidence that higher age, cognitive impairment, vision impairment, and poor self-rated health are prognostic factors of disability. They found limited evidence that physical activity benefited older adults with disability.

The case for physical activity

There are some indications that physical activity (PA) is related to functional limitations as well as disability, and thereby influences the pathway from disease to disability⁴³. Theoretically, physical activity can influence all stages, transitions, and associations, although some argue that physical activity primarily affects the stage of functional limitation and only indirectly influences disability⁴⁴. A closer look at recent evidence shows that physical activity or exercise does have an effect on all stages of the DPM. First of all, physical activity has a preventive effect on major disabling diseases⁴⁵⁻⁴⁷. Secondly, in observational as well as experimental studies, the documented beneficial effects of physical activity include impairments such as muscle strength and aerobic capacity^{48,49} as well as on functional limitations^{50,51}. Likewise, lack of physical activity or a sedentary lifestyle may exacerbate the impairments in physiological and structural systems that are typically observed in the ageing process⁵². Evidence supporting the beneficial relationship between physical activity and disability has been growing but is not yet clear^{50,51}. Whether PA affects disability directly⁵¹ or indirectly through other stages of the disablement process such as functional limitations^{44,53,54} or related concepts such as self-efficacy⁵⁵ needs to be studied further⁵⁶.

Given the indications that PA can prevent or slow down the disablement process, it would also be interesting to know if specific PA interventions can intentionally affect this process. Although some clinical trials have shown that exercise programs are effective in slowing down the disablement process in older adults with disabling chronic diseases^{57,58} as well as

in frail older adults⁵⁹, there is still a need to better understand which types of exercise and physical activity are feasible, safe and effective in reducing disability in older adults who are already disabled. A recent meta-analysis showed that the effects of exercise programs on the level of physical activity and quality of life in physically impaired older adults were not evident and that no definite conclusions on the most effective type of physical exercise therapy intervention could be drawn⁵⁸. In particular, aspects relating to the high rates of dropouts in exercise programs need to be addressed^{60,61} in order to optimize the effectiveness of exercise interventions in this group.

Paradoxically, those groups that would benefit most from an active lifestyle are also those known to be the least active: older persons and those with disabilities or chronic disease⁶²⁻⁶⁴. This discrepancy warrants additional and different approaches to the promotion of physical activity in this group of older adults. Specific motivators and barriers for these groups need to be addressed⁶⁵. This is not only relevant for the promotion and initiation of physical activity but also to adherence and maintenance of exercises and an active lifestyle⁶⁶. Of those who start taking structured exercise, about 10-50% of participants drop out during the first 6 months, with most relapses occurring during the first 3 months^{60,67}. Given the fact that carrying out research within groups of older vulnerable adults brings about major methodological challenges, these groups are often excluded from research on how to prevent or delay functional decline and disability^{68,69}. In the fields of both physical activity and disability research, the question of how physical activity can reduce functional limitation and disability in those with geriatric conditions therefore needs to be addressed⁵⁶.

Objective

The aim of this thesis is to study the role of physical activity in preventing or reducing the level of functional limitations and disability in older adults with geriatric conditions.

Three separate research questions have been developed to address this issue:

- I. What is the association between habitual physical activity and disability in older persons with and without geriatric conditions?
- II. Can the impact of geriatric conditions on functional limitations and disability be reduced by specifically designed exercise programs?
- III. What are the determinants of initiation, adherence to and maintenance of exercise programs in older persons with geriatric conditions?

Using the Disablement Process Model as the theoretical background, the role of physical activity in the pathway from chronic disease or geriatric condition to disability is studied. Physical activity is defined as any bodily movement produced by contraction of skeletal muscle that substantially increases energy expenditure above basal level⁷⁰. In the first part, the focus is on habitual physical activity (everyday activities such as walking, cycling,

gardening, sports etc.), while in the second part the focus is on specifically developed exercise programs aimed at improving physical functioning. The third part combines specific exercise activities and habitual physical activity since this part focuses on physical activity behavior as an outcome. All studies were carried out in the community dwelling, independently-living older adults with the exception of one study in part II, which was carried out among frail older women living in homes for the elderly. Of the geriatric conditions studied, osteoarthritis (OA) is represented in all parts with separate studies on generalized radiological OA (part I), clinical OA of the hip (part II) and diagnosed OA of the knee and/or hip (part III). The other geriatric conditions studied include urinary incontinence (part II) and mild cognitive impairment (part III).

Outline of the thesis

The thesis will be divided into three parts as reflected by the three research questions, together with an introduction (this **Chapter 1**) and discussion (**Chapter 8**).

In Part I the association between physical activity and functional limitations and disability will be studied using observational data and to this end **Chapter 2** will describe a systematic review and meta-analysis of prospective longitudinal studies analyzing the association between physical activity and disability in basic activities of daily living in older community dwelling adults. The association of PA with both incident disability as well as and progression of disability will be reported. **Chapter 3** will include the results of secondary data analysis of longitudinal data of the Rotterdam Study (ERGO data)^{71,72}. The aim of this study is to establish the level and progress of disability in a population of older community dwelling adults with generalized radiological osteoarthritis (GROA) and will examine if physical activity is associated with a change in disability.

Part II will focus on the reduction of functional limitations and disability by specific exercise programs in older adults with geriatric conditions. **Chapter 4** will report on a multilevel randomized controlled trial into the effects of a group-based program delivered by physical therapists to train pelvic floor muscles (PFM), bladder, and mobility in order to reduce urinary incontinence and improve functional performance in frail elderly women living in homes for the elderly. **Chapter 5** will present the results of a randomized controlled trial into the effects of an exercise program for older adults with osteoarthritis of the hip. This chapter describes the effect of an 8-week exercise program on hip function, self-reported and observed disability in 109 community dwelling older adults with hip osteoarthritis.

Finally, Part III will address the issue of sustaining the impact of physical activity on functional limitations and disability in older adults with geriatric conditions. For this purpose, **Chapter 6** will report on older persons' initiation into, adherence to and maintenance of two different exercise programs which were part of the Folate physical Activity Cognition Trial (FACT), a randomized controlled trial⁷³. Older adults with mild cognitive impairment

(MCI) were followed during the 1-year trial and at 6-months follow-up. This is followed by **Chapter 7** which reports on a study aimed to identify predictors of self-reported change in physical activity behavior and objective physical activity in community dwelling older persons with radiographic OA of the knee and/or hip who took part in a randomized controlled trial into the effectiveness of a self-management program, including an exercise program.

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The association between physical activity and disability

Prevention of onset and progression of basic ADL disability by physical activity in community dwelling older adults: a meta-analysis

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REDUCING
THE IMPACT OF
GERIATRIC
CONDITIONS BY
PHYSICAL
ACTIVITY

CHAPTER

2

Abstract

Introduction

Physical activity (PA) is an important behavior when it comes to preventing or slowing down disablement caused by aging and chronic diseases. It remains unclear whether PA can directly prevent or reduce disability in activities of daily living (ADL). This article presents a meta-analysis of the association between PA and the incidence and progression of basic ADL disability (BADL).

Methods

Electronic literature search and cross-referencing of prospective longitudinal studies of PA and BADL in community dwelling older adults (50+) with baseline and follow-up measurements, multivariate analysis and reporting a point estimate for the association.

Results

Compared with a low PA, a medium/high PA level reduced the risk of incident BADL disability by 0.51 (95% CI: 0.38, 0.68; $p < .001$), based on nine longitudinal studies involving 17,000 participants followed up for 3 to 10 years. This result was independent of age, length of follow-up, study quality, and differences in demographics, health status, functional limitations, and lifestyle. The risk of progression of BADL disability in older adults with a medium/high PA level compared with those with a low PA level was 0.55 (95%CI: 0.42, 0.71; $p < .001$), based on four studies involving 8,500 participants.

Discussion

This is the first meta-analysis to show that being physically active prevents and slows down the disablement process in aging or diseased populations, positioning PA as the most effective preventive strategy in preventing and reducing disability, independence and health care cost in aging societies.

Introduction

Aging is often accompanied by a decline in functional performance and disability as described in the disablement process model^{1,2}. According to this model, pathological processes specific to a disease or trauma result in impairments (anatomic and structural abnormalities) which in turn lead to functional limitations (restrictions in basic physical and mental actions), which ultimately result in disability (difficulty in doing activities in daily life). Disability threatens the independence of older persons and, through demands of long-term care, leads to increases in health care costs. Although there are indications that the prevalence of some types of disability is declining³⁻⁶, especially in older or frail populations prevalence is still high^{7,8}. As hypothesized by the disablement process model and supported by recent studies, disability is not a static but a dynamic process⁹ in which several factors play a role in the onset, recovery or worsening of older persons' disability status.

Different types of factors are conceptualized to speed up and slow down the pathway from aging and disease to disability in the disablement process. These include risk factors (e.g. demographic factors), extra-individual factors (e.g. medical care) and intra-individual factors including behavioral factors such as physical activity which are thought to be primarily interacting with functional performance which subsequently effects disability^{2,10}. Although some studies confirm that part of the effect of physical activity on disability goes via improved functional performance¹⁰⁻¹² there is evidence indicating a direct effect of physical activity on disability¹³. There have been longitudinal studies that underscore the protective effect of physical activity on disability, although there are some methodological challenges in reviewing this evidence^{13,14}. Especially the diversity in used definitions and methods to measure physical activity as well as disability make the synthesis of evidence into a challenging enterprise. So far in systematic reviews, physical activity has been identified as a risk factor for functional decline¹⁵ and as a prognostic factor of disability, although the evidence was qualified as limited¹⁶. A recent systematic review¹⁷ reported an association between physical activity and a reduced risk of functional limitations, disability, and loss of independence, although the distinction between the entities of the disablement process model was not always clearly followed. Also, older adults with and without baseline disability were included and data from different studies were not pooled because of heterogeneity in physical activity and outcome measures. A systematic review¹⁸ focused on physical frailty indicators including low physical activity which predicted future ADL disability but also no meta-analysis was performed on these data.

Objective

In an effort to overcome these limitations and add to this evidence, our objective is to report a systematic review and meta-analysis of (prospective) longitudinal studies analyzing the association between physical activity and both incidence and progression of disability in

(basic) activities of daily living (BADL) in older community dwelling adults. This report was written in accordance with the PRISMA and MOOSE statement for reporting systematic reviews and meta-analyses^{19,20}.

Methods

Data collection

Publications before January 2012 were electronically searched via PubMed using the following terms: (a) older adults; (b) physical activity/exercise; (c) disability, activities of daily living (ADL); (d) longitudinal, prospective. A full description of the search terms used for these criteria and the results of the search can be found in Appendix A. The search was conducted by an experienced librarian with broad experience in searching electronic healthcare databases. Publications were screened for additional references.

We included studies that (i) reported prospective, longitudinal data on the association between physical activity and subsequent disability, (ii) identified and measured physical activity as a possible predictor/risk factor at baseline, (iii) included onset or progression of disability of basic ADL as an outcome (iv) included older community dwelling adults (50+ at baseline; studies focusing on specific populations (i.e. specific diseases, athletes) were excluded with the exception of studies with a focus on gender (i.e. only women)), and (v) used multivariate analysis and reported the association explicitly in a point estimate preferably as a risk, hazard or odds ratio. We included reports that were published as full-text articles in peer-reviewed journals.

To distinguish disability from functional limitations, defined as restrictions in basic and mental actions, we defined disability as having any difficulty in performing basic ADL, i.e. those activities related to personal care and hygiene, such as dressing/grooming, arising, eating, bathing, and using the toilet. Physical activity was defined as any bodily movement produced by contraction of skeletal muscle that substantially increases energy expenditure above the basal level²¹. No restrictions were imposed on the literature search, with the exception that studies referring to specific exercise programs (i.e. planned or structured types of physical activity) not including habitual activities (i.e. walking, cycling, sports, leisure-time activities, and household) were excluded. Titles and abstracts of identified reports were reviewed to identify relevant articles. Two authors (ET, MH) scanned all the titles and abstracts independently. If necessary, the full-text article was scanned by one author (ET) to extract further information on eligibility criteria. Disagreement between reviewers was resolved by consensus.

Next, two authors (ET, MH) independently reviewed all selected full-text articles using a structured data extraction form, that included, the origin of the study, sample size, follow-up period, population description, used definition and measurement of physical activity and disability, included predictors, analytic method, parameter estimates, and factors for which

the reported association was adjusted. Selected cohort studies were searched to extract relevant information referred to, but not reported in the selected publications. Articles reporting on the same original cohort were included at first, but were excluded if there was data overlap that resulted in duplication of results. All studies were assessed for risk of bias using a 14-item checklist for assessing the methodological quality of prospective studies (based on Singh et al.²²). The checklist covered four dimensions: (i) study population and participation rate, (ii) study attrition, (iii) data collection, and (iv) data analysis. Half of the items dealt with information and half with validity. The two non-blinded reviewers (ET, MH) rated each criterion as positive, negative, or insufficient. Disagreement between the reviewers was discussed until a consensus was reached. A sum score was assigned to each study based on the number of items that were scored positively (range for total 0-14, information and validity scores ranged from 0-7).

Reported levels of physical activity were reduced to a maximum of three levels: none/low, medium, high/vigorous as presented in table 1.

Table 1: Overview of reported physical activity levels and reduction to (a maximum of) three levels

Categories*	Low		Moderate	High
Odds Ratios[†]				
Avlund	Sedentary		Active (at least a weekly activity)	
Haveman-Nies	Inactive (1st tertile)		Active (2nd and 3rd tertile)	
Ishizaki	No habit walk		Habit to walk	
Jenkins	<3 times/week			≥3 times/wk vigorous
Leveille	Rarely,never,1 month		1-2 on PA scale	3-6 on PA scale
Miller [‡]	Not		Walking at least 1 mile/week	
Ostbye	Never	Other	1-2 p/w heavy or 3 p/w light	≥ 3 p/w heavy
Puts [‡]	Low (<76 min/day)		Higher (>76 min/day)	
Stessman (2009)	Sedentary		Vigorous PA or walking 1 hr/day	
Stessman (2002) [‡]	Less		Exercise/PA ≥ 4 d/wk	
Van den Brink	1st tertile EE [‡]		2nd tertile EE	3rd tertile EE
Young [‡]	1st tertiel EE [§]		2nd tertile EE	3rd tertile EE
Relative Risks				
Wu	No routine		Routine exerciser, at least twice a week	

*the categories mentioned after the separate authors refer to the names reported in their respective publication.

[†]reports are further categorized based on the point-estimate used. [‡]reports on progression of disability [‡] EE energy expenditure; values for tertiles not reported [§] Low= 914.6-2110.2 kcal/day, moderate = 2111.1-2533.9 kcal/day, high=2534.1-6360.6 kcal/day

The outcome was defined as new onset of basic ADL disability (incidence) or increase in disability (progression, either defined as a change score between measurements or increase on the respective ADL scale score). Summary measures recorded were point

estimates of the (adjusted) association between the specified physical activity levels and the incidence or progression of basic ADL disability.

Analysis

Studies were included in the meta-analysis if they reported odds ratios (OR) or relative risk (RR), comparing medium, medium/high, or high versus low physical activity levels (see table 1 for details). For those studies that reported ratios for medium versus low and high versus low comparisons, the ratios were averaged to compare medium/high versus low.

In each analysis, we incorporated the ratio and its 95% confidence interval for each study. To allow generalization we used a random-effects model and present results in a forest plot, which gives an overview of the studies, their ratios (treatments effects), and the relative strengths of the treatment effects (weights). Since we used the random-effects model, the weights incorporate the within-study variance (including sample size) and the between-study variance. Additionally, we calculated three measures of heterogeneity, namely Q , T^2 , and I^2 . To obtain insight into bias, such as publication bias and selective reporting within studies, we inspected the funnel plot visually and used Egger's test, Duval and Tweedie's trim and fill, and the Rosenthals' fail-safe N . In addition, we performed subgroup analysis and meta-regression. In the subgroup analysis, we compared two or more subgroups and, in the meta regression, we examined the association between the mean effect size with a continuous variable. This was done for age older than 75 years (yes/no), follow-up longer than 72 months (yes/no), analyses adjusted for demographics, health, functional limitations or lifestyle (yes/no), and quality of the study (continuous). We performed a fixed-effects analysis to examine the differences between the subgroups.

Results

One hundred and four full-text articles were retrieved and screened for eligibility (figure 1). Of these articles, 80 were excluded mostly because physical activity was not studied as a predictor or basic ADL disability was not studied as an outcome. In most of these cases a specific type of disability was studied that did not involve personal care (such as instrumental ADL disability or mobility disability), or measures were used that resembled functional limitations (i.e., walking, climbing stairs, crouching, kneeling, carrying ¼ lb etc.), although these were often referred to as disability. Of the remaining 24 publications, 13 were eligible for the meta-analysis.

Table 2 reviews the characteristics of the 13 included studies. Most studies were conducted in the USA or Europe. With the exception of the Jerusalem Longitudinal Cohort Study^{23,24}, no study was reported in more than one publication. Since one publication from this group reported on incidence²⁴ and the other on progression²³, there was no overlap of participants in the analyses. With respect to the other characteristics of included studies, most involved

participants aged between 70 and 80 years at baseline, with only 1 study reporting on 50 years and older²⁵. The follow-up ranged between 36-42 months in 5 studies and 60-72 months in 5 studies; 3 studies had a follow-up longer than 100 months.

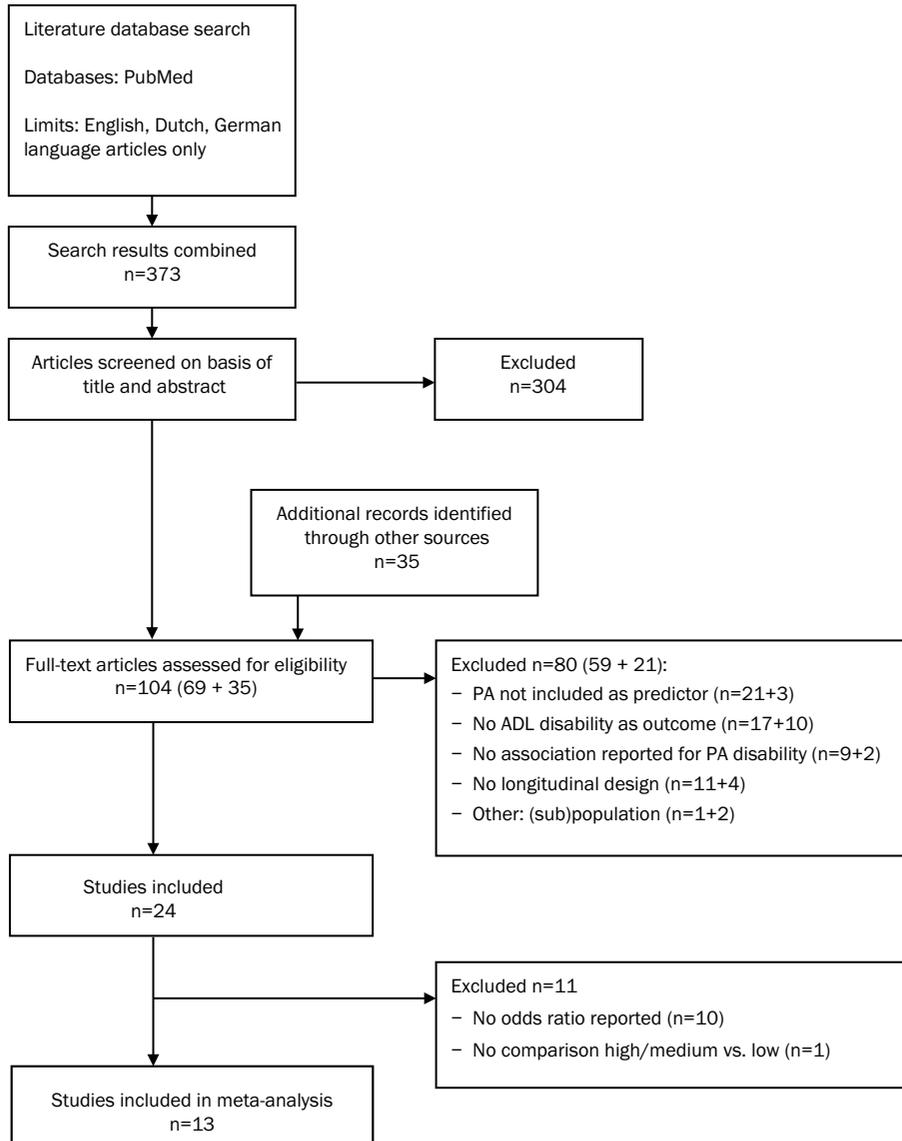


Figure 1: Flowchart: results of the literature search and selection

Table 2: Characteristics of included longitudinal studies

First author, year	Study (country)	Mean age (SD) at baseline	Number included in analysis	FU-period (months)	PA measurement (mode)	PA types	PA predictor status	ADL-disability measurement	Disability outcome measure (criterion)	Quality score, range 0-14 (validity items, 0-7)
Avlund, 2002	NORA [†] (DK, FI)	NR, ≥74	429	60	single question (frequency)	sports, walking, gardening	covariate	PADLH scale	incidence (help in one of more activities)	10 (4)
Haweman-Nies, 2003	SENECA [†] (EU)	m 72.6 (1.6) w 72.7 (1.7)	381	120	Voorrips questionnaire ⁷⁶ (frequency)	sports, household, leisure-time	one of 3	6 self-report questions	incidence (no difficulty or difficulty in only 1 activity)	9 (3)
Ishizaki, 2000	LISA [‡] (JP)	70.9 (4.9)	583	36	single question (frequency)	walking	one of 28	5 self-report questions	incidence (loss of independence in each activity)	11 (5)
Jenkins, 2004	AHEAD [§] (US)	78.0 (4.9)	3373	36	single question (intensity)	vigorous exercise	covariate	4 self-report questions	incidence (difficulty in at least 1 activity)	7 (3)
Leveille, 1999	EPESE (US)	NR, ≥65	1097	73 (range 24-96)	several questions (frequency)	vigorous exercise, walking, gardening	one of 7	6 self-report questions	dying without disability (need help with activities)	9 (3)
Miller, 2000	LSOA [†] (US)	78.2 (6.0)	3589	72	single question (frequency)	walking	principal	ADL-scale ^{77,78}	progression (none, 1-2 or 3-5 disabilities)	10 (4)
Ostbye, 2002	HRS ^{**} (US)	NR, 51-64	7845	72	two questions (frequency, intensity)	sports, walking, dancing, gardening	one of 8	4 self-report questions	incidence (need of help in at least one of 4)	7 (3)

First author, year	Study (country)	Mean age (SD) at baseline	Number included in analysis	FU-period (months)	PA measurement (mode)	PA types	PA predictor status	ADL-disability measurement	Disability outcome measure (criterion)	Quality score, range 0-14 (validity items, 0-7)
Puts, 2005	LASA ^{††} (NL)	between 74.1 (6.1) and 78.3 (6.1)\$\$\$	1321	72	LAPA questionnaire 79 (frequency)	sports, cycling, walking, gardening, household,	one of 9 frailty markers	OECD questionnaire	progression (decline based on change scores)	10 (4)
Stessman, 2002	JLCS ^{††} (IS)	m 77.1 (0.8) w 77.1 (0.7)	287	96-108	NR	exercise	principal	ADL scale ²⁹	progression (carry out at least 3 activities with ease)	9 (4)
Stessman, 2009 ^{***}	JLCS ^{††} (IS)	NR, ≥70	(1861)†††	42	single question (frequency)	vigorous sports, physically active	principal	ADL scale ²⁹	incidence (dependence in at least one activity)	10 (3)
Van den Brink, 2005	FINE ^{§§} (FI, IT, NL)	F 74.7 (4.0) IT 76.1 (3.4) NL 74.2 (4.1)	286	120	Zutphen questionnaire 21 (frequency, intensity)	sports, cycling, walking, gardening, hobbies, odd jobs	principal	Questionnaire ⁸⁰	Incidence (needing help on at least one item)	11 (4)
Wu, 1999	LS 65+ Taipei (TW)	NR, ≥65	1321	36	NR (frequency)	hiking, jogging, walking, dancing	one of 11	ADL scale ²⁹	incidence (incapable of performing one or more of activities for 3 months)	11 (4)
Young, 1995	HHP ^{††} (US)	77.8 (4.7)	3428	36	18 activities scored (frequency) and transferred into KCal ^{††}	sports, walking, gardening, leisure time, work	principal	ADL scale ²⁹	progression (difficulty in performing at least one activity)	8 (4)

PA= Physical Activity; ADL= Activities of Daily Living; NR = not reported; SD = standard deviation; FU=Follow-up

* Nordic Research on Aging ; † Survey in Europe on Nutrition & the Elderly; †† Longitudinal Interdisciplinary study on Aging; ††† Established Populations for Epidemiologic Studies of the Elderly; †††† Longitudinal Study On Aging, includes institutionalized participants and only men; ** Health Retirement Study; †††† Longitudinal Aging Study Amsterdam; includes institutionalized participants; ††††† Jerusalem Longitudinal Cohort Study; †††††† Finland, Italy and the Netherlands Elderly Study; †††††††† Longitudinal Study; †††††††††† Honolulu Heart Program;

*** 2 outcomes reported: 1) maintaining ease in performing ADL at 78- 2) remaining independent while performing ADL at 85; only the last one was chosen because of its stricter definition and closer resemblance to other outcome measures; †††† Not specified for LR analysis; ††††† Kilo-calories; †††††† distinguishes four subgroups (no decline performance, decline performance, no self-reported decline and self-reported decline)

Physical activity was usually measured with a single question, but in 3 studies it was measured with a validated questionnaire²⁶⁻²⁸.

Most of these measures registered frequency or intensity of physical activity, but 2 studies converted physical activity data into a measure of energy expenditure. Disability in basic ADL was usually measured with questions about different activities or with a validated scale, mainly the Katz scale²⁹. Several levels of disability were used, ranging from difficulty in performing basic ADL, needing help to perform, to inability to perform one or more activities. Nine publications reported on the association between physical activity and new onset of disability, and 4 publications reported on progression of disability as the outcome measure. All studies adjusted for either demographic factors, life style, or health status; 6 studies for all three; about half of the studies adjusted for functional limitations (table 3).

Table 3: *Number of reported adjusted factors per category and per study on incidence and progression*

First author, year	Demographic [*]	Lifestyle [†]	Functional limitations [‡]	Health status [§]
Studies on incidence of basic ADL disability				
Avlund, 2002				2
Haveman-Nies, 2003	2	2		
Ishizaki, 2000	2		1	1
Jenkins, 2004	6	3	1	1
Leveille, 1999	3	1		3
Ostbye, 2002	5	3		
Stessman, 2009	1	1	1	3
Van den Brink, 2005	2	3		
Wu, 1999	4	3	1	2
Studies on progression of disability				
Miller, 2000			2	
Puts, 2005	3			
Stessman, 2002	2	1	1	4
Young, 1995	1			1

^{*}Demographic includes: age, sex, race, education, marital status, income, country/study site

[†]Lifestyle includes: smoking, alcohol, diet, BMI/weight, sleep, social network

[‡]Functional limitations includes: cognitive function, functional limitations, gait speed, hand grip

[§]Health status includes: (chronic) diseases (vascular diseases, cancer, stroke, urinary incontinence, hypertension, psychiatric, joint pain, neurological, diabetes mellitus, back, arthritis, COPD, depressive symptoms, tiredness), self-rated health and health care utilization (hospitalization, service use, preventive tests, home modification)

The included studies had total quality scores between 7 and 11 (out of 14) and a validity score of 3 or 4 (out of 7), with the exception of 1 study which scored 5³⁰. The average quality score on quality for all reports was 9.4 out of 14 (67%). All studies scored negatively on the criterion 'measurement of physical activity' and 'measurement of disability' because only self-report measures were used. Lack of information was the main reason for poor scores

on the quality item 'selective dropout', and 'baseline response levels'. Most studies did not mention reasons for dropout, but when it was reported by the authors, selective dropout occurred. Response levels were scored negatively in 8 studies on short (80% of participants up to 12 months) or a longer follow-up (70% of participants at baseline); response data were missing in 5 studies. For all other quality aspects 79% of the publications scored positively.

Association between physical activity and incident disability

Nine studies reporting incident disability were entered into the meta-analysis^{24-26,28,30-34}. Table 4 and figure 2 provide information about the type of comparison, outcome and effect estimates, forest plot, and study weights for these studies. The pooled OR estimate for the association between medium/high physical activity levels versus low physical activity levels on the incidence of basic ADL disability was 0.51 (95% CI: 0.38, 0.68; $p < .001$), indicating a lower risk. With the exception of 1 study, all studies reported that medium/high physical activity levels significantly reduced the risk of basic ADL disability. In one study by Jenkins et al.³², the association between physical activity and the onset of disability only lost significance when health conditions such as symptoms and functional limitations were added to the model.

Table 4: Results of the meta-analysis of the level of physical activity on the incidence of basic ADL disability

First Author, year	Comparison [†]	OR	Lower limit	Upper limit	Relative weight
Avlund, 2002	hm vs low	0.370	0.191	0.715	3.81
Haveman-Nies, 2003	hm vs low	0.449	0.227	0.887	3.57
Ishizaki, 2000	med vs low	0.470	0.230	0.960	3.25
Jenkins, 1999	hm vs low	0.850	0.616	1.173	16.01
Leveille, 1999	hm vs. low [†]	0.657	0.445	0.970	10.92
Ostbye, 2002	high vs low	0.280	0.219	0.358	27.33
Stessman, 2009	hm vs low	0.520	0.300	0.901	5.49
Van den Brink, 2005	hm vs. low [†]	0.615	0.392	0.965	8.17
Wu, 1999	hm vs low	0.520	0.394	0.687	21.45
Summary		0.507	0.379	0.679	

[†] hm = high/medium PA level, high= high PA level, med=medium PA level, low = low PA level

[†] combined with med vs. low (mean of the two comparisons was used)

There was statistical heterogeneity ($Q = 35.21$, $df = 8$, $p < .001$; $I^2 = 77.28\%$; $T^2 = 0.14$). There was no significant publication bias according to either Egger's Test ($p = .58$), Duval and Tweedie's trim and fill (0 studies are trimmed both to the right and to the left of the mean), and Rosenthals' fail safe N (= 220). In subgroup analyses and meta-regression, age (older than 75 years), follow-up period, and factors controlled for in the analysis did not significantly alter the relationship between low levels of physical activity and the incidence

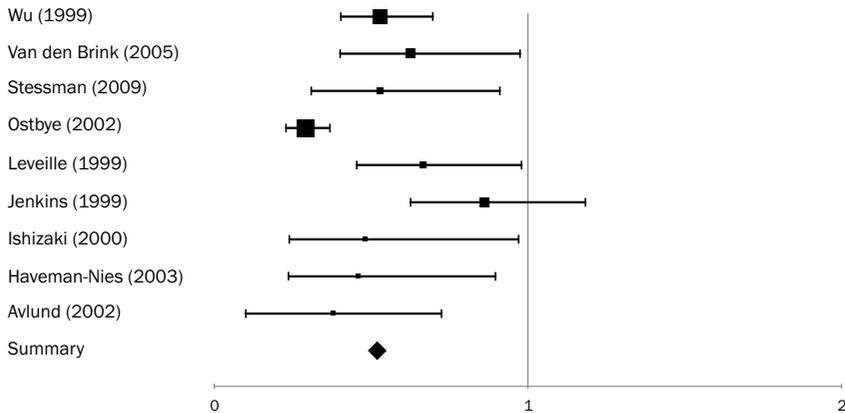


Figure 2: Forest plot meta-analyses on incidence of basic disability

of basic ADL disability (for details see table 5). However, as there were only 9 studies, there might not have been enough power to detect whether these factors had a significant effect.

The meta-regression on quality yielded the following estimated model:

$\ln(\text{OR}) = -0.83 + 0.02 * \text{quality}$, where both the intercept and slope cannot be rejected as differing from zero. Because of this, we do not report further meta-regression results on quality. We conclude that the quality of the study was not linearly related to the association between physical activity and disability.

Table 5: Results subgroup analysis and meta-regression

Factor	N no/0	N yes/1	Est. no/0	Est. yes/1	Qbetween	df	p-value
Age above 75 [*]	2	4	0.701	0.421	2.36	1	.12
Follow-up time larger than 72 months	3	6	0.604	0.475	0.95	1	.33
Control for demographic factors	1	8	0.370	0.523	0.86	1	.35
Control for health factors	3	6	0.413	0.586	1.30	1	.26
Control for function limitations	6	3	0.451	0.623	1.55	1	.21
Control for factors of lifestyle	1	8	0.370	0.523	0.86	1	.35

N = Number of studies per group (i.e. for no/0 and for yes/1)

* Note that (the range of) age was not available for all studies.

Association between physical activity and progression of basic ADL disability

Four studies reported on the progression of disability^{12,23,27,35}. The pooled OR estimate for the associations between medium/high versus low physical activity levels on progression of basic ADL disability was 0.55 (95% CI: 0.42-0.71; $p < .001$) (table 6 and figure 3).

Different studies used different models in their analyses. Miller et al.¹² differentiated

between a model that included or excluded functional limitations and found the latter to reduce risk more (OR = 0.77, 95% CI: 0.60-0.98, vs. OR = 0.58, 95% CI: 0.46-0.73). Puts et al.²⁷ differentiated between static and dynamic physical activity (decline in physical activity levels during follow-up) and reported lower risk reduction in older adults with declined physical activity levels (OR = 0.49, 95% CI: 0.36-0.67 vs. OR = 0.59, 95% CI: 0.41-0.85). One study compared medium as well as high levels of physical activity with low levels and found similar reductions in risk³⁵. This association was also seen in subsamples of healthy or chronically diseased older adults.

Table 6: Results of the meta-analysis of the level of physical activity on the progression of basic ADL disability

First Author, year	Comparison*	OR	Lower limit	Upper limit	Relative weight
Young, 1995	hm vs. low [†]	0.543	0.386	0.764	23.67
Stessman, 2002	hm vs. low	0.230	0.097	0.544	3.72
Puts, 2005	hm vs. low	0.538	0.383	0.754	24.04
Miller, 2000	hm vs. low	0.668	0.527	0.848	48.58
Summary		0.550	0.420	0.710	

* hm = high/medium PA level, low=low PA level

[†] combined with med vs. low (mean of the two comparisons was used)

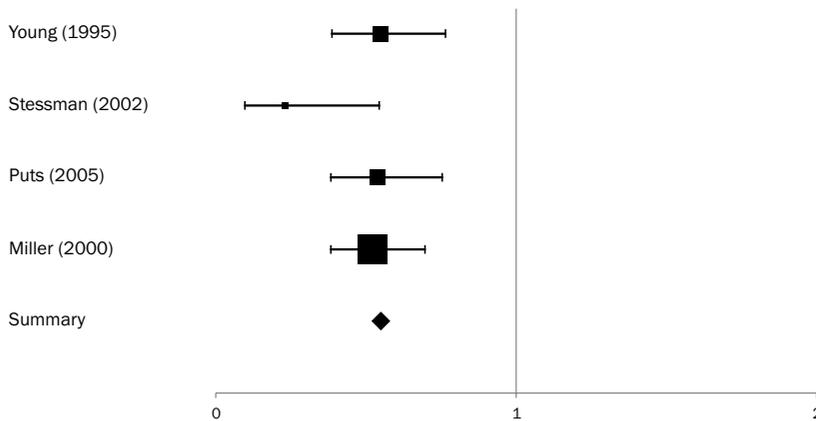


Figure 3: Forest plot meta-analyses on progression of basic disability

There was no statistical evidence of heterogeneity ($Q = 6.12$, $df = 3$, $p = .10$; $I^2 = 51.00$; $T^2 = 0.04$); however as there were only four studies the precision of T^2 is poor and the insignificance of the heterogeneity test might be due to the low power. According to Egger's Test ($p = .004$), Duval and Tweedie's trim and fill (0 studies are trimmed to the right and 2 to the left of the mean, changing the estimate and Q from 0.54 and 6.12 to 0.61 and 12.77,

respectively) and Rosenthals' fail safe N (= 46), there was significant publication bias. For these reasons, we did not perform additional analyses (i.e. subgroup analyses and meta-regression).

Discussion

This is the first meta-analysis to show that physical activity can not only prevent but also slows down the disease and age-related functional decline that leads to basic ADL disability up to 10 years later. The preventive effect was found in both older (≥ 75 years) and younger (< 74 years) older adults, in individuals with or without diseases, and in older adults who already had functional limitations or disability. Studies were consistent in reporting that physical activity positively influences pathways between aging or disease and disability.

These results emphasize increasing physical activity levels are vital for reducing disability and healthcare costs in an aging society. Most older adults in the included studies were over 70 years of age at baseline, indicating that also for these age groups having an active lifestyle offers a possibility to actively influence their independence. The prevention of new-onset basic ADL disability is important because this type of disability in particular is strongly associated with receiving home-care services³⁶, the risk of long-term nursing home admission³⁷, and healthcare costs^{38,39}. Despite these beneficial effects of physical activity, older adults are the least physically active age group⁴⁰⁻⁴², and especially when they suffer from chronic diseases⁴³. It is not easy to get older adults to become and stay physically active^{44,45}. Although the reviewed studies measured different types of activities, almost all of them included walking. Promoting accessible, popular, and everyday activities such as walking and active form of transport provides opportunities to increase habitual physical activity levels⁴⁶⁻⁴⁹.

On the basis of the studies reviewed, we may conclude that any activity above a low level is beneficial. In most studies a low level was defined as being sedentary or a lack of habit of being physically active. A moderate level would constitute a regular habit of being physically at least 1 time a week³¹ to 3 days a week²⁵ while a vigorous level would mean at least 3 days a week being active with a vigorous intensity^{25,32}. However, these findings need to be taken with caution as the selected studies used different ways to measure and define physical activity levels. Also there was a lack in reporting of the different aspects of physical activity such as types, frequency, intensity and duration. More research and probably consensus is required in defining and measuring physical activity to provide a clear advice on what constitutes medium or high levels of physical activity in older adults. Current guidelines advice older adults to be physically active at a moderate level, preferably daily, but at least 150 minutes per week spread out over 5 days of 30 minutes each^{50,51}.

Earlier reviews concluded that the evidence for an effect of physical activity on basic ADL disability was limited and difficult to synthesize^{13,16,17}. Our study clearly fills this gap

in knowledge since it is the first meta-analysis to report an association between physical activity and basic ADL disability and distinguished between the onset of disability and the progression of disability.

To fully use the potential of physical activity in preventing or reducing disability a further understanding of the underlying mechanisms is needed. It is likely that the major influence of regular physical activity on disability is mainly through delaying the start of the disablement process as it prevents (chronic) diseases⁵²⁻⁵⁴, slows down the aging process and prevents disuse. Next, there is also evidence that physical activity has direct beneficial effects, on impairments such as muscle strength and aerobic capacity^{55,56} and on functional limitations^{13,17}. Functional limitations (such as lower extremity limitations, mobility limitations) have been shown to act as a mediator between impairments and disability^{10,12,57}. Our results show that even in those longitudinal studies that adjusted for functional limitations, being physically active still resulted in a reduced risk of basic ADL disability. The interplay between different determinants of disability is probably more complex than the chronological pathway of the disablement process projects. Therefore alternative pathways of the effect of physical activity on disability cannot be ruled out and should also be part of further investigation. For instance, being physically active may serve as a proxy for a broader healthy lifestyle which leads to prevention of negative consequences. A lifelong history of physical activity may have a stronger effect on delaying the disablement process than current physical activity status. The effect of physical activity has also been shown to work through other, psychological, pathways such as depression and self-efficacy. Depression influences the level of physical activity and the subsequent risk of disability⁵⁸. And finally, a lack of complete understanding of which confounding factors are related to disability may lead to overestimation of the contribution of current known factors related to disability.

The reduced risk of progression of disability is clinically important. Older adults who are disabled can recover from a disabled state^{9,59} but the risk of remaining disabled increases with time and chances of recovery decrease^{60,61}.

In order to sustain these effects, effective strategies are needed to prevent disability from becoming persistent in older adults, which results in dependence and a need for care. In addition to physical activity promotion⁶², clinical trials have shown that exercise programs are effective in slowing down the disablement process in older adults with disabling chronic diseases^{52,63-65} as well as in frail older adults⁶⁵.

Limitations of this study

The electronic database search identified relatively few articles, as reported by others¹⁷ and more than half of the selected studies were recovered by the additional search strategy of cross-referencing. Search strategies are hampered by the lack of standardized definitions of key terms, such as basic ADL disability, and liberal use of these terms by authors. Some

of the studies included in this analysis may have suffered from selective sampling. For instance, only participants without missing data on key variables were included in the studied cohorts. Drop-outs or non-selected cases were rarely discussed, so we could not establish whether selective non-response or dropout occurred. If selective dropout was reported and corrected for in the analysis, the association between physical activity and basic ADL disability was weaker²⁸. This might have been the case in more included studies. All studies measured physical activity and basic ADL disability by means of self-report information. Although there seems to be consensus that self-reported information about disability is reliable, objective tests have been developed⁶⁶⁻⁶⁸. While reliable and objective measures of physical activity do exist⁶⁹, they may be ineffective when used in large cohorts. It was difficult to compare the low, medium, or high classifications used in the different studies, which may have resulted in overestimation or underestimation of the physical activity level in some studies. In the future, continuous measures of physical activity could be used⁷⁰, standard validated instruments (either questionnaires or objective measures) should be used, or the comparability of physical activity data could be increased by using response conversion techniques⁷¹.

In most prospective longitudinal studies, baseline physical activity levels were compared with disability status 3-10 years later. Physical activity behaviors⁷² and disability^{9,73} change over time, especially in older populations that suffer from newly acquired diseases or the general consequences of aging. Although some of the included studies took these changes into account⁵⁹ or used multiple measurements^{74,75}, most used only a single point in time to define disability status. Also as most studies did not adjust for the influence of lifelong physical activity, the effect we found might be overestimated.

Lastly, was the heterogeneity of the included studies in the meta-analysis too large to pool the data, as discussed by Paterson & Warburton¹⁷ and by Keysor¹³? In order to reduce heterogeneity, we used only one outcome, basic ADL disability, distinguished between the incidence and progression of basic ADL disability, and we only included studies that presented odds/risk ratios, so that the data could be pooled. We used a random-effects model and did not assume a true effect as in the fixed-effect model. We also evaluated the differences in mean age of the study populations, follow-up period, and confounding in subgroup analyses (and meta-regression) and found no significant effect on the onset of disability. That study quality did not have an effect is probably because of the low number of studies that was included.

Conclusion

This is the first meta-analysis to show that being physically active at a medium/high level reduces not only the risk of becoming disabled by approximately one half (compared to a low physical activity level), but also the risk of progression of basic ADL disability

in community dwelling adults. The preventive effect on incidence was irrespective of age group, follow-up period, and other factors related to disability. This result adds to the body of evidence showing that sufficient physical activity may slow down the disablement process in aging or diseased populations, making increasing physical activity an effective strategy to reduce disability, and thereby, independence and healthcare costs in aging societies. Efforts need to be intensified to decrease inactivity and to increase habitual activities, such as walking in older adults with and without disability.

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Appendix A: *Electronic search strategy*

#38	Search #33 or #37 Limits: Aged: 65+ years, 80 and over: 80+ years	07:08:35	245
#37	Search (#34) AND #36 Limits: Aged: 65+ years, 80 and over: 80+ years	05:41:32	245
#34	Search #20 and #26 and #31	05:40:39	386
#33	Search #28 and #31	05:38:54	247
#31	Search "Longitudinal Studies"[Mesh] OR "Longitudinal Studies"[Mesh] Field: Title	05:36:32	676536
#28	Search (#27) AND #26 Field: Title	05:34:58	908
#27	Search (#15) AND #20 Field: Title	05:34:40	20860
#26	Search ("Disability Evaluation"[Mesh] OR "Disabled Persons"[Mesh]) Field: Title	05:33:43	64871
#23	Search "Activities of Daily Living"[Mesh] Field: Title	05:25:12	39456
#20	Search ("Exercise"[Mesh] OR "Physical Fitness"[Mesh]) OR "Motor Activity"[Mesh] Field: Title	05:23:49	145245
#15	Search ((((#10) OR #11) OR #12) OR #13) OR #14 Field: Title	05:19:31	1900165
#14	Search older people Field: Title	05:17:57	4049
#13	Search older persons Field: Title	05:17:46	1861
#12	Search older adults Field: Title	05:17:28	9467
#11	Search aged or elderly Field: Title	05:17:07	100542
#10	Search "Aged"[Mesh]	05:16:17	1873626
#9	Search "Aged"[Majr]	05:14:57	23789
#0	pubmed clipboard	07:26:46	2

Changes in disability in older adults with generalized radiological osteoarthritis: a role for physical activity?

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To be submitted

REDUCING
THE IMPACT OF
GERIATRIC
CONDITIONS BY
PHYSICAL
ACTIVITY

CHAPTER

3

Abstract

Introduction

To report on factors associated with changes in disability after 5 years, with a special focus on physical activity (PA) in community dwelling older adults (55+) with generalized radiological osteoarthritis (GROA).

Methods

Assessment of GROA (in hand, knee and/or hip) and disability (Health Assessment Questionnaire) in a prospective study. A good outcome at follow-up was defined as improved or mild disability, and a poor outcome as worsened or severe disability. Factors potentially associated with outcome were baseline demographics, joint complaints, other chronic health problems or limitations (BMI, number of chronic conditions, cognition) and level of different types of PA.

Results

A total of 309 community dwelling older adults with GROA showed mild to moderate disability with minor increases in 5 years. At baseline PA levels decreased with increasing disability especially in sport and walking. PA was univariately associated with a better outcome at follow-up, but when adjusted for other factors only higher age, having knee pain and stiffness and having more than 2 other chronic conditions were associated with negative changes in general and lower limb disability, but not with upper limb disability.

Conclusion

This is the first study to report that community dwelling older adults with generalized radiological OA show moderate levels of disability, and that reduced levels of disability are associated with physical activity but when adjusted for other confounders this association is lost. Further research is needed to study which (physical activity) recommendations can be made to reduce and prevent disability in this group.

Introduction

Osteoarthritis (OA), the most common form of arthritis, is an important cause of impairment, functional limitations, and disability, especially in older populations. Worldwide, OA affects 9.6% of men and 18.0% of women aged 60 years and older ¹ and is expected to become the fourth leading cause of disability in 2020 ¹⁻³. In Western countries, OA is the most common chronic disorder and, given the aging population, it is becoming a growing public health problem.

OA has a substantial impact on physical performance and disability, with 80% of patients having some limitation of movement, and 25% not being able to perform major activities of daily living ⁴. The course of disablement via impairments and limitations to disability ⁵ is described as slowly in patients with knee and hip OA, but shows great variations among individual persons ^{6,7}. High quality longitudinal studies are therefore necessary to identify protective and risk factors. From these, *functional decline* in knee or hip OA is shown to be associated with poor body functions, higher comorbidity, poor cognitive functioning, reduced range of motion, decreased muscle strength, increased pain, low vitality, avoidance of activity, and higher age ^{7,8}.

Factors associated with a high risk of *incident disability* in patients with OA include pain, muscle weakness, poor aerobic capacity, and disease severity ³. Heavier weight, increased varus-valgus laxity, higher proprioceptive inaccuracy, older age, and more intense knee pain are associated with *progressive disability*. In contrast, greater strength, better mental health, higher self-efficacy, more social support seem to be protective ⁹⁻¹¹.

In general, physical activity has a complex relationship with OA and subsequent limitations and disability. Strenuous occupational tasks and high-intensity competitive sports are risk factors for incident OA of the hand, hip, and knee ^{3,12-14}. There is debate on which type or intensity of physical activity is associated with degeneration of joint tissue and which is protective. One study found moderate/strenuous exercise associated with cartilage damage compared to light levels of exercise ¹⁵. In a study by Verweij et al. ¹⁶, physical activities that require a low muscle strength (e.g., light household work) or a high mechanical strain (e.g., dancing and playing tennis) were found to be associated with an increased risk of OA of the knee, whereas high-intensity activities did not seem related to clinical OA of the knee. Other studies did not find an association between non-specified lifelong physical activity and risk of (radiological) OA of the knee ^{17,18}.

In longitudinal studies in older adults with knee or hip osteoarthritis higher physical activity levels have been associated with a slower decline in function ¹⁹. There is evidence for the role of physical activity in preventing or slowing down disability ²⁰ but less is known about its role in community dwelling older adults with OA, especially those with OA in other joints than knee or hip and in those with OA in multiple joints.

The joints most commonly affected by OA are those of the knee, hip, hand, foot, and

spine²¹. Associations between OA of different joints have been reported, indicating that poly-articular subsets of OA exist^{13,22,23}, such as between knee and hand OA²⁴⁻²⁸, hand and hip OA^{26,28,29}, and foot-hand and foot-knee³⁰. These results suggest that generalized OA may be a distinct disease in which systemic (genetic) predisposition plays a more important role than local (mechanical) factors^{23,31,32}.

Although there are studies that report higher levels of disability in patients with OA in multiple joints compared to patients with only a single affected joint³³, not much is known about the levels of disability in community dwelling older adults with generalized OA, and how levels of disability change over time. Given the lack of a cure for OA, prevention of functional limitations and disability is important in order to reduce the burden of disease from the perspective of both patients and society, especially if multiple joints are simultaneously affected.

Objective

The aims of this study were to establish the level and change in disability in a cohort of older community living adults with generalized radiological osteoarthritis (GROA) and to identify factors associated with changes in disability, including several types of physical activity.

Methods

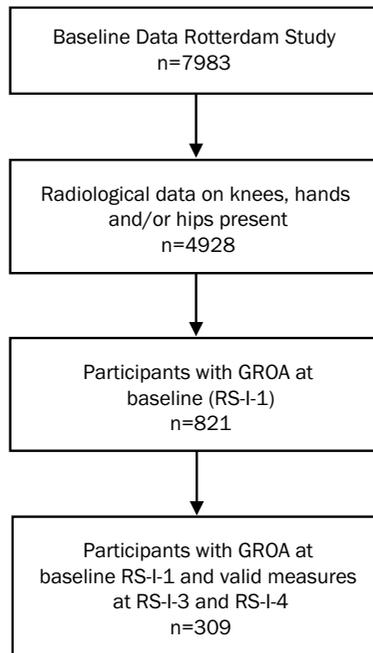
Study design

The data were collected in the Rotterdam Study, a prospective study of a cohort of men and women aged 55 years and older. The aim of the Rotterdam Study is to investigate the incidence of, and risk factors for, chronic disabling diseases^{34,35}. All inhabitants of the district of Ommoord in Rotterdam (n= 10,275) were invited to participate. At baseline (RS-I-1, 1990–1993) 7983 subjects participated (response of 78%). In a home interview, trained interviewers collected information on demographic characteristics, medical history, risk factors for chronic disease, and therapeutic drug use. Radiographs of joints were taken at the research center. The same complete measurements were repeated between 1997 and 1999 (RS-I-3), with an average follow-up time of 6.5 years and between 2002-2004 (RS-I-4). Data on physical activity were registered at the second follow-up measurement (RS-I-3). Therefore for this study we used the RS-I-3 measurement as baseline and the RS-I-4 measurement as follow-up. GROA cases were defined based on data from RS-I-1 (1990-1993) due to the fact that radiological data were not present at the RS-I-3 measurement.

For our study, a subsample of the Rotterdam Study was used consisting of participants for whom radiographic data on hands, knees, or hips were available at baseline (n=4928). In this sample, there were complete sets of radiographs of the hands for 5530 participants, of the knees for 5649 participants, and of the hip for 5620 participants. Radiographs of the hands (standard anteroposterior) were scored for six individual radiographic features

of OA in five distal interphalangeal joints, four proximal interphalangeal joints, and the first carpometacarpal joint. Each joint was graded for overall radiological OA using a modified Kellgren-Lawrence (KL) scale from 0 to 4³⁶. Presence of radiological OA was defined as a Kellgren-Lawrence grade 2 or higher in individual joints.

Anteroposterior radiographs of the hip and knee were taken with the subject in a standing position. Radiographs of the pelvis were obtained with both feet in 10 degrees internal rotation and the x ray beam centered on the umbilicus, and of the knee with the patellae in central position. Radiological OA in knee or hip was present if either the left or right joint was scored Kellgren-Lawrence grade 2 or higher.



GROA = ROA in at least hand + either one of the knee or hip joints
(G)ROA = (Generalized) Radiological Osteoarthritis

Figure 1: Flowchart

We used a definition for generalized OA which requires presence of radiological OA in the hand (2 out of 3 hand joint groups (distal interphalangeal, proximal interphalangeal joints or carpometacarpal joint) with at least 1 joint (KL \geq 2) combined with radiological OA in either one of the knee or hip joints. From the total of 4928 cases with radiological data that were analyzed, 821 (6.9%) could be classified with generalized radiological OA at baseline (RS-I-1) according to this definition. Subsequently, all cases were selected that had complete measurements on disability at RS-I-3 and RS-I-4. This resulted in a total of 309 cases selected for this study (figure 1).

Data collection

Demographic data concerning age, sex, education and marital status were collected at the baseline interview. Height and weight were measured at physical examination, with participants wearing indoor clothing without shoes. Body mass index (BMI) was calculated as weight (kg) divided by height (m²).

Disability was assessed at baseline (RS-I-3) and at follow-up (RS-I-4) with the Disability Index of the Stanford Health Assessment Questionnaire (HAQ)³⁷. The 24 questions in eight domains of the HAQ (dressing and grooming, rising, eating, walking, hygiene, reaching, grip and common daily activities) result in a score for general disability (including all domains; Cronbach's alpha in this dataset = 0.94), upper limb disability (including items from the domains dressing and grooming, eating, hygiene, reaching and grip; Cronbach's

Disability level	Follow up			
	None	Mild to moderate	Moderate to severe	Severe to very severe
Baseline				
None	<div style="display: flex; flex-direction: column; align-items: center; justify-content: center;"> <div style="margin-bottom: 10px;">None</div> <div style="margin-bottom: 10px;">Mild to moderate</div> <div style="margin-bottom: 10px;">Moderate to severe</div> <div>Severe to very severe</div> </div>			
Mild to moderate				Poor Outcome
Moderate to severe		Good Outcome		
Severe to very severe				

Figure 2: Definitions of good and poor outcome in disability transitions. The shaded area refers to a good outcome

alpha=0.94) and lower limb disability (including items from the domains rising, walking, reaching and common daily activities; Cronbach's alpha = 0.89). Answer categories range from 0 (no difficulty), 1 (some difficulty), 2 (much difficulty) to 3 (unable to do), resulting in a scale ranging from 0 to 3, with a higher score indicating more disability. Four categories of disability were formed³⁸: none (score of 0), mild to moderate (0-1), moderate to severe (1-2), and severe to very severe (2-3). Then, using data from baseline and follow-up, a distinction was made between 'good outcome' and 'poor outcome' based on Sharma et al. (4). A 'good outcome' meant that, at follow-up, a patient was classified in a lower disability category or remained in the 'none' or 'mild to moderate' category, and a 'poor outcome' meant that a patient was classified in a higher disability category or remained in the 'moderate to severe' or 'severe to very severe' category (figure 2).

Data on pain and stiffness, the most common joint symptoms of OA, were collected during the home interview. Participants were asked the following question about pain: did you have

pain in the (right, left) hand (knee, hip) during the last month (yes/no)?, recoded into three variables at baseline and at follow-up: pain present in hands, pain present in hips, pain present in knees. Likewise, the presence of morning stiffness was established with the following question: do you suffer from morning stiffness in your joints when you get up in the morning (yes/no)? For analysis, results were dichotomized into presence of stiffness in either knee, hip, or hands.

To control for co-morbidity the number of recorded chronic conditions (depression, Parkinson disease, diabetes, hypertension, myocardial infarct and stroke) was used dichotomized in 0-1 versus 2 or more conditions, as well as the number of used medications as a continuous measure. Also for cognition measured with the Mini Mental State Examination (MMSE)³⁹ a continuous variable was included ranging from 0-30 with a higher score indicating better cognitive performance. Finally, visual impairment was included measured with a questionnaire and dichotomized being visually impaired or not.

Physical activity was measured at baseline with a self-report scale in which respondents were asked to report the time spent on activities during a usual week and transferred to an average per day. Activities are divided in four categories: walking & cycling (including walking or cycling if carried out for transfer), domestic activities (light, moderate, and heavy), sports (ballgame, exercising on music, playing billiards, dancing, gymnastics, stretching exercises, rowing, ice skating, shovel board, tennis, fishing, swimming and other sports), and leisure time activities (gardening and do-it-yourself jobs).

A summary score per activity category was calculated by multiplying the number of hours per day with the appropriate metabolic equivalent task (MET value) from the Compendium of Physical Activity⁴⁰ and adapted for older adults¹⁶. A MET score of 1 represents the energy spent sitting quietly and is equivalent to 3.5 ml O₂ per kilogram of body weight per minute. Next to the four main categories a total score was computed, including all different categories.

Analysis

Descriptive statistics were used to describe the baseline variables of the study participants, and only for descriptive purposes the participants were divided into high levels and low levels of physical activity (based on the median value of the total PA level). Next, participants were divided into the good and poor outcome groups, as described above. On these, univariate analyses were performed to identify risk factors at baseline related to a poor outcome at follow-up. The two groups (good and poor outcome) were compared for differences in demographic variables (age, sex, marital status, education), BMI, subsets of generalized radiological OA (hip, knee, hip+knee), joint complaints (pain and morning stiffness), confounders (chronic conditions, medication, cognition and visual impairment) and physical activity. Continuous variables were tested with an independent samples t-test and nominal variables with a Chi-square test (Pearson). Lastly, a multivariate logistic

regression analysis was performed using a stepwise variable selection procedure. The criterion for selecting a variable in the model was a p-value of .05, with the exception of the different types of PA which were all entered but one (leisure time was not included due to the low number of cases present). Variables showing differences between the two outcome groups were selected as independent variables and a variable indicating poor outcome (1=yes, 0=no) was used as outcome variable in the logistic regression analysis. Odds ratios and 95% confidence intervals are reported. Data were analyzed with SPSS version 20.0. A two-sided p-value of lower than .05 was considered to be statistically significant.

Results

In our sample of older adults with generalized radiological OA, most participants had a combination of radiological OA of the hand and knee (75% out of 281 with complete data of knee and hand), and 12% had radiographic OA of all three joints (hand, knee, and hip). The average age of the participants with generalized radiological OA at baseline was almost 75 years; 72% of participants were female and 36% had only a lower level of education. The mean BMI at baseline was 28.5 kg/m² with almost 78% of participants being classified as overweight (BMI of 25 or more) with a large part being obese (BMI of 30 or more). Knee pain was present in almost half of these participants.

Participants with a higher level of overall PA were younger, lived together more, had less overweight, lower disability levels (upper and lower), had less pain in the hip, used less medication and were less visually impaired than those who were less physically active.

The mean disability scores on the Health Assessment Questionnaire was between 0.61-0.68 for overall disability and lower limb disability, and was 0.18 for upper limb disability. A minority (14.6%) of participants did not report overall disability at baseline (table 2a). Most participants had mild to moderate disability and 6 participants reported severe to very severe disability.

At follow-up, 31% of participants without baseline disability (13 out of 42) remained without disability, and in participants who changed disability mostly had become more severe. Of the 287 participants with complete HAQ data, 112 could be classified as having a good outcome and 175 as having a poor outcome in terms of general disability (table 2a). One hundred twenty seven participants would be classified as having a good outcome in terms of upper limb disability (table 2b) and 145 participants showed good outcome on lower limb disability (table 2c).

Table 1: *Baseline characteristics of all persons with generalized radiographic osteoarthritis (n=309)[†] and stratified for level of physical activity at baseline*

Variables	Baseline	Overall PA below median n=143	Overall PA above median n=144
Age in years	74.6 (6.8)	75.7 (6.9)	73.5 (6.6)**
Sex, female (%)	72.2	72.7	72.2
Only lower education [‡] (%)	35.6	30.8	41.7
Marital status (% living alone)	56.9	57.3	68.7*
BMI, kg/m ²	28.5 (4.6)	29.3 (5.0)	27.9 (3.9)*
BMI <20 (%)	0.7	0.8	0.7
BMI 20-25 (%)	21.2	16.7	25.4
BMI 25-30 (%)	45.7	41.7	49.3
BMI >30 (%)	32.2	40.9	24.6*
Hip ROA (%)	39.0	42.6	33.6
Knee ROA (%)	75.2	73.2	79.7
Knee + hip ROA (%)	12.4		
HAQ-DI score	0.68 (0.6)	0.82 (0.6)	0.54 (0.5)***
HAQ-ULD score	0.18 (0.3)	0.23 (0.4)	0.12 (0.3)***
HAQ-LLD score	0.61 (0.6)	0.73 (0.6)	0.49 (0.5)**
Pain complaints knee (%)	47.9	50.7	45.1
Morning stiffness knee (%)	20.6	23.2	18.1
Pain complaints hip (%)	25.9	31.0	20.8*
Morning stiffness hip(%)	8.1	9.9	6.2
Pain complaints hand (%)	37.8	40.1	35.4
Morning stiffness hand (%)	16.1	15.5	16.7
More than 2 chronic conditions (%)	21.0	21.7	22.2
Number of medications	3 (2.3)	3.3 (2.4)	2.7 (2.1)*
Cognition, MMSE	27.4 (4.6)	27.4 (2.4)	27.4 (1.8)
Visual impairment (%)	45.1	51.0	39.6*

[†] values are presented as mean (standard deviation) unless otherwise indicated

[‡] Primary education or primary education plus a higher not completed education

BMI=Body Mass Index; ROA=Radiological Osteoarthritis; HAQ=Health Assessment Questionnaire; DI=Disability Index; LLD=Lower Limb Disability; ULD=Upper Limb Disability; MMSE=Mini Mental State Examination.

* p<.05, ** p<.01, *** p<.001

The baseline relationship between physical activity and overall disability is visualized in figure 3. The overall level of physical activity declines in the more disabled participants. There is a significant decline in overall PA levels between the group with mild-moderate and moderate-severe group (F=4.89;df=286, p=.002). This is mainly caused by a significant decline in sports (F=1.48;df=261, p=.000) and walking/cycling (F=2.65; df=286;p=.049).

Table 2a: *Disability index levels at baseline and at follow-up (n=287)*

Disability level	n	Follow up			
		None	Mild to moderate	Moderate to severe	Severe to very severe
Baseline	287				
None	42	13	25	3	1
Mild to moderate	154	7	84	56	7
Moderate to severe	85	0	7	49	29
Severe to very severe	6	0	0	1	5

Table 2b: *Upper limb disability levels at baseline and at follow-up (n=287)*

Disability level	n	Follow up			
		None	Mild to moderate	Moderate to severe	Severe to very severe
Baseline	287				
None	159	40	110	7	2
Mild to moderate	118	9	75	33	1
Moderate to severe	9	0	2	6	1
Severe to very severe	1	0	0	1	0

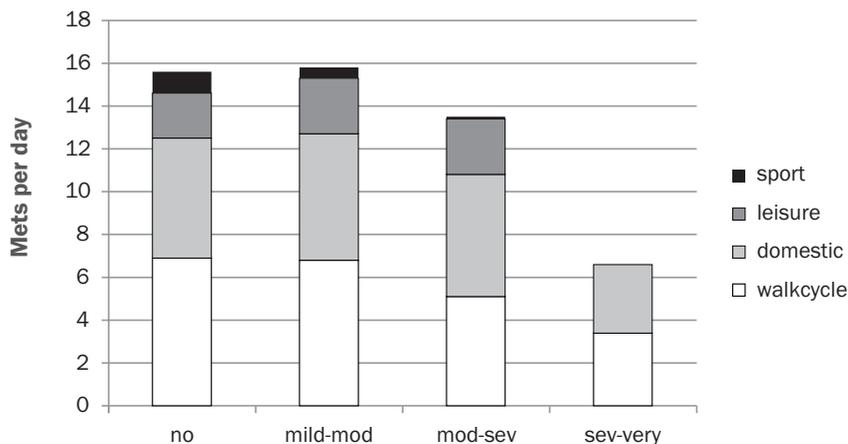
Table 2c: *Lower limb disability levels at baseline and at follow-up (n=287)*

Disability level	n	Follow up			
		None	Mild to moderate	Moderate to severe	Severe to very severe
Baseline	287				
None	68	39	23	5	1
Mild to moderate	136	16	76	39	5
Moderate to severe	78	0	11	50	17
Severe to very severe	5	0	0	3	2

There is also a significant decline in sports between the group with no disability and those with mild to moderate disability.

The severe-very severe group consists of only 6 participants, none of whom take part in sports. There is no difference in levels of activity between the different disability groups for domestic and leisure time activities which shows a fairly consistent level throughout the different levels of disability, severe-very severe excluded. Baseline and follow-up risk factors levels were compared between the groups with a good and poor outcome at follow-up. Participants with a poor general disability outcome were older, female, lived alone, had more overweight, reported pain and morning stiffness in knee and hip, had more chronic conditions and medications. They were also less physically active overall and specifically in walking/cycling and sport (table 3). Similar results were found for worsened lower limb disability (table 3). Only there was no association with living alone and instead of having pain and morning stiffness in hip joints (next to knee), only having pain in the hands predicted

a worse outcome. Again, being less physically active overall predicted worse outcome, specifically in walking/cycling and sports. Participants with a poor upper limb disability outcome had more morning stiffness in the knee, and more chronic conditions. There was no association between levels of physical activity and poor lower disability outcome.



Levels of baseline disability: no=no disability (n=42), mild-mod=mild to moderate (n=154), mod-sev=moderate to severe (n=85), sev-very=severe to very severe (n=6);

Figure 3: Baseline relationship between physical activity and disability

Multivariate stepwise logistic regression analysis was carried out and included all risk factors associated with disability outcome at follow-up as independent factors, including all physical activity measures (with the exception of leisure time activities). Table 4 shows that, corrected for all other variables in the model, older age, more overweight and more than 2 chronic conditions were associated with a poor general disability outcome at follow-up. Having more than 2 chronic conditions was the only predictor that came close to being associated with a poor outcome on upper limb disability, but did not reach a statistically significant level. Older age, having knee pain and stiffness and having more than 2 chronic conditions were associated with a poor lower limb disability outcome. None of the physical activity measures was multivariate associated with any poor disability outcome.

Table 3: Baseline risk factor levels in subjects with good versus poor outcome in terms of general disability[‡]

	General Disability		Upper Limb disability		Lower limb disability	
	Good (n=112)	Poor (n=175)	Good (n=127)	Poor (n=160)	Good (n=145)	Poor (n=142)
Age in years	72.1 (6.4)	76.2 (6.7) ^{***}	73.9 (7.0)	75.1 (6.7)	72.7 (6.7)	76.6 (6.4) ^{***}
Sex, female (%)	64.3	77.7 [*]	70.1	74.0	66.2	78.9 [*]
Only/lower education [‡] (%)	33.9	37.7	30.7	40.6	34.5	38.0
Marital status (% living alone)	28.6	52.0 ^{***}	40.2	45.0	37.2	48.6
BMI, kg/m ²	27.2 (4.2)	29.5 (4.6) ^{***}	28.0 (4.8)	29.0 (4.3)	27.9 (4.0)	29.3 (5.0) [*]
Hip ROA (%)	34.8	40.0	32.0	42.8	36.1	40.0
Knee ROA (%)	75.5	77.2	79.0	74.5	74.8	78.3
Knee + hip ROA (%)	9.1	15.5	9.0	16.0	9.9	16.2
Pain complaints knee (%)	34.8	56.3 ^{***}	40.9	53.5	37.2	58.9 ^{***}
Morning stiffness knee (%)	11.6	26.4 ^{**}	18.1	22.6 [*]	12.4	29.1 ^{***}
Pain complaints hip (%)	17.0	31.6 ^{**}	22.8	28.3	23.4	28.4
Morning stiffness hip (%)	2.7	11.6 ^{**}	9.5	6.9	7.6	8.6
Pain complaints hand (%)	33.9	40.2	41.7	34.6	29.7	46.1 ^{**}
Morning stiffness hand (%)	13.4	17.8	15.7	16.4	11.0	21.3 [*]
More than 2 chronic conditions (%)	10.7	29.1 ^{***}	15.7	16.4 [*]	13.8	30.3 ^{**}
Number of medications	2.4 (1.9)	3.4 (2.4) ^{***}	2.8 (2.3)	3.1 (2.3)	2.5 (2.0)	3.5 (2.5) ^{***}
Cognition, MMSE	27.6 (2.4)	27.3 (1.9)	27.6 (1.8)	27.3 (2.3)	27.6 (2.3)	27.2 (1.8)
Visual impairment (%)	38.4	49.7	44.9	45.6	40.7	50.0
PA walking/cycling [†]	7.3 (5.8)	5.5 (5.0) ^{**}	6.0 (4.9)	6.4 (5.8)	6.9 (5.3)	5.5 (5.4) [*]
PA sports [†]	0.7 (1.3)	0.3 (0.8) ^{**}	0.6 (1.2)	0.4 (0.9)	0.6 (1.3)	0.3 (0.7) ^{**}
PA leisure [†]	1.9 (2.7)	1.4 (2.2)	2.1 (2.9)	1.3 (1.9)	2.0 (3.3)	1.1 (1.8)
PA domestic [†]	6.2 (3.7)	5.5 (2.7)	5.5 (3.1)	5.9 (3.2)	6.1 (3.6)	5.4 (2.6)
PA total [†]	14.8 (7.8)	11.2 (6.5) ^{***}	12.7 (6.6)	12.5 (7.7)	14.0 (7.8)	11.1 (6.6) ^{***}

[‡] values are presented as mean (standard deviation), unless otherwise indicated; ^{*} Primary education or primary education plus a higher not completed education; [†] in MET per day
^{*} p-value < .05; ^{**} p-value < .01; ^{***} p-value < .001

Table 4: *Multivariate stepwise logistic regression results for baseline; presented are those variables that contributed significantly to the model*

	Disability Index [‡]		Upper Limb Disability [*]		Lower Limb Disability [†]	
	Adj. OR	95% CI	Adj. OR	95% CI	Adj. OR	95% CI
Age	1.09	1.03-1.15	ns		1.09	1.03-1.14
BMI	1.13	1.04-1.23	ns		ns	
Knee pain	ns		ns		2.00	0.99-4.02
Knee stiffness	ns		ns		2.40	0.97-5.89
> 2 chronic conditions	4.99	2.01-12.41	1.82	0.98-3.38	2.20	1.04-4.66

[‡] adjusted for sex, marital status, knee pain, knee stiffness, hip pain, hip stiffness, number of medications, physical activity (sport, walking/cycling, domestic, total)

^{*} adjusted for knee stiffness, physical activity (walking/cycling, sport, domestic, total)

[†] adjusted for sex, BMI, hand pain, hand stiffness, number of medications, physical activity (walking/cycling, sport, domestic, total)

Discussion

As far as we know, this is the first study to investigate changes in disability severity in community dwelling older adults with generalized radiological OA and to identify risk factors for a poor outcome at follow-up, including types of physical activity. Disability levels at baseline were low, and although there was an increase in disability 5 years later, the changes were minor for both lower and upper limb disability. Most participants in our study who reported disability indicated this as mild to moderate. Nonetheless, only a small percentage (5%) remained without any form of disability at follow-up.

Higher levels of disability as measured with the HAQ are usually reported in clinical populations with localized forms of OA⁴¹ as well as OA in multiple joints³³. Although our participants were not included on the basis of having clinical signs of OA, between 21-48% of the participants reported pain or stiffness in at least one joint during the past month. Nonetheless, the multivariate analysis showed that both symptoms did not contribute significantly to the poor disability outcome indicating that our population was not burdened severely by GROA. Even so, most participants were less able to carry out daily-life activities at follow-up than at baseline. Other studies also show that the self-reported physical functioning of patients deteriorates⁴² albeit slowly and with individual differences^{6,7}. Fortunately, few of our participants were classified in a higher disability class at follow-up, comparable with a study reporting longitudinal HAQ data showing minor, yet clinically significant decline⁴³. Within the total cohort of the Rotterdam Study, disability at follow-up (RS-I-3) showed lower levels, with 49% showing no disability (7% in our GROA sample), 16% with severe disability (15% in our GROA sample) and especially mild to moderate levels were higher in our GROA sample (80% vs. 18% for the total cohort)⁴⁴.

In this group with generalized radiological OA, there was a greater impact on lower than upper limb disability, despite the high prevalence of hand OA. Other cross-sectional data

on disability, as measured with the HAQ questionnaire, have shown that OA of the knee in general leads to higher levels of (unadjusted) disability than OA of the hand or hip, with disability being greatest with a combination of OA of the hand and knee³³. Another -cross-sectional- study revealed similar HAQ disability levels for OA of the hand and knee, although this study included younger adults⁴¹.

Higher levels of PA at baseline were related to disability status, with declining volumes of physical activity with increasing disability levels. This was especially true for sport. Domestic activities seemed to be rather robust for increasing disability levels. These type of activities offer less choice than sports activities and therefore need to be carried out even when pain or stiffness occur. This might provide directions for future exercise programs as previous studies have shown that even low-level physical activity can prevent or slow the progression of functional limitations to disability in older adults^{45,46}. It also may open ways for recommendations for older adults regarding physical activity in general. Current recommendations state that patients with diagnosed OA should avoid high-intensity and long-lasting activities, such as sport and occupational activities, and especially if patients experience pain when carrying out these activities. Different types of structured activities are recommended if carried out without pain and if not associated with increased risk of trauma¹³. Knowledge of which type or domain of activities is associated with lower levels of disability is needed¹⁶.

We found that being physically active was associated with a better outcome at follow-up univariately. Poor outcome on general disability as well as lower limb disability was associated with overall physical activity and sport as well as walking/cycling. Participants with a poor outcome at follow-up were less physically active in these domains. Several explanations for this associations can be discussed. First of all, those participants who have lower levels of disability (at baseline) or better outcome (at follow-up), can keep up higher intensity activities such as sports. In this respect these participants could be classified as better survivors of OA. Alternatively, some types of physical activity, such as sports and exercise, have been found to mediate between symptoms (especially chronicity of pain) of OA and levels of disability⁴⁷. Also, is it known that aerobic exercise reduces the likelihood of a poor outcome in terms of self-reported and performance-based disability in patients with OA of the knee¹¹, even after correction for strength and proprioceptive inaccuracy.

When corrected for other predictors there was no longer an influence of baseline physical activity on disability outcome. The same results were found in a study looking at adults with knee OA and functional performance as outcome where associations lost significance after adjusting for health and socio-demographic factors¹⁹. In our study older age, being overweight, knee pain and stiffness and especially having 2 or more chronic conditions were associated with a negative change in disability over a period of 5 years. These findings are consistent with results reported for localized forms of OA^{10,11,42,48,49}. Age was earlier identified as a strong predictor of disability in the total cohort of the Rotterdam

Study^{44,50}. BMI is known to be a risk factor for progression of OA of the knee and, to a lesser extent, hip and has been linked to functional outcome of OA of the knee¹¹. The disabling effect of chronic conditions, especially in the case of co-morbidity has already been well established^{51,52}, also in the total cohort of the Rotterdam Study⁵³ and showed the strongest association in our sample with an increased risk up to 5 times.

Symptoms such as pain are not only known determinants of functional limitations and disability⁵⁴ but also have been identified as mediators between physical activity and functional limitations in osteoarthritis⁵⁵. Fear of pain during activities can lead to avoidance of physical activity and thereby increasing the impact of OA and disability^{56,57}. Again this shows that the relationship between physical activity and osteoarthritis is a complex one. The population of our study underwent this relationship in everyday normal life and could benefit from specifically designed programs for exercise in OA in the future, especially those who target knee OA⁵⁸⁻⁶⁰.

Limitations of this study

This study had several limitations. First, since there is no consensus on a definition for generalized OA²², we had to make a choice. The currently used definition was partly based on the availability of radiological OA data in the Rotterdam Study. Other definitions stipulate at least three sites with radiological evidence⁶¹, with an emphasis on hand, neck, lower back, and knee joints, or define subsets of generalized OA²⁵. The contribution of OA of the hip to the definition is debated²⁹. In the absence of clear consensus on a definition of generalized OA or generalized radiological OA, investigators should clearly state what definition they use. Although these data come from a prospective cohort, we had to define our sample at the original study baseline but use the first follow-up as baseline to include physical activity as it was only measured once. This means our baseline data on radiological OA status are probably underestimated and potential changes in the severity of radiological OA could not be addressed. Given the weak association of radiological OA with disability this will probably not influence our results much³⁶.

Conclusion

In conclusion, this is the first study to report that community dwelling older adults with generalized radiological OA show moderate levels of disability, and that reduced levels of disability are associated with physical activity but when adjusted for other confounders this association is lost. Higher age, overweight and a higher number of chronic conditions do lead to a poorer outcome in terms of disability. Further research is needed to study how to address these factors and which physical activity recommendations can be made to reduce and prevent disability in this group.

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**Reducing the impact of geriatric conditions by
physical activity**

Does improved functional performance help to reduce urinary incontinence in institutionalized older women? A multicenter randomized clinical trial

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REDUCING
THE IMPACT OF
GERIATRIC
CONDITIONS BY
PHYSICAL
ACTIVITY

CHAPTER

4

Abstract

Introduction

Urinary incontinence (UI) is a major problem in institutionalized older women. Management is usually restricted to dealing with the consequences instead of treating underlying causes such as bladder dysfunction or reduced mobility.

The aim of this multicenter randomized controlled trial was to compare a group-based behavioral exercise program to prevent or reduce UI, with usual care. The exercise program aimed to improve functional performance of pelvic floor muscle (PFM), bladder and physical performance of women living in homes for the elderly.

Methods

Twenty participating Dutch homes were matched and randomized into intervention or control homes using a random number generator. Homes recruited 6-10 older women, with or without UI, with sufficient cognitive and physical function to participate in the program comprising behavioral aspects of continence and physical exercises to improve PFM, bladder and physical performance. The program consisted of a weekly group training session and homework exercises and ran for 6 months during which time the control group participants received care as usual. Primary outcome measures after 6 months were presence or absence of UI, frequency of episodes (measured by participants and caregivers (not blinded) using a 3-day bladder diary) and the Physical Performance Test (blinded). Linear and logistic regression analysis based on the Intention to Treat (ITT) principle using an imputed data set and per protocol analysis including all participants who completed the study and intervention (minimal attendance of 14 sessions).

Results

102 participants were allocated to the program and 90 to care as usual. ITT analysis (n=85 intervention, n=70 control) showed improvement of physical performance (intervention +8%; control -7%) and no differences on other primary and secondary outcome measures. Per protocol analysis (n=51 intervention, n=60 control) showed a reduction of participants with UI (intervention -40%; control -28%) and in frequency of episodes (intervention -51%; control -42%) in both groups; improvement of physical performance (intervention + 13%; control -4%) was related to participation in the exercise program.

Conclusions

This study shows that improving physical performance is feasible in institutionalized older women by exercise. Observed reductions in UI were not related to the intervention. [Current Controlled Trials ISRCTN63368283]

Introduction

Urinary incontinence (UI) is one of the major problems in the geriatric population with high impact on quality of life in the community dwelling¹ and the institutionalized older adults². High prevalence^{3,4} and incidence rates are reported⁵, especially among older women in long-term care facilities with prevalence running between 50 to 90%^{6,7}.

Although conservative treatment for UI, such as pelvic floor muscle training (PFMT) and bladder training (BT), have been proven effective in both adult women⁸⁻¹⁰, and community dwelling older adults^{11,12}, current practice for institutionalized women focuses on managing the consequences by providing incontinence pads and toileting assistance^{7,13,14} instead of treating underlying conditions or causes of UI.

Functional decline of cognition and mobility are among the most important independent risk factors for UI in community dwelling women¹⁵⁻¹⁷, and in older women living in institutions⁶. A decline in mobility may even lead to UI with no urogenital pathology, therefore addressing functional decline in order to prevent or reduce UI in older adults seems to be a promising strategy¹⁸.

Strategies such as prompted voiding and individual physical training have been shown to have a positive effect on frail nursing home residents. These interventions significantly reduce the frequency of incontinence episodes and improve mobility endurance^{19,20} even in people with mental and physical impairments^{2,12,21,22}. The main disadvantages of these interventions are the increased workload for nursing staff and high costs which could obstruct large-scale implementation. Recent reviews report that there is still a lack of prevention studies on maintaining continence in care homes and that factors associated with incontinence need to be considered^{23,24}.

For these reasons it would be worthwhile to develop a strategy that targets the main causes and risk factors of UI without increasing the workload for nursing staff in long-term care facilities.

To evaluate such a strategy we developed a group-based physical exercise program to be delivered by physical therapists. It consisted of exercises that target the functional causes of UI both directly by strengthening of the pelvic floor muscles and bladder training, and indirectly by improving physical performance relevant to continence behavior.

Objective

The aim of this study was to evaluate the effectiveness of this group-based program by improving functional performance in institutionalized older women. We hypothesized that on comparing a group of participants in the exercise program with those receiving usual care, the number of participants with UI and the frequency of UI episodes would be reduced and physical performance relevant to continence behavior (mobility, dexterity etc.) would be improved.

Methods

Study design

In designing the trial and developing the intervention, results from an epidemiological study into urinary incontinence in homes for the elderly were used ⁷. One finding was that despite the high prevalence of UI in homes for the elderly, there was still a taboo among residents on talking about these problems or addressing them in public. For this reason, the intervention was designed to also include women without UI, thereby avoiding the stigma of UI when participating. The goals of the intervention for the participants were to prevent development of UI and to improve physical performance. To avoid contamination between the intervention and the control groups, it was decided to allow only one intervention or one control group per home, and randomize on the level of the home.

The study was approved by the TNO medical ethics committee. This report has been drafted in accordance with the CONSORT criteria ²⁵ and adds to a previously published Dutch report of this study which included the per-protocol analysis ²⁶ and is now elaborated in this report with an Intention to Treat analysis on imputed data focusing on functional performance.

Power calculations revealed that to be able to show a 20% overall reduction in UI, 103 participants per group (power 0.8; alpha=0.05) were needed. A multilevel design with the same number of participants, 10 homes per group and an Intra Class Correlation (ICC) of 0.05 would make a reduction of 23% detectable. We aimed to recruit 103 participants per group, with 7 extra per group to adjust for withdrawal.

A multicenter, randomized controlled trial was carried out to evaluate the exercise program 'Incondition'. Homes for the elderly were recruited via a newsletter distributed by the National Organization for Institutionalized Care in the Netherlands and through direct mailing. In total, 27 homes were interested 20 of which finally agreed to participate. Homes that withdrew feared that in cooperating with the study the workload for staff members would be too large. Participating homes were matched and randomized into either the intervention condition (Incondition program) or the control condition (care as usual). Matching was done to assure that intervention and control homes were comparable by using the following factors: prevalence of UI and use of incontinence pads, number of residents, percentage of residents receiving psychogeriatric care (i.e. for dementia), number of staff members, percentage of residents with impaired mobility, and average level of care per participant in minutes. These data were provided by the participating homes. Matched pairs were randomized using a random number generator. Comparing participating homes using these factors showed that intervention and control homes were comparable, with the exception of the percentage of use of incontinence pads which was slightly higher in the control homes (100% vs. 89% of the homes).

Before randomization, participating homes were asked to recruit between 6-10 residents. Homes that recruited less than 6 residents were excluded. Inclusion criteria for participants

were being female and having sufficient cognitive and physical function to allow them to participate in the program. Residents who were catheterized were excluded. Inclusion criteria were initially evaluated by staff and at baseline measurement checked with validated instruments. Cognitive function was measured with the Cognitive Screening Test (CST)²⁷; participants with a score of 9.6 or lower were excluded. The Barthel Index²⁸ was used to exclude those who could not use the toilet independently. Eligible residents were contacted by staff members and given written and oral information on the study. All residents who agreed to participate filled out an informed consent form before taking part. Measurements were taken at baseline, halfway through (3 months), and at the end of the intervention period (6 months). Measurements, including an interview and physical tests, were carried out by students trained in physical therapy (blinded). For additional self-report measures (i.e. bladder diary), staff from the participating homes (not blinded) assisted participants (not blinded).

Intervention

The intervention was based on the results of a previous inventory in Dutch homes for the elderly⁷. It addressed the main causes of UI in this population: strength of pelvic floor muscles, bladder control and mobility. It had to be accessible, fun, easy to understand, of low intensity, and interesting for women both with and without UI. The Incondition program consisted of weekly, 1-hour training sessions for groups of 6–10 women over a period of 22 weeks.

Each session consisted of behavioral instructions and physical exercises. The behavioral element aimed to improve the control of micturition by improving knowledge about continence, improving toilet behavior (position, relaxation etc.), BT, and PFMT including relaxation and breathing.

The aim of the physical exercises was to increase the functional ability to use the toilet independently and in time. Exercises were kept functional and pleasant, and used materials to enhance compliance. The 30-minute exercise session included warming up, exercises to improve the mobility of the upper extremities, hand function, standing up and sitting down on a chair or bed, walking, and cooling down.

Participants received a written leaflet containing guidelines on good toilet behavior and micturition. After each session, homework exercises were given, if possible on an individual basis, and evaluated at the start of the following session. The intervention was delivered by physical therapists specialized in PFMT who had experience with group training and affinity with the elderly. The physical therapists received special training to carry out the intervention correctly.

At the end of the program, data on compliance, reasons for missing sessions and for dropping out, general opinion of the program, subjective improvement, and adverse effects of the program were collected.

The participants in the control group received care as usual, including prescription of incontinence pads (100% of participants with UI) and toilet assistance.

Data collection

Primary outcome measures were UI status, severity of UI and physical performance. Physical performance was measured with the Physical Performance Test (PPT) which assesses multiple domains of physical function by timing how long it takes to perform tasks of varying degrees of difficulty (i.e. writing a sentence, putting on and taking off a jacket, turning around 360 degrees, walking 15 meters)²⁹. Total score ranges from 0 (worst) to 28. Next, involuntary urine loss was measured using a 3-day bladder diary to evaluate the presence and severity (i.e. frequency of episodes) of urinary loss. Participants, assisted by their caregivers, recorded micturition and fluid intake (the latter only at three months). For each participant UI status was defined in two ways. First UI status was defined as having at least one episode of involuntary urine loss during this 3-day period, resulting in yes or no UI. Secondly, UI frequency was defined as the total number of episodes during 3 days.

Secondary outcome measures included quality of life measured with two self-report questionnaires: the SF-12 questionnaire which describes the mental and physical health status of adults³⁰, score ranges from 0 (worst) to 100, and the Incontinence Quality of Life Instrument (I-QOL)³¹ which contains 22 items that measure incontinence-related quality of life, with a total score ranging from 0 (worst) to 110.

At baseline, descriptive statistics included information on age (years), level of education (low, intermediate, high), length of stay (months), physical disability, cognition, subjective symptoms of urinary and fecal incontinence, use of incontinence pads, and comorbidity (number of chronic diseases). The level of physical disability was assessed with the Barthel Index²⁸, which consists of 10 items concerning basic activities of daily living (ADL). Scores range from 0 to 20, with a higher score indicating greater independence.

Cognition was evaluated with the 14-item version of the Cognitive Screening Test²⁷. The maximum score of 14 indicates normal cognitive function. All other measures were part of the interview.

Analysis

Two separate analyses were done to evaluate the effect of the program: 1) Intention to Treat (ITT) analysis performed in all participants who started the Incondition program, or care as usual, and 2) a per protocol analysis of the data of all participants who completed the study and for the intervention group those who had attended a minimum of 14 sessions. For the ITT analysis, linear and logistic regression analyses were performed using the baseline measure as confounder. We restricted the use of mixed-effects multilevel analyses to those cases of significant differences between intervention and control groups because the imputation program used to enhance the data set did not take the multilevel structure of

our data into consideration. We used Multivariate Imputation by Chained Equations (MICE) R version 2.12.2³². The main reason for imputation was that caregivers were not always able to assist participants with their bladder diaries, some of which were not completed properly. In addition, participants were not always able to comply due to illness or absence. The imputation model included all outcome measures and characteristics shown in table 1 and table 2, as well as the number of the home. In total, five predictions were conducted and then pooled to produce estimates and confidence intervals that incorporated missing-data uncertainty. P-values < 0.05 (two-sided) were considered statistically significant.

Table 1: *Baseline characteristics of intervention group and control group*

	Intervention group (n=85)	Control group (n=70)
Age, years (SD)	84.6 (6.5)	84.7 (5.7)
Education (n)		
High	14	6
Intermediate	19	20
Low	52	44
Cognition, 0-14 [‡] (SD)	12.7 (2.0)	12.7 (1.4)
Barthel index, 0-20 [‡] (SD)	16.1 (3.6)	15.4 (2.8)
Length of stay, months (SD)	61.6 (65.5)	42.1 (43.6)
Subjective urinary incontinence, participants (n)	46	39
Subjective fecal incontinence, participants (n)	31	20
Comorbidity, number of chronic illnesses (SD)	1.8 (1.9)	3.0 (2.3) ^{***}
Number of incontinence pads in 3 weeks (SD)	63.7 (43.6)	54.4 (31.2)

*** p<.001; † higher score indicates better performance

Results

After randomization, two of the control homes dropped out because they were not able to recruit the minimum of 6 participating residents. The remaining 18 homes enrolled a total of 192 participants, of which 22 withdrew before baseline measurement and 15 were not eligible.

Baseline characteristics (table 1), showed the average age of participants to be around 85 years, most having a lower level of education and an average stay in a home of 42-61 months. Slightly more than half of the study participants (54%) indicated they suffered from UI. They used an average of 54 to 64 incontinence pads every three weeks.

During the study period, 18 participants were lost to follow-up and 22 dropped out for various reasons (see figure 1). Lack of motivation and not being satisfied with the program or physical therapist were reasons for dropping out of the program (n=12). Of the participants who completed the study, 40% attended all training sessions, 30% missed one session, and

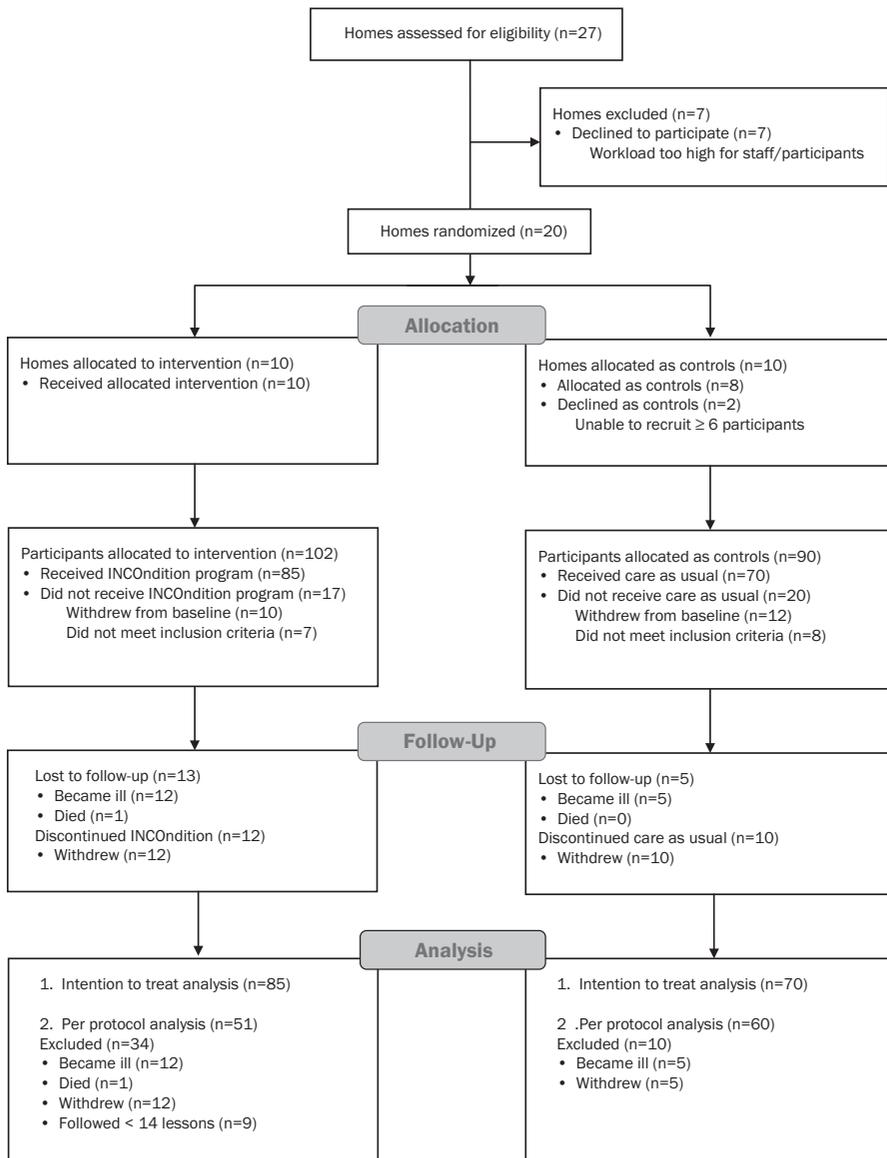


Figure 1: Study flowchart

30% missed two or more sessions. Illness and other appointments were reasons for missing sessions. More than 50% of the participants indicated they did their homework exercises, 11% did only the pelvic floor exercises, and 3% only the physical exercises; 25% did not do the exercises independently. Of the participants who did their homework exercises, 33% said they did them more than once a day, 25% once a day, and 20% more than twice a

week. About 65% of the participants indicated that they would certainly keep doing these exercises after the program had ended.

Table 2: Regression analysis for intervention (n=85) and control (n=70) group[†]

	Baseline T1	3 months T2	6 months T3	Test-statistic (T2-T1, T3-T1)
Number of participants with UI				
Intervention	40	37	40	0.66 (0.15,2.90);
Control	40	38	34	0.80 (0.34,1.88)
Frequency incontinence episodes (number/3 days); mean (SD)				
Intervention	8.0 (11.0)	6.6 (9.1)	9.0 (11.4)	-1.71 (-5.99,2.56);
Control	9.5 (11.5)	7.4 (10.1)	7.1 (9.6)	1.38 (-3.03,5.79)
Physical Performance Test (0-28 [†]); mean (SD)				
Intervention	17.2 (4.87)		18.5 (4.14)	-- ; 3.21 (1.81,4.62)***
Control	15.8 (5.16)		14.7 (4.27)	
Health Related Quality of Life SF-12 (mental; 0-100 [†]); mean (SD)				
Intervention	47.0 (14.2)		52.0 (10.0)	-- ; 0.07 (-4.24,4.39)
Control	46.0 (12.8)		51.3 (8.5)	
Health Related Quality of Life SF-12 (physical; 0-100 [†]); mean (SD)				
Intervention	34.7 (12.0)		38.3 (11.6)	-- ; 1.70 (-3.39,6.80)
Control	34.1 (10.1)		35.0 (12.1)	
Specific Quality of Life (I-QOL; 0-110 [†]); mean (SD)				
Intervention	68.9 (17.9)		65.7 (15.6)	-- ; -3.30 (-10.2,3.63)
Control	62.2 (17.7)		66.2 (15.6)	

*** p<0.001

[†] Corrected for chronic status † Higher score indicates better performance

The linear and logistic regression analysis performed over all participants that started the Incondition program or care as usual (n=155) showed, with the exception of physical performance, no differences in primary and secondary outcome measures (table 2). The number of participants with UI declined slightly in both the intervention and control groups, while the frequency of incontinence episodes increased slightly in the intervention group after a decline at three months compared with a steady decline in the control group. UI-related quality of life seemed to improve more in the control group, but if we adjust for the multilevel structure this was not statistically significant. Physical performance (PPT) significantly improved in the intervention group (+8%) compared to a decline in the control group (-7%).

In table 3 the per protocol analysis shows a decline of almost 20% of participants with UI (as registered with the bladder diary) at 3 months, and 40% at 6 months for those participating in the Incondition program. In the control group however, there was also a decline of 13% and 28% respectively. There was no significant difference between the two groups.

The frequency of incontinence episodes decreased by 27% at 3 months and by 51% at 6

months in the intervention group, and by 24% and 42%, respectively, in the control group. This did not prove to be significantly different between the two groups.

Physical performance (PPT) was significantly better in the intervention group (improved by 13%) than in the control group (- 4%). There was no difference in quality of life between the two groups. The SF-12 scores for mental and physical functioning showed no differences over time or between groups. The seemingly better scores of the control group on the I-QOL were no longer found after correction for baseline differences.

Table 3: Results Per Protocol Analysis for intervention (n=51) and control (n=60) group

	Baseline T1	3 months T2	6 months T3	Test-statistic
Number of participants with UI				
Intervention	29/51	25/51	18/51	Z=-.053 [‡]
Control	36/60	31/60	26/60	Z=-.531 [§]
Frequency incontinence episodes (number/3 days); mean (SD)				
Intervention	9.0 (12.2)	6.6 (9.6)	4.4 (7.4)	F=0.1
Control	9.3 (11.3)	7.1 (10.5)	5.4 (8.5)	
Physical Performance Test (0-28 [†]); mean (SD)				
Intervention	16.7 (4.7)		18.8 (3.9)	F=10.1 [*]
Control	16.4 (4.5)		15.7 (4.5)	
Health Related Quality of Life SF-12 (mental; 0-100 [†]); mean (SD)				
Intervention	51.4 (10.5)		49.9 (10.9)	F=1.5
Control	52.7 (10.1)		53.6 (7.7)	
Health Related Quality of Life SF-12 (physical; 0-100 [†]); mean (SD)				
Intervention	35.5 (11.0)		36.6 (11.2)	F=2.4
Control	34.7 (10.2)		32.4 (11.2)	
Specific Quality of Life (I-QOL; 0-110 [†]); mean (SD)				
Intervention	66.6 (15.0)		63.5 (15.0)	F=0.5
Control	59.1 (15.2)		66.1 (13.2)	

^{*} p<.01; [†] Higher score indicates better performance; [‡] difference between baseline and 3 months (Mann-Whitney Test)

[§] difference between baseline and 6 months (Mann-Whitney Test); ^{||} Corrected for baseline difference

More than 80% of the participants who completed the program considered it to be good to very good. Fourteen percent said the program was neither good nor bad, and 3% said it was bad to very bad. When asked if they had benefited from the program, 55% said they had benefited a lot, 11% a little, 15% were neutral, and 20% indicated they had not benefited. Almost 40% said they were better able to postpone or control micturition, 33% thought they had more information, 9% was especially satisfied with the contact with others, 7% reached the toilet quicker, and 5% indicated less loss of urine.

Ten percent of the participants in the program complained of muscle pain, fatigue, trouble with breathing or more involuntary urine loss.

Discussion

The exercise program 'Incondition' was developed to prevent or reduce urinary incontinence in older women in homes for the elderly and to improve physical performance. Participation in the intervention resulted in a small improved physical performance but a reduction in UI was reported only in compliant study participants and irrespective of group allocation.

Being able to improve physical performance is important since the inability to walk or transfer independently is associated with UI in frail older individuals^{15,33}. The improved physical performance in the intervention group did not lead to a reduction in UI. It might be that the improvement was too small for a change in UI or there were other more dominant causes that were not improved by the intervention. The exercise program itself was well received by most participants, considered satisfactory, and contributed to subjective improvement.

Interestingly enough these results show that reduction in UI in frail elderly women in homes for the elderly is possible, even without participating in an exercise program aimed at reducing the major causes of UI in this group. A possible explanation for the improvement in the control group could be that the close monitoring of incontinence by means of a bladder diary functioned as an intervention in itself. Other studies have found bladder diaries to be a way of modifying behavior³⁴. In addition, the extra attention given by caregivers may have supported a change in behavior. Thus, it may be more appropriate to consider the control group as a second intervention group that received attention and monitoring of UI. It is also known that UI in older persons is of a transient nature, arising suddenly and being related to reversible causes³⁵. In our sample, most participants had not received a diagnosis of UI from a doctor and were unaware of the cause of their involuntary urine loss. It should be pointed out that physical performance was the only outcome measure (primary or secondary) that was measured with an objective test while UI status was evaluated by self-report and the reported results therefor less reliable.

There was no significant effect on the quality of life measures. It may be that a small change in incontinence frequency or physical performance may not necessarily lead to a detectable effect on a general quality of life measure. Most participants had at least one other chronic condition and were dependent on care from others. Nevertheless, even in frail, functionally and cognitively impaired nursing home residents, changes in continence status have a negative impact on quality of life and need to be addressed³⁶.

Other studies have reported positive effects of PFMT and/or BT in elderly women with a 50%-74% decrease in incontinence episodes in community dwelling older people, including those who are homebound^{12,37}. However, these participants were younger, more highly educated, and more independent than our participants.

Other exercise programs have been proven effective in nursing home residents, and even in older individuals with mental or physical impairment. There was longer endurance, a

reduction in incontinence episodes²⁰, and subjective improvement of urine loss³⁸. Unlike 'Incondition', these programs use an individualized training schedule with assistance. In these types of program gaining compliance of the nursing staff is problematic²¹. Although group- and individual-based programs are equally effective in younger people³⁹, it is very well possible that disabled older individuals may benefit more from an individual approach. One study that evaluated such an approach in frail elderly women living in Dutch nursing homes, resulted in an improvement in UI status, but one that was not significantly different from the control group²². One of the aims in this study was to improve functional capacities by training toileting skills, which was, as in our study, the only significant result. According to the authors one reason for the lack of effect of the intervention, was the lack of motivation of participants, resulting in dropout and reduced power of the study²². Nevertheless these and other studies⁴⁰ show that in motivated frail elderly, functional improvement is feasible, even with relatively low intensity exercise regimes.

Limitations of this study

It proved difficult to recruit homes for the study. Some declined because of the anticipated high workload and expected difficulty with adherence to the research protocol, while others were unable to recruit the minimum of 6 participants.

Overall, there was a considerable dropout rate among participants during the study period. For disabled care-dependent women with several chronic conditions a relatively long study period can be too demanding⁴¹. Those who withdrew had relatively few or no symptoms and were therefore less motivated to complete the study. In younger women the level of severity of UI also influenced adherence to training⁴². However, in the imputation analyses we tried to account for possible selection bias by including all outcome measures and possible confounders described in table 1 and table 2 in the model. Unfortunately the imputation program did not take the multilevel structure for dichotomized outcomes into account. Therefore we did not apply multilevel analysis.

Resistance by participants and nursing staff to diagnostic testing meant it was impossible to establish the presence of UI through validated medical tests. This has two important implications. First, we had no information on the type, severity or cause of incontinence among participants. This means that the population studied was probably heterogeneous and may have been more receptive to individualized treatment approaches. Second, it proved impossible to establish the performance of the pelvic floor muscle and bladder function prior to and at the end of the program. Therefore, based on these results no conclusions can be drawn about the role of functional performance in causing or reducing UI. These limitations are not rare: heterogeneity of the population, lack of standardized terminology, lack of validated instruments, and lack of long-term follow-up are frequently encountered⁴³. Moreover, even our relatively simple measurements could not always be carried out as intended.

The frailty of the participants also meant that the training had to be of low intensity, which led to a longer training period which may have increased the dropout rate. This also influenced the adherence to the exercise regimen, which has been shown to be a consistent predictor of responsiveness to behavioral therapy¹².

It was not possible to reach our target of 103 participants per group and therefore enough statistical power. Because of drop out and possible selection bias, it is difficult to generalize our results to the entire population of homes for the elderly. The results from the per protocol analysis therefore only apply to participants, who are motivated, have serious UI symptoms, and do not need assistance with toileting. Over the course of our study, it became apparent that in most homes the emphasis is on controlling incontinence at an institutional level rather than on solving or preventing it at an individual level which may limit future implementation of effective incontinence interventions⁴⁴⁻⁴⁶. Staff of the homes, especially caregivers, had difficulty in maintaining the study protocol in participating clients and carrying out measurements. Some of this resistance originated from staff shortages and high workload. This shows that controlled studies in real life settings in which UI care is not a high priority is difficult. Nevertheless, fundamental changes in daily routine are necessary to implement effective interventions in incontinence care^{23,24,38}. In the Netherlands improvements have been made in this area including increased diagnostic testing for the cause of incontinence⁴⁷.

Conclusion

In conclusion, our results show it is feasible to improve physical performance in older women in homes for the elderly by a group-based exercise program, but this does not lead to a reduction in UI. These results also show that it is possible to reduce the problem of self-reported UI in women in homes for the elderly. Attention to and monitoring of UI seem already to have led to a decrease in the occurrence of UI and higher priority should be given to the prevention and reduction of UI in this care setting.

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The effects of an exercise program for older adults with osteoarthritis of the hip

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REDUCING
THE IMPACT OF
GERIATRIC
CONDITIONS BY
PHYSICAL
ACTIVITY

CHAPTER

5

Abstract

Introduction

Evaluation of an 8-week exercise program with strength training and lifestyle advice for older adults with osteoarthritis (OA) of the hip. Outcome measures were pain, hip function, disability, quality of life (QOL), and body mass index (BMI).

Methods

Randomized controlled trial. Inclusion criteria were age (≥ 55 years), clinical diagnosis of OA according to ACR criteria, and living independently. Interview and physical data were collected at baseline, post-test, and follow-up (3 months) by trained interviewers and physical therapists with validated instruments: Harris Hip Score, SIP, GARS, functional tests (walking, timed Up & Go, ascending and descending stairs and toe reaching), and VAS scales (pain and QOL). Data were analyzed on an intention to treat basis. Effect sizes were calculated.

Results

There were 109 participants (55 experimental, 54 controls). Fifteen participants dropped out; they were characterized by less tolerance to pain and younger age. The program had a positive effect on pain (moderate effect at post-test and small effect at follow-up), hip function (small effect at post-test), self-reported disability (small effect at follow-up), and the timed Up & Go test (small effect at follow-up). It did not affect QOL, other measures of observed disability, or BMI.

Conclusion

The exercise program had positive effects on pain and hip function, which are important mediators of disability. This study fulfilled a need for older adults with hip OA and provides evidence of the benefit of exercise in the management of hip OA.

Introduction

Osteoarthritis (OA) is a common locomotor disorder and the most common rheumatic disease. OA is more prevalent in older people. The rapid increase in the percentage of people older than 55 years in Western countries means that OA is becoming a public health problem¹. The most frequently affected joints are the knee and hip. Symptoms of OA, such as joint pain, tenderness, limitation of movement, crepitus, and variable degrees of local inflammation, are the most reported complaints at general practices. These symptoms often cause difficulties in performing normal daily activities^{2,3}. The prevalence of OA of the hip in general practice in the Netherlands is estimated to be 10 to 13 per 1000 patients, with a total incidence of 2.1 per 1000. Based on these figures it was estimated that in 1994 a total of 180,800 patients in general practice suffered from OA of the hip⁴. The total cost of OA is estimated to be about 303 million euro annually, accounting for 0.8% of the total Dutch healthcare budget⁵. About 75% of these costs are made by older adults (65 years and older).

There is no cure for (hip) OA, and the aim of treatment is to control the symptoms with painkillers, physical therapy, and, in severe cases, hip replacement. Disease-related factors, such as impaired muscle function and fitness, are potentially amenable to exercise intervention. Exercise therapy has been recommended as an important conservative treatment for OA⁶⁻⁸. Exercise therapy aims at reducing pain and disability by improving muscle strength, joint stability, range of motion, and aerobic fitness. However, there is little evidence for the efficacy of such programs for OA of the hip, as opposed to OA of the knee, and few studies have evaluated the long-term effects of such programs⁸.

The most recent systematic reviews^{9,10} only found four studies that included patients with OA of the hip¹¹⁻¹⁴. One review⁹ excluded all four because they did not meet the study inclusion criteria, and the other included only one study (including 71 patients with hip OA)¹³, which obviously limited the ability to draw conclusions about the benefit of exercise therapy for OA of the hip. No studies were found that evaluated exercise programs specifically developed for people with OA of the hip.

In 1997 a program called 'Hop with the Hip' was developed especially for people with OA of the hip.

Objective

This article describes the results of a randomized controlled trial involving 109 people with clinical symptoms of OA of the hip. We evaluated the short- and long-term effect of this 8-week exercise program on pain, hip function, self-reported and observed disability, quality of life, and body mass index (BMI).

Methods

Study design

Participants were older adults with complaints of OA of the hip. Inclusion criteria were age 55 years and older, clinical diagnosis of OA of the hip, and living independently. People who were on a waiting list for hip replacement (or who had a hip replacement in the past year) were excluded because an operation could affect their participation in the study and the program was not developed for a pre-surgery group. Other exclusion criteria were having serious disorders or impairments which jeopardized safe use of fitness equipment, such as neurological or cardiovascular problems, serious depression or dementia (as judged by general practitioners), and regular treatment by a physical therapist (more than once a week). Criteria were checked by means of a screening questionnaire (for details see diagnosis section) completed by all potential participants. The size of the experimental and control group (both 70) was based on a power analysis on the Harris Hip Score ¹⁵ (expected effect 10%, power 80%, alpha 0.05, one-sided testing).

Participants were recruited by means of announcements placed in regional newspapers, health centers, offices of general practitioners, and local television. The 140 people who responded were sent a short questionnaire to check for inclusion criteria. Thirty-one people were excluded because they did not meet these criteria (n=25) or withdrew from the study before the start (n=6). For details see the flowchart of the study in figure 1. All eligible subjects were asked to give written informed consent. The remaining 109 subjects were randomly assigned (using computer generated randomized numbers) to one of the two conditions: 55 subjects to the experimental group receiving the 'Hop with the hip' program and 54 subjects to the control group receiving no special interventions except their (self-initiated) contact with their own general practitioner.

Participants were tested at baseline, at the end of the program (post-test), and 3 months after the program ended (follow-up). All three assessments consisted of a written questionnaire filled out at home and a physical examination at the research center. The examination was carried out by one of three trained physical therapists who were blinded for the condition. The TNO Medical Ethics Committee approved the study.

Symptoms of OA were deemed present if:

1. the diagnosis of OA of the hip had been made by the general practitioner (checked via questionnaire);
2. clinical symptoms of OA, evaluated by physical therapists at baseline, met the criteria of the American College of Rheumatology of the hip ¹⁶, namely, pain in the hip together with endorotation ≥ 15 degrees, pain present at endorotation of the hip, morning stiffness less than or equal to 60 minutes after rising, and age > 50 years. Clinical OA

was also diagnosed when pain of the hip concurred together with an endorotation <15 degrees and flexion ≤ 115 degrees.

Data collection

Background variables Information about age, sex, marital status, education, income, occupation, self-reported health, number of chronic conditions, and number of medications was obtained. Body weight and height were recorded during the examination by a physical therapist. The BMI was calculated as body mass/height² and was used as an outcome variable (according to standard norms, acceptable ratios are in the range 20-25, a ratio of 26-29 considered to reflect overweight and a ratio > 30 obesity).

Compliance and Satisfaction Participants who followed the program were asked at post-test whether they performed home exercises as intended (expressed as the percentage of people that performed them regularly) and whether they exercised more or less outside the program. They could answer on a three point scale with '1' indicating more '2' equal and '3' less. Participants also judged the program on a scale from 1 to 10, with 1 indicating very bad and 10 excellent.

Pain Subjects rated tolerance and severity of pain in the past month on a 10-cm Visual Analogue Scale (VAS). A higher score indicated more severe pain or more intolerable pain. Pain was also measured with the pain subscale of the Harris Hip Score (HHS)¹⁵ by physical therapists who observed patients while performing standardized ADL activities and walking pattern. Scores range from 0 – 44, with a higher score indicating less pain.

Hip function The Harris Hip Score (HHS), which is treated as the primary outcome measure, consists of four variables: pain, functional capacity, range of motion, and deformity. The total score is 100 (patient functions without pain or limitations); a score of less than 70 reflects moderate/poor functioning^{15,17}.

Observed disability and activity restrictions Activity restriction was measured as the time (in seconds) it took to perform four functional tasks: 20 m walking with a turn halfway¹⁸, the timed Up & Go test¹⁹, ascending and descending stairs (combined score)^{11,18,20}, and reaching for toes in a sitting position (combined score of left + right)²¹. Toe reaching is measured on a 4-point Likert scale running from 0-4, with a lower score indicating greater litness.

Self-reported disability Self-reported activity restrictions were measured with the Groningen Activity Restriction Scale (GARS), which is a measure of the level of disability while performing 18 daily activities²². Scores range from 18 (no problems) to 72 (only with help of others). The Sickness Impact Profile (SIP) is a 136-item self-administered health status questionnaire which is behaviorally based²³. Two dimensions can be evaluated, psychosocial and physical, of which only the latter is reported here. The scale ranges from 0 – 100 which can be interpreted as the percentage of disability²⁴.

Quality of life (QOL) QOL was measured in two ways. Subjects rated their generic QOL on a

10-cm VAS and this was coded as a score between 0 and 10²⁵. A higher score indicates a better quality of life. In addition, Health-Related QOL (HRQOL) was measured as the sum score for 7 questions (range 7-39) regarding judgment of physical functioning (5-point Likert scale), psychological functioning (5 points), evaluation of own health (5 points), expectation of future functioning (in the next 2 years; 5 points), image of the future (5 points), happiness in last month (7 points), and satisfaction in last month (7 points). A higher score indicates a higher quality of life. The sum scale, which is presented here, shows good validity²⁶.

Intervention

The content of the intervention program was established in a pilot study²⁷. Briefly, using information from the literature, personal interviews with patients and health professionals, and protocols for referral, we determined that pain, hip function, (im)mobility, activities of daily living, eating habits and weight control, and use of aids were important elements to be included in the program. The program was developed in co-operation with a physical therapist, an occupational therapist, and a dietician.

The program 'Hop with the Hip' consists of 8, 1-hour weekly group sessions of strength training using fitness equipment under supervision of a physical therapist. Participants were also offered a home exercise program, personal ergonomic advice (given by an occupational therapist), and dietary advice (given by a dietician). Each training session started with group warming-up exercises, followed by instructions on and individual use of fitness equipment and exercises: leg press, leg raise, rotation in sit, leaping squat, pull down, treadmill, home trainer, pulleys, bow flex, and walking. The training session ended with group cooling-down exercises. The starting level of each participant was based on the Harris Hip Score at baseline. All fitness equipment could be used at two levels (light and moderate) and was adjusted as the program (and participant) progressed. A home exercise program was developed that included warming up/cooling down and specific exercises for the lower extremities. Feedback was given at each group session. The physical therapist informed participants about health-related aspects of OA, exercises, risk factors etc. Separate education on dietary aspects (healthy eating and drinking habits) in relation to body mass was given by a dietician. Participants with a BMI >30 were invited for a personal consultation. All participants could get further information via a special telephone line. An occupational therapist visited all participants at home for individual counseling regarding activity restrictions caused by OA and ways to deal with them.

Analysis

Analyses were performed in SPSS for Windows version 11.5. ANOVA repeated measures analysis was used on an intention to treat basis to test for significant differences between the experimental group and the control group. The mean scores per group of the three measurements (baseline, post-test, and follow-up) are reported. Contrasts were used to

analyze time-group interaction effects for differences between baseline vs. post-test and baseline vs. follow-up. An alpha level of 0.05 was used. Because the program was expected to have a significant positive effect in the experimental group, one-sided tests of significance were used. Differences in nominal variables were analyzed with chi-square tests. For comparison of means, t-tests were used. Effect sizes for comparisons of baseline vs. post-test and baseline vs. follow-up were calculated according to Cohen²⁸, by dividing the difference of change scores of both groups by the standard deviation of the change scores in both groups together. A score of 0.2 is regarded as a small effect, 0.5 as a moderate effect, and 0.8 and higher as a large effect²⁸.

Results

Fifteen people dropped out of the study: five in the control group and ten in the experimental group. The main reasons for dropping out were not related to aspects of the study, intervention, or symptoms of OA. One participant of the program withdrew because she thought the content was too simple, two complained of pain in back and hip, and one started treatment with a physical therapist (for further details see figure 1).

The characteristics at baseline of the experimental, control, and drop-out group participants are shown in table 1. There was no difference between the control and experimental groups on these characteristics. Drop-outs were younger and reported less tolerance to pain, although they did not have more pain. The remaining subjects (n=94) had a mean age of 68 years and were predominantly female. Most subjects were married, had completed secondary education, and were slightly overweight. More than half considered their general health to be good or excellent.

The level of program compliance was high, with 77% performing the home exercises as intended. In the experimental group twice as much participants indicated at post-test that they also had been doing more exercise outside the program ($\chi^2= 5,0;df=2;p<0.05$). The program in total was awarded an average score of 8 on a scale of 1 to 10, indicating that the program satisfied participants.

Table 2 presents all the results for the outcome variables of the intention to treat analysis. No statistically significant differences between the experimental and control groups were found at baseline (t-test). The number of participants included in the separate analyses was different because of different levels of response to the different measurements. Numbers were low for the GARS, which was mainly due to the way the instrument deals with missing values on individual questions.

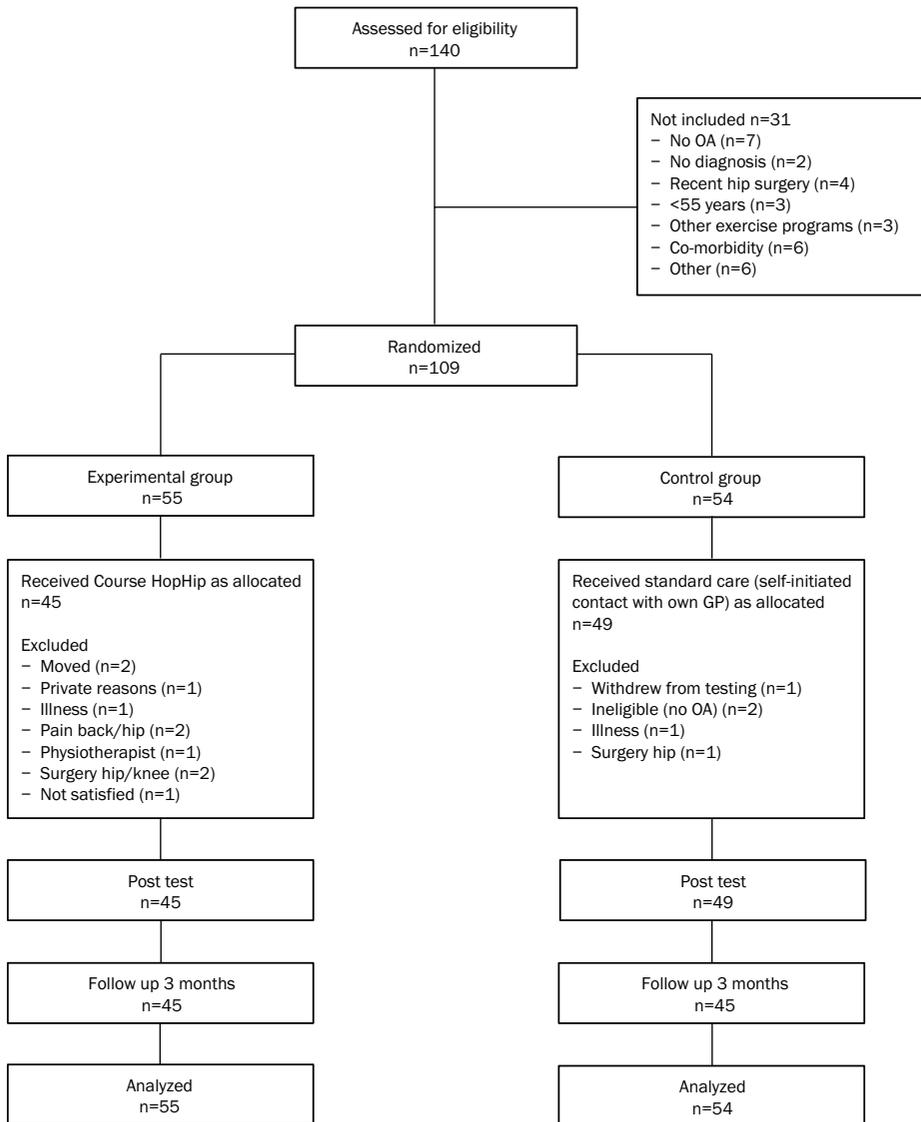


Figure 1: Flow chart of the study

Pain In the experimental group, pain had decreased slightly at both the post-test and follow-up assessments whereas in the control group pain was diminished only at the post-test assessment (not significantly different between both groups) and was even much higher at the follow-up assessment. The difference in change in pain was significant ($p < 0.05$). This improvement in pain in the experimental group was not only subjective but also objective, as measured with the pain scale of the Harris Hip Score at both post-test ($p < 0.01$) and follow-up ($p < 0.05$).

Table 1: Baseline characteristics of the experimental group, control group and drop-outs with a diagnosis of OA of the hip

Variable	Experimental n= 45	Control n=49	Drop-outs n=15
Sex, n (%)			
Male	16 (36)	14 (29)	4 (27)
Female	29 (64)	35 (71)	11 (73)
Age, years, mean (SD)	67.4 (7.6)	68.9 (6.9)	64.9 (6.4) [†]
Marital status, n (%)			
Married	27 (60)	27 (55)	10 (67)
Living together	1(2)	2(4)	1 (7)
Divorced	3(7)	4(8)	2 (13)
Widowed	7(16)	6 (12)	2 (13)
Living alone	6 (13)	8 (16)	-
Education, n (%)			
Primary	9 (20)	10 (20)	2 (13)
Secondary	28 (62)	21 (43)	9 (66)
College/university	7 (16)	8 (16)	2 (13)
Body Mass Index, mean (SD)	26.4 (3.0)	26.6 (4.3)	26.1 (4.5)
General Health, n (%)			
Moderate /bad	18 (40)	22 (45)	5 (33)
Good/very good	27 (60)	26 (53)	10 (67)
No. of chronic conditions, mean (SD)	2.6 (1.8)	2.7 (1.9)	2.8 (1.5)
No. of medications, mean (SD)	1.6 (1.8)	1.7 (1.4)	1.7 (1.8)
Pain, mean (SD)			
Tolerance [†]	4.2 (5.2)	4.1 (3.7)	6.7 (5.6) [†]
Quantity [‡]	3.8 (2.3)	4.4 (2.2)	4.8 (3.1)

[†] 0 = bearable , 10 = unbearable ; [‡] 0 = no pain, 10 = very severe pain

[†]statistical significant difference p< 0.05

Hip function The total score of the Harris Hip Score increased significantly in the experimental group at post-test (p<0.05) but had diminished at the follow-up assessment. There was no statistically significant effect (though a trend was visible, p<0.10).

Disability On all three measurements, the experimental group showed a lower level of restrictions on self-reported disability, measured with the GARS questionnaire (though not statistically significant). On the physical subscale of the SIP, there was a significant difference (p<0.05) at follow-up, indicating an improvement in the experimental group. At the post-test assessment, there was only a trend to improvement (p<0.10). Disability measured with four functional tasks (walking, timed Up & Go, ascending stairs, and toe reaching) was not significantly different in the two groups, with the exception of a significantly better timed Up & Go performance at follow-up (p<0.05) in the exercise group and a tendency to an improvement in walking speed. As can be seen from table 2, the

experimental group seemed to show a slight (non-significant) improvement on some other tasks whereas the control group showed a marginal decline or stabilization.

Table 2: Results on the outcome variables of Group x Time interaction effects: pain, hip function, observed and self-reported disability, quality of life and BMI; values are mean (SD)

Outcome measure	n	Baseline	Post-test	Follow-up	Baseline vs. Post-test		Baseline vs. Follow-up	
					F-statistic	P-value (one sided)	F-statistic	P-value (one sided)
Pain								
Subjective (VAS)								
Exp	35	3.8 (2.1)	3.6 (2.5)	3.5 (2.1)				
Contr	39	4.2 (2.2)	4.1 (2.1)	5.1 (2.3)	0.09	.385	4.49	.019
Observed (pain scale HHS)								
Exp	39	27.9 (8.1)	31.0 (8.6)	29.6 (10.4)				
Contr	44	28.8 (9.0)	26.5 (8.7)	26.9 (9.8)	6.39	.007	2.86	.047
Hip function								
Harris Hip Score								
Exp	39	71.1 (12.9)	77.0 (11.6)	75.4 (14.6)				
Contr	44	71.0 (13.3)	71.2 (13.2)	71.1 (15.1)	3.61	.031	2.01	.081
Observed disability								
Walking 20 m (in seconds)								
Exp	39	19.8 (4.4)	19.8 (4.3)	19.4 (5.1)				
Contr	44	20.6 (4.8)	20.8 (5.0)	21.1 (5.8)	0.27	.302	1.43	.079
Stairs (up + down in seconds)								
Exp	39	17.4 (8.9)	17.1 (7.4)	16.9 (6.3)				
Contr	42	18.5 (7.0)	18.1 (6.6)	18.8 (6.1)	0.01	.465	0.75	.195
Timed Up & Go (in seconds)								
Exp	39	10.4 (3.4)	10.1 (2.8)	9.4 (3.2)				
Contr	44	10.5 (2.6)	10.4 (3.5)	10.6 (3.6)	0.18	.333	3.04	.043
Toe reaching (left + right)								
Exp	38	2.07 (1.16)	1.99 (1.10)	2.04 (1.15)				
Contr	42	2.10 (1.91)	2.10 (1.14)	2.27 (1.22)	0.20	.328	1.46	.116
Self-reported disability								
GARS								
Exp	23	22.8 (5.4)	22.5 (5.0)	23.7 (5.4)				
Contr	25	25.3 (5.7)	25.5 (6.2)	26.3 (6.3)	0.37	.274	0.18	.447
SIP Physical								
Exp	39	7.2 (9.2)	5.7 (7.2)	5.1 (4.7)				
Contr	41	7.6 (8.3)	7.5 (8.1)	8.4 (8.4)	2.15	.074	3.12	.041

Quality of life								
Generic quality of life (VAS)								
Exp	36	7.0 (4.3)	5.9 (2.0)	5.0 (1.4)				
Contr	39	5.6 (2.3)	5.5 (2.3)	4.2 (1.5)	1.44	.117	0.69	.204
Health related quality of life								
Exp	35	28.2 (3.1)	28.1 (5.6)	28.6 (3.6)				
Contr	38	27.3 (2.4)	26.5 (5.6)	27.3 (2.7)	0.35	.279	.041	.262
BMI								
Exp	39	26.1 (2.8)	26.2 (2.8)	27.3 (2.8)				
Contr	44	26.8 (4.3)	26.7 (4.2)	28.1 (4.6)	0.46	.249	0.59	.222

VAS=visual analogue scale; HHS=Harris Hip Score; GARS=Groningen Activity Restriction Scale; SIP=Sickness Impact Profile; BMI=body mass index

Quality of life Quality of life (VAS and sum score) remained stable in both groups throughout the study.

Overweight The BMI remained fairly stable during the program but had increased in both groups by the follow-up assessment.

Table 3: *Effect sizes[†] outcome measures baseline vs. post-test and baseline vs. follow-up*

Outcome measure	Baseline vs. Post test	Baseline vs. Follow up
Pain (VAS)	0.00	0.17
Pain scale HHS	0.51	0.38
Harris Hip Score	0.41	0.34
Walking 20 m	0.15	0.22
Stairs	0.00	0.13
Timed up & go	0.10	0.35
Toe reaching	0.05	0.14
GARS	0.04	0.02
SIP Physical	0.31	0.29
Generic QoL	0.25	0.23
Health Related QoL	0.14	0.07
BMI	0.15	0.15

[†]Small effect > 0,2; moderate effect > 0,5; large effect > 0,8 28. VAS=visual analogue scale; HHS=Harris Hip Score; GARS=Groningen Activity Restriction Scale; SIP=Sickness Impact Profile; QoL=Quality of life; BMI=body mass index

Table 3 gives an overview of the effect sizes that were calculated according to Cohen. At post-test, a moderate effect was found on the pain scale of the Harris Hip Score and small effects were found for the total score of the HHS, SIP physical and generic QoL, as measured with a VAS scale. At follow-up, small effects were again found for the pain subscale and total score of the HHS, and for the timed Up & Go and walking test. The effects for all functional tests increased between the post-test and follow-up assessments, whereas the HHS scores decreased slightly. The small effects for both SIP and generic QoL were maintained at follow up.

Discussion

This study evaluated the effect of an exercise program for older adults with OA of the hip, which consisted of (guided) physical exercise and specialized (and in some cases individualized) OA-focused health education. The program diminished pain and improved general hip function and self-reported disability. One of the measures of observed disability showed slight improvement at follow-up while three others as well as quality of life and BMI, were not affected.

Although OA of the hip is a common disease, there have been few specific intervention studies. In their systematic review ¹³, which included only one study of OA of the hip (in combination with OA of the knee), van Baar et al. ¹⁰ concluded that there was sufficient evidence that exercise therapy had a beneficial effect on OA of the hip. Small short-term effects were mainly found on pain and self-reported disability. Our results are in line with

these effects. Fransen et al. decided not to draw conclusions at all because of the limited number of studies concerning hip OA⁹. Two recent studies of the long-term effect of exercise therapy on OA of the hip have been published. Van Baar et al.²⁹ reported the 12- and 24-week follow-up data of a previous study¹³ of exercise therapy for patients with OA of the hip and/or knee. They found that the effects of the intervention had diminished after 12 weeks and had almost completely disappeared after 24 weeks. In their interventional study without a control group, Weigl et al.³⁰ investigated patients with OA of the hip and/or knee who had been referred to an inpatient rehabilitation center, where they received a 3- to 4-week intervention consisting of exercises, flexibility, and endurance training and consultation for preventive measures. Both pain and functional disability improved at the end of the intervention but these effects had almost disappeared after 12 months. We found stable effects of the training program on pain and hip function, although the effect diminished slightly 12 weeks after completion of the program. In contrast, disability seemed to improve after 12 weeks. These results seem to resemble those of van Baar et al.²⁹ at 12 weeks. Unfortunately we do not have data for a longer period.

The 'Hop with the Hip' program is one of a few programs specifically designed for hip OA. Most programs combine people with knee and hip OA, although this doesn't always seem to be compatible. A previous program developed for OA of the hip and knee¹⁴ proved less beneficial to patients with OA of the hip than to patients with OA of the knee. In a recent study which did evaluate specifically patients with OA of the hip, individual manual therapy was found to be superior to individual exercise therapy, with an 80% improvement in general well-being as the primary outcome³¹. Also pain, hip function, and range of motion improved significantly more in the manual therapy group. Further research will be needed to explore this kind of (individual) therapy but these preliminary results show good prospects for older adults.

Of the outcome variables, pain showed the most stable effect. Given that pain is an important mediating factor of physical and social restrictions^{32,33}, this is an important outcome and makes exercise therapy important in pain control. Other research indicated that exercise can be an important mediator for reducing pain levels³⁴. It should be kept in mind that in OA pain severity fluctuates and is often not very severe, which makes it difficult to find large effects on pain.

On a functional level the Harris Hip Score showed a small significant effect at post-test, which diminished at follow up. This possibly can be related to a relapse in exercising during the period between post-test and follow up, but we do not have data to confirm this.

There also were some mixed results between the different outcome measures and measurements for disabilities. This warrants some caution in interpreting the effect of the intervention although some of these differences can be explained. For the self-reported

disabilities these mixed results could be a result from the differences between both questionnaires. For instance the GARS questionnaire suffered from a relatively low number of cases in the analysis due to the way it deals with missing values, which is not the case for the SIP. Several reasons can be given for the relatively small effects that were found. First of all the participants had a relatively high level of performance at the start of the study (they showed moderate limitations and restrictions, and fairly good hip function), which raises the possibility of a ceiling effect. Given the fact that most of the evaluated activities were not trained specifically (with the exception of walking) also limits possible effects. It could be expected that if pain, hip function and exercise level stay improved these functional capacities will show an effect in the future³⁵. This already can be seen at follow-up, 12 weeks after the end of the intervention, where effect sizes for the functional tests had increased. Finally the level of training intensity was kept moderate (1 hour a week) so that participants could exercise without pain and limitations. Increasing the intensity or extending the duration of the training program also could enhance effects on the functional level. Exercising on a regular basis could reduce or prevent further limitations. Participants who completed the training program also exercised more often outside the program. Additionally 77% of the participants indicated that they performed the home exercises regularly.

We did not find an effect on the QOL, possibly because we used a generic (health-related) QOL measure instead of a questionnaire addressing the specific problems of OA which were dealt with in the program. The combination of exercise and dietary information did not lead to weight reduction in the experimental group. In fact, all participants gained weight after the program ended, so it seems that factors outside the program accounted for this effect. In contrast to OA of the knee, there is only moderate evidence that overweight is a risk factor for the development or aggravation of OA of the hip^{36,37}. It may be that extra attention and information are needed to achieve weight reduction. In the current program only a part of one session was devoted to dietary concerns and only people with BMI > 30 received additional individual information. It could be argued that the group with BMI > 25 would also benefit from this kind of individual approach.

Limitations of this study

The main limitation of our study was the fact that we did not meet the target of 140 included patients at the start of the study, which affected the statistical power of the study. This could have affected small differences, which would not reach the level of statistical significance. This was probably the case for the total score on the Harris Hip Score at follow-up and SIP Physical, which showed a statistical trend at post-test. We recruited participants in several ways but always stated the criteria for study participation. The fact that many people responded who did not meet these criteria suggests that there is a (broad) need for this type of program. One way to increase recruitment of participants could be through general

practitioners. Although we approached several practices, only 10 general practitioners were willing to participate (mostly because of lack of time). Another option would have been to use patients on a waiting list for (hip) surgery, but this would mean a different population with more serious symptoms. Our group had an average score on the HHS of 71 ± 13 while patients on a waiting list have a much lower score (57 ± 17)¹⁷. Fifteen participants dropped out during the study for reasons that were mostly not related to the program. It seems that drop-outs evaluated their pain as less tolerable, which could have been a reason for dropping out.

On a statistical level the number of tests that were carried out (22 in total) to evaluate the effects of the program on the outcome measures, should warrant a caution when interpreting the results. Carrying out this amount of tests increases the chance of finding a significant result, although this study was hypothesis driven.

While the 'Hop with the Hip' program was being developed and evaluated, a separate self-management program for OA of the knee and hip was developed and evaluated. This program, called 'Coping with OA', has a broader scope and relies more on behavioral and self-management aspects. It has a positive effect on pain, quality of life, knowledge, self-efficacy, lifestyle, and health care use¹⁴. Both programs have since been adapted and evaluated in a pilot implementation study in the Netherlands, which yielded results similar to those obtained in a research setting³⁸. Minor changes were made to the hip program – separate dietician's advice was omitted (integrated in the group health education by the physical therapist), an additional session for general advice and instruction was added, and the ability to telephone for extra information was omitted.

Conclusion

The participants of 'Hop with the Hip' awarded the program a score of 8 on a satisfaction scale ranging from 1 to 10. Clearly it filled a need and lived up to expectations in this group. With a growing population of people with OA in the future and rising costs and pressure on the health care system, this type of program is a ready alternative to prevent or reduce the negative effects of OA.

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Sustaining the impact of physical activity

Adherence to exercise programs and determinants of maintenance in older adults with mild cognitive impairment

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REDUCING
THE IMPACT OF
GERIATRIC
CONDITIONS BY
PHYSICAL
ACTIVITY

CHAPTER

6

Abstract

Introduction

After a RCT showing that improvement on some aspects of cognitive function was related to adherence to an exercise program, determinants of adherence and maintenance were further studied.

Methods

Older adults with mild cognitive impairment were contacted 6 months after the end of exercise programs for a telephone interview addressing patterns of (non)adherence and determinants of maintenance.

Results

Mean adherence during the trial was 53%. About one-third of participants had lapses during the trial but completed, one-third had no lapses, and one-third dropped out or never started. Practical barriers (time, location) were related to not starting, functional limitations to dropout. After the trial 25% of participants continued the programs, 14% reported intention to continue, 61% quit. Maintenance was determined by fewer health complaints, higher satisfaction with the programs and better adherence during programs.

Conclusion

Although maintenance was low, this study identified several reasons and barriers to adherence and maintenance that could be addressed.

Introduction

Regular physical activity and exercise have been widely associated with a variety of health benefits in older adults^{1,2} and also prevents and reduces the risk of developing secondary health problems in older adults with chronic conditions³.

Physical activity and exercise have also been reported to be associated with a better cognitive status. According to prospective observational studies, being physically active not only prevents cognitive decline in healthy community dwelling older women⁴, but also results in a reduced risk of cognitive impairment and any type of dementia five years later⁵. Furthermore, a meta-analysis of exercise interventions concluded that aerobic fitness training improves some domains of cognitive function (i.e. executive-control processes) in healthy sedentary older adults depending on length and type of intervention and duration of the training sessions⁶. In another meta-analysis among older adults with dementia and cognitive decline, it was concluded that exercise training (the majority of included studies used walking) had a positive effect on physical, cognitive, functional and behavioral outcomes⁷. Likewise, the cognitive status of older adults with Mild Cognitive Impairment (MCI)⁸ may improve as well if they participate regularly in aerobic exercise^{9,10}.

Despite the health-enhancing benefits of physical activity, initiating exercise programs and adhering to them is often problematic for older adults. For those starting with structured exercise, about 10-50% of participants drop out during the first 6 months, with most relapses occurring during the first 3 months^{11,12}. Stiggelbout et al. evaluated dropout and predictors of maintenance in healthy older adults participating in different types of exercise programs^{12,13}. Predictors of maintenance to exercise programs six months after the start were: having short lapses or no lapses; a high intention to start exercise at baseline; a high-perceived quality of the program; a positive attitude towards exercise and some practical obstacles such as bad weather, being bored with the program, etc. Known barriers for exercise maintenance include poor health, physical limitations, female gender, lack of exercise experiences and several psychological factors, such as low self-efficacy and external locus of control^{14,15}.

Little is known about adherence and maintenance in older adults with MCI who participate in structured exercise programs. The results of the Folate physical Activity Cognition Trial (FACT), a randomized controlled trial examining the effect of moderate intensity walking and low intensity physical activity on cognitive function¹⁶ showed an interaction between the effect of the exercise program and adherence¹⁰. In women each percentage increase in session attendance to the walking program, was associated with a significant improvement in performance on two cognitive tests. In men, there was no interaction, but session attendance of 75% or more to the walking program was associated with memory/delayed recall (1 test out of 7), compared with the activity program.

Therefore, information on reasons for dropout, for having lapses and on barriers of

maintenance can be vital for sustaining the effect of a walking program for this population and could also provide essential information for successful implementation of exercise programs in general. It was decided to follow up participation in both exercise programs with an additional 6 months focusing entirely on adherence and maintenance to these two exercise programs (walking program and placebo low intensity program).

Objective

The purpose of the present study was to: (1) determine the level of participation, adherence and maintenance to the exercise programs in older adults with MCI during the 12 months trial and six months after the end of the trial; (2) describe reasons and barriers for participation, adherence and lapses; and (3) identify determinants of maintenance six months after the end of the trial.

Methods

Study design

The FACT study was designed as a randomized placebo-controlled trial, to examine the effects of a moderate intensity aerobic walking program (MI-WP) on cognitive function of community dwelling older adults with MCI. A non-aerobic low intensity activity program (LI-AP) was added as a placebo exercise program. The study-protocol has been described in detail elsewhere ¹⁶ and was approved by the VU University Medical Center medical ethics committee. Written informed consent was obtained from all participants. For the follow-up study presented in this paper, participants were interviewed about their physical activity and exercise behavior six months after the end of the 12 month exercise programs of the RCT. For this paper, the distinction between the MI-WP and LI-AP program as intervention vs. control group was no longer relevant. Adherence and maintenance was studied for participants in both groups together.

Recruitment of the participants has been described in detail elsewhere ¹⁷. In short, all community dwelling adults in a medium-sized Dutch town aged 70 to 80 years (n=5491) were approached by mail. From the adults willing to participate, participants with MCI were identified using a two-step population screening, consisting of a postal questionnaire and a telephone interview in which the following inclusion criteria were assessed: self-reported memory complaints, no report of disability in activities of daily living as measured with the Groningen Activity Restriction Scale ¹⁸, objective memory impairment as measured with a Dutch version of the 10 Word Learning Test ¹⁹ and normal cognitive function/absence of dementia as assessed by the Telephone Interview for Cognitive Status ²⁰. In addition, participants completed the MMSE in a face-to-face interview and those with an MMSE score <24 points were excluded.

After baseline measurements, included participants (n=179) were randomly assigned

to the MI-WP or LI-AP group. Randomization was stratified by baseline physical activity level in minutes per day. All participants who participated in the twelve months' follow-up measurement of the RCT (n=138) were invited for a telephone interview 6 months later, focusing on participation, adherence, and maintenance of both program activities and habitual physical activity.

Intervention

Both the moderate intensity MI-WP program and the low intensity LI-AP program were group-based and lasted 12 months (June 2004 – June 2005). The frequency was twice a week and session duration was 60 minutes. Sessions were supervised by qualified and trained instructors²¹.

MI-WP was based on 'Sportive Walking', an existing aerobic walking program²². Intensity was moderate (> 3 Metabolic Equivalent) and the aim was to improve aerobic fitness. Each session consisted of a warming up, moderate intensity walking exercises and a cooling down. The intensity of walking in the MI-WP increased gradually during the program by increasing the walking-pace and distance. The program was developed in such a way that all participants could perform the walking exercises at their own level, but still walk in a group. This was achieved by using walking routes with the same start and endpoint. In this way the participants could stay together in a group on the same track, and by covering the track more times during the session, adjust their pace. Sessions took place outdoors in municipal parks. LI-AP mainly consisted of aspects of programs which are widely available to older adults in The Netherlands, e.g. balance and flexibility training, and exercises for improving posture during activities of daily living. The program consisted of an introduction, low intensity (< 3 Metabolic Equivalent) non-aerobic group exercises such as light range of motion movements and stretching, and a closing. The program was carried out in community centers. After the intervention period for the RCT, the exercise programs continued as part of the local community service. Participants could participate at their own initiative for a small fee.

Data collection

Demographic variables were collected using a postal screening questionnaire prior to randomization. Data on cognitive function were collected during the baseline interview, using the Mini Mental State Examination (MMSE)²³ to assess general cognitive function. The Auditory Verbal Learning Test (AVLT) was used to assess memory (direct and delayed recall with maximum scores of 75 and 15 words respectively)²⁴. In this paper, both instruments were used to describe the study population and as a possible determinant of maintenance. Physical activity levels were measured at baseline and after 6, 12 and 18 months using the LASA Physical Activity Questionnaire (LAPAQ). The LAPAQ addresses the frequency and duration of housekeeping, sports activities, cycling, gardening, and walking during the last

two weeks²⁵. A summary measure per activity category was calculated by multiplying the number of hours (minutes/60) per day with the appropriate Metabolic Equivalent Task (MET value) from the Compendium of physical activity²⁶, adapted for older adults²⁷.

Six months after the end of the exercise programs for the trial (T18), additional data on maintenance, determinants and potential barriers for maintenance were collected from the participants during a structured telephone interview. Participants were asked to rate the general quality of the exercise programs, and their satisfaction with 17 program-related aspects¹³, on a five-point Likert scale with a higher score indicating a better rating. These program-related aspects included instruction, attention, location, time, duration, other participants, both intensity and frequency of the activity, effects on health, safety issues, and variation within the program. Dropout was defined as withdrawal from the exercise programs before the end of the programs at T12 as registered during the RCT. Adherence was defined as the proportion of attended sessions during the programs as registered by the instructors. Having lapses, defined as missing two consecutive sessions in a row, was evaluated by a single question during the structured telephone interview ('During the study, did you temporarily miss sessions of the walking or activity program?'). Reasons for dropout and lapses were asked with one open ended question ('If you temporarily missed sessions, please indicate the reason(s)'); answers were later summarized in categories for presentation.

Finally, maintenance to the exercise program at T18 (continuing the exercise programs after the end of the RCT) was evaluated by a single question ('At the end of the study, did you continue with the program (walking or activity)?'). Participants were grouped as 'continued', 'intention to continue' or 'discontinued' on the basis of their answers. Participants who discontinued were asked to evaluate 19 possible barriers¹³ and to indicate whether each barrier was (1) very important, (2) important, (3) somewhat important or (4) not important. Barriers included health complaints (injuries, limitations), practical aspects (time, location), whether progress was noted, program related aspects (intensity, frequency), and personal aspects (interest in exercise, social contacts).

Analysis

All analyses were performed using SPSS for Windows (release 14.0). For descriptive purposes, demographic and cognitive variables at baseline were compared between the drop-outs from the RCT and the participants who attended the follow-up measurements at T6 and T12 using the Students *t*-test for continuous variables and Chi-square test for categorical variables.

Secondly, to see if physical activity levels changed over time between MI-WP and LI-AP a MANOVA for repeated measures was carried out.

The number of participants that started the programs, dropped out or had lapses, and the adherence was reported and compared between the MI-WP and LI-AP group using chi-

square analysis. Possible determinants for maintenance were compared between three groups: 'continued', 'intention' and 'discontinued', using Chi-square and univariate analysis of variance (ANOVA). A difference was considered to be statistically significant if $p < .05$.

Table 1: *Baseline characteristics of participants and drop outs of the RCT and of the telephone interview at T18*

	Total (RCT, T0)	Interview (T18)	Dropouts RCT (T0-T12) [†]
Number of participants	179	134	45
MI-WP	86/179	71/134	15/45
LI-AP	93/179	63/134*	30/45
Age, years, mean (SD)	75.1 (2.9)	74.8 (2.9)*	75.9 (2.6)
Female, %	44	41	51
Education, %			
Low	54	55	51
Middle	25	28	18
High	18	17	20
Living alone, %	31.8	25.4 [‡]	51.1
MMSE, mean (SD)	28.3 (1.5)	28.4 (1.4)	28.0 (1.5)
Range [0-30]	24-30	24-30	24-30
AVLT direct recall, mean (SD)	32.5 (8.1)	33.1 (7.9)	30.9 (8.4)
Range [0-75]	9-54	15-54	9-46
AVLT Delayed recall, mean (SD)	5.9 (2.5)	5.9 (2.4)	5.6 (3.0)
Range [0-15]	0-12	1-12	0-11

MI-WP=moderate-intensity walking program; LI-AP=low intensity activity program; MMSE=Minimal Mental State Examination; AVLT=Auditory Verbal Learning Test

[†] Consist of 41 participants who did not attend the last follow-up measurement at 12 months + 4 participants that participated in all measurements but could not be contacted for the interview at 18 months (1 died, 3 not reached)

[‡] Significantly different from dropouts, $p < .05$

Results

Hundred-thirty-eight out of the 179 participants who participated in the baseline measurement of the project FACT participated in the two follow-up measurements at T6 and T12 as well. Hundred-thirty-four of them could be contacted and were willing to participate in the telephone interview six months after the end of the exercise programs (response rate 97%). One participant had died, and three others could not be contacted. There were hardly any missing data, with a maximum of 2% of cases missing on some variables (indicated in results if relevant). Table 1 provides an overview of baseline characteristics for study participants in the telephone interview ($n=134$) and participants lost to follow-up during the 12 month trial ($n = 45$). Participants lost to follow-up were older ($t=2.25; df=177, p < .05$), lived alone more often (chi square=10.3; $df=1; p < .01$) and were in the LI-AP group more

often (chi square=5.2;df=1;p<.05) than those 134 participants who continued the trial and participated in the telephone interview.

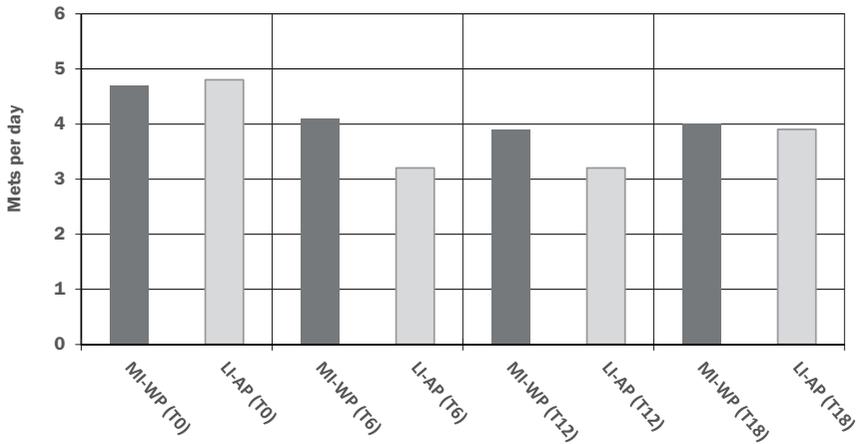


Figure 1: *Level of intensity of habitual physical activity as measured with the LAPAQ on 4 measurement times (T0, T6, T12 and T18) for two exercise programs: moderate intensity-walking program (MI-WP) and low intensity activity program (LI-AP)*

Figure 1 displays the levels of different types of physical activity in MET values at T0, T6, T12 and T18 for MI-WP and LI-AP groups separately. There was a significant decrease in overall habitual daily PA level ($F=7.94$; $p<.001$) over time, but no difference between groups.

Results from the telephone interview at T18, presented in table 2, show that 30 out of 134 participants did not start their designated exercise program (equally distributed over both programs). Main reasons for not starting were being too occupied with other activities (23%), having trouble with walking/moving (23%), estimating the intensity of the program as being too vigorous or too light (20%) or being ill (17%) (table 3).

Of the 104 participants who started one of two exercise programs, data from 2 participants were missing. Of the 102 remaining, 13 participants dropped out during the program, (10 in the MI-WP group; 3 in the LI-AP group) (table 2). Main reasons for dropping out were having trouble with walking/moving and being ill or injured (not related to the program). Two participants dropped out because they experienced complaints as a result of the exercise programs (one out of each program). One participant judged the intensity of the MI-WP program as being too vigorous.

Mean adherence rates during the 12 month exercise programs were around 50% and did not differ between exercise groups ($t=1.07$; $df=132$, $p=.29$). The 13 dropouts attended around one-third of the sessions (34%) before leaving the program.

Of the 89 participants who finished the total MI-WP or LI-AP program, 51 did not report any

Table 2: *Participation, adherence, and maintenance in the walking program (MI-WP) and low intensity program (LI-AP): number of participants (%)*

Stage	Status	Program		
		MI-WP (n=68)	LI-AP (n=64)	Total (n=132) [†]
Participation	Started	52 (76%)	50 (78%)	102 (77%)
	Not started	16 (24%)	14 (22%)	30 (23%)
Adherence	Finished without lapses	25 (48%)	26 (52%)	51 (50%)
	Finished with lapses	17 (33%)	21 (42%)	38 (37%)
	Dropped out	10 (19%)	3 (6%)	13 (13%)
	% Attendance, mean (SD)	49 (33.9)	55 (36.3)	53 (34.8)
Maintenance	Continued	18 (26%)	19 (29%)	37 (28%)
	Intention to continue	14 (20%)	5 (8%)	19 (14%)
	Discontinued	37 (54%)	41 (63%)	78 (58%)

[†] Data from two participants missing

Table 3: *Reasons for not starting the program, dropping out, and having lapses for two programs MI-WP and LI-AP (number of participants that mention the reason); summarized into categories*

Type	Reason	Status		
		Never started	Dropped out	Lapses
Program related	Intensity too high	4	1	0
	Intensity too low	2	0	0
	Complaints related to program	0	2	0
Practical	Too occupied	7	1	0
	Bad location	1	0	0
Physical	Problems with walking/moving	5	5	0
	Illness/injury not related	5	4	10
Other	Holiday	2	0	28
	Not in preferred program	1	0	0
	Does not need it	2	0	0
	Doesn't feel like it	2	0	0
Total		30	13	38

lapses, and 38 reported one or more lapses, either due to being on a holiday (74%) or being ill/injured (26%; not related to the program).

The number of participants that did not start, dropped out, or had lapses did not differ significantly between the two groups (chi-square 4.2;df=3, p=.24).

More than half (n=78) of the 132 participants interviewed at T18, had discontinued participation in the exercise programs after the end of the trial, one quarter (n=37) continued and one out of seven (n=19) intended to continue in the near future. Maintenance status did not differ significantly between the MI-WP and LI-AP group (chi-square=4.38;df=2, p=.11).

Health complaints (including injuries) and practical barriers (time and location) were the most frequently mentioned barriers for maintenance (see table 4). Also, personal reasons such as lack of interest ('don't feel like it'), lack of (subjective) progress or the program not living up to their expectations were mentioned by 15-20% of the participants. Two barriers showed a statistically significant difference concerning importance rating between both groups. Participants in the MI-WP group ranked health complaints as a more important barrier compared to participants in the LI-AP group (mean 2.6 vs. 3.6) ($t=3.969;df=76,p<.001$) as was 'being too tired' (3.5 vs. 3.9), ($t=2.56;df=75,p=.01$).

Table 4: *Barriers for continuing the exercise program*

Reason	Percentage of participants that mentioned the barrier	Mean level of importance [†] (SD)
Health complaints	36	3.1 (1.2)
Lack of time	35	3.2 (1.2)
Injuries	31	3.4 (0.8)
Don't feel like it	21	3.7 (0.7)
Practical: time during day	20	3.6 (0.9)
No progress	16	3.8 (0.5)
Doesn't live up to expectation	15	3.7 (0.7)
Practical: location	15	3.7 (0.9)
Too tired	15	3.8 (0.7)
Intensity too high / low	13	3.8 (0.7)
Too expensive	10	3.8 (0.7)
Not used to making effort	8	3.9 (0.5)
No contact with others	6	3.9 (0.4)
Doesn't want to go alone	5	3.9 (0.4)

[†]Range 1-4, lower score indicating higher importance

Finally, demographic, cognitive, adherence, and quality factors relevant to maintenance were compared between three status groups: participants who continued ($n=37$), intended to continue ($n=19$), or discontinued ($n=78$). There were no significant between-group differences in demographic factors, cognitive function at baseline, and type of program (table 5).

The percentage of participants with lapses was significantly higher in the group that continued the exercise programs after the end of the RCT, compared with the other two groups. The highest number of dropouts during the RCT was found among those who discontinued. Attendance rates during the RCT were highest among those who continued, followed by those who intended to continue.

Table 5: Scores of three groups with different maintenance status on possible determinants

	Continued (n=37)	Intention to continue (n=19)	Discontinued (n=78)	
Demographic factors				
% female	54	47	64	$\chi^2=2.28$; df=2, p=.32
% living alone	27	42	20	$\chi^2=3.84$; df=2, p=.15
% only low education	67	47	57	$\chi^2=2.35$; df=2, p=.68
Cognition				
MMSE, mean	28.7	28.7	28.3	F=1.57; p=.21
AVLT direct recall, mean	33.3	33.0	33.0	F=.02; p=.98
AVLT delayed recall, mean	6.2	6.3	5.7	F=.82; p=.44
Type of program				
% MI-WP	49	74	47	$\chi^2=4.38$; df=2, p=.11
Attendance/Lapses/Dropouts				
% with lapses	46	21	22	$\chi^2=26.50$; df=4, p=.00
% dropouts	5	21	50	
% attendance (T0-T12)	72	56	42	F=11.30; p=.00
Quality aspects ^{†,*} , mean (SD)				
General satisfaction	4.8 (.07)	4.8 (0.4)	4.5 (1.1)	F=1.78; p=.17
Quality instructor	4.9	4.9	4.7	F=4.66; p<.05
Contents program	4.9	4.7	4.5	F=3.63; p<.05
Intensity	4.7	4.7	4.0	F=8.22; p<.05
Costs	4.9	5.0	5.0	F=4.19; p<.05
Progress	4.8	4.2	4.3	F=6.62; p<.05

MI-WP=moderate-intensity walking program; LI-AP=low intensity activity program; MMSE=Minimal Mental State Examination; AVLT=Auditory Verbal Learning Test

[†] higher score indicates higher quality; range 1-5

^{*} specific quality aspects that show no difference between the three groups are not reported

Although general satisfaction was not associated with maintenance status, other specific quality aspects were. Quality of the instructor and contents of the program were rated significantly lower in the 'intention' and/or 'discontinue group'. Participants who did not continue evaluated the program as not being of the right intensity (most of them rating intensity as too high). Finally, participants who did not continue or only showed an intention to continue, reported to have experienced significantly less progress in their health and/or fitness level as result of the program, compared to the group that continued.

Discussion

This study showed that maintenance of participation in exercise programs in elderly with MCI is low, as only 25% continued exercising after the end of a 12-month RCT study. Also, self-reported habitual physical activity levels reduced compared with pre-intervention levels, although seasonal effects cannot be ruled out.

There were differences in the reasons for starting, dropping out, having lapses and maintenance to the two exercise programs, which calls for phase-specific interventions to improve compliance. Although not starting was mainly related to practical reasons, participants dropped out mainly due to physical limitations, while the most important barriers for maintenance were health complaints, practical limitations and quality aspects of the exercise programs (instruction, contents, and intensity). Demographic and cognitive factors were not associated with maintenance. Lapses did not lead to drop out if they occurred due to holiday or illness.

Adherence levels in this study varied between 50-80% and were comparable to other group-based exercise programs with 12 month duration. Average adherence of older adults to exercise programs is reported around 75%²⁸, but is known to decrease if dropouts are included²⁹. The number of dropouts from the MI-WP in our study sample with MCI was relatively low (13%) and corresponded to drop out from Sportive Walking programs in the Netherlands, available to older adults outside a research setting¹². Most frequently mentioned reasons for dropping out in other studies are illness, pain and lack of time/being too occupied²⁹, while in our study these were mainly related to (physical) problems in carrying out the program. This can explain that fewer participants dropped out from the less intensive LI-AP program.

About 25% of participants continued the exercise program after the end of the RCT, which is comparable to other programs in community dwelling older adults³⁰. As is known from other studies, most important barriers for maintenance of exercise programs include health problems and practical limitations^{14,31}. In this study quality aspects also played an important role in maintaining physical exercise. This overlaps with a previous study in which quality of the instructor and contents of the program were important in maintaining participation in exercise programs¹³. Furthermore, participants in this study reported that the intensity of the program affected their maintenance. This was specifically the case in the MI-WP program. A potential method to avoid this in future studies could be to monitor and adjust the intensity of the exercise program (as this has been shown to be associated with motivation³²). Although participants were offered options to adjust exercise intensity in the MI-WP program, these were too limited for some of them. Ten participants mentioned in the interview costs being a barrier. Participation in the exercise program was for free during the 12 month intervention period. Although participation in the programs after the RCT was

subsidized and participants only had to pay a small fee, it was still considered to be too expensive by some.

Our finding that determinants for starting, dropping out and maintaining participation in exercise programs are different corresponds with other studies^{33,34}; this suggests difference between determinants for initiating, adhering to or maintaining exercise. Physical health status and a busy lifestyle are among the few reasons, which determine both initiation and maintenance. This provides possibilities to address the most relevant barriers and determinants related to the specific phases of exercise behavior.

Limitations of this study

We could only include participants who had completed the RCT and participated in all measurements. This means that participants in this extension study were a selective subgroup of the original study. Comparisons between the drop-outs and the adults who remained involved in the trial indeed showed differences; participants who were lost to follow-up were older, mainly in the LI-AP arm of the RCT and a higher percentage of them lived alone. This means that the findings of this study may only be generalizable to older adults with memory complaints who are interested in starting exercise programs.

Data concerning the quality of the exercise programs, having lapses and reasons for dropping out were gathered 6 months after the end of the main study. Since the population of MCI was defined by having memory problems, possible incorrect recollection should be taken into account. However, the median MMSE score indicated that participants had good general cognitive function and it is therefore not likely that this 'recall' bias affected the results to a large extent.

Other relevant predictors of maintenance such as self-efficacy, attitude, and social support³⁵ were not evaluated in this study in order to reduce the measurement burden to this population. But it is known from the literature that self-efficacy is a major determinant of physical activity³⁶ and it is likely not to be different in our study sample.

The intensity differed between the moderate-intensity walking and the low intensity activity program. Since intensity can play a role in (dis)continuing the program, participants in the walking program could have been more prone to dropout than participants in the activity program before the follow-up measurement (at T18) and therefore may not have been included in the study sample of the present study. Further research is therefore needed to investigate the critical balance between minimal intensity and duration and effectiveness, taking the increased dropout risk that is associated with exercise intensity into account.

Since the FACT study was designed as an RCT, people were randomized to a program which may not have been the program of their choice. Although it was ensured that the program was run in the area where the participant lived, they couldn't choose a specific time. This may have affected the results, since location and time affect participation. However, only

one person mentioned this as a reason to not start an exercise program and it is therefore not likely that this has affected the results to a large extent.

This study adds to the current knowledge about behavioral aspects of physical activity promotion. Given the fact that most Western countries face ageing populations and an associated increase in prevalence of age-related neurocognitive disorders, the specific focus on older adults with memory complaints living in the community is important. Improving their lifestyle, by increasing their participation in physical activity and exercise, can prevent functional decline, reduce the demand for health care and prolong independent living until higher age.

Adherence was registered by instructors, but these data were not usable to measure lapses in adherence because they were collected as a percentage of attended sessions, rather than patterns of attendance. Therefore we had to rely on self-report measures regarding lapses. Although we have no indication that self-report measures in this group with MCI were unreliable, future research should look into the possibility of using objective measures for physical activity, such as accelerometers. In addition, future studies should look into possibilities to monitor patterns of adherence and consequently collect data on lapses during interventions.

Conclusion

Although it is not easy for older adults with MCI to maintain participation in exercise programs, this study shows there are different reasons and barriers that can be addressed. Practical aspects such as time and location of a program are important reasons for not starting, and these factors should be individually tailored to prevent them from becoming an actual barrier. Lapses due to holidays and illness do not jeopardize adherence, but dissatisfaction with the content (intensity) of the program and physical limitations do. Especially in moderate intensity programs, such as an aerobic walking program, exercises tailored to the individual should be offered to prevent dropout and to improve attendance. Individually tailored exercises could also be a solution for health complaints and limitations that prevent elderly from participating in exercise programs. Since participants who reported clear benefits were more likely to continue participation in the exercise programs, feedback by instructors on subjective indicators could be worthwhile. Last but not least, providing a high quality instructor, feasible content, and addressing specific outcome expectations of the participants could further enhance adherence and maintenance in order to reach the highest possible health benefits.

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Predictors of self-reported change in physical activity in older adults with knee or hip osteoarthritis

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To be submitted

REDUCING
THE IMPACT OF
GERIATRIC
CONDITIONS BY
PHYSICAL
ACTIVITY

CHAPTER

7

Abstract

Introduction

Although physical activity (PA) has been shown to be beneficial in older adults with osteoarthritis (OA), most show low levels of PA. This study evaluated if behavioral aspects self-efficacy, attitude, social norm and coping styles predict change in PA in older adults with OA in the knee and/or hip.

Methods

Prospective study following 105 participants in an RCT (self-management intervention) with baseline, post-test (6 weeks) and follow-up (6 months). Univariate associations and multivariate regression with self-reported change in PA as the dependent factor. Potential predictors entered into the model: demographic, illness-related and behavioral variables (attitude, self-efficacy, social norm, and intention (ASE model)), coping style, and pain coping.

Results

Forty-eight percent of participants reported increased PA at 6 weeks and 37% at 6 months which corresponded with registered PA levels. At 6 weeks, use of the pain coping style 'resting', intention and participation in the intervention were univariately and multivariately positively associated with more self-reported change, whereas being single and less use of the pain coping style 'distraction' predicted less change. Higher pain severity only predicted less change multivariately. At 6 months, univariate associations for age, general coping style 'seeking support' and participation in the intervention were found; higher age was associated multivariately with less self-reported change.

Conclusion

At short-term, self-reported change of PA was predicted by the behavioral factors intention and several pain coping styles. Together with other predictors of self-reported change (pain severity, higher age, being single), these can be addressed in future interventions for enhancing PA in older adults with OA.

Introduction

Osteoarthritis (OA) is the most common form of arthritis, with knee and hip joints affected most. OA leads to pain, tenderness, swelling and decreased function of weight bearing joints which in turn will lead to disability^{1,2}. Since the prevalence of OA increases with age and it is more prevalent in women and overweight people³, it is expected that in the Netherlands between 2000 and 2020⁴ the absolute prevalence of OA will rise by 38% and at considerable societal cost⁵.

As there is no cure for OA, the prevention and management of its consequences are important. One of the most widely known and recommended non-pharmacological methods for the effective management of OA is physical activity⁶. Exercise helps regain muscular condition, balance and joint stability⁷⁻⁹ which improves physical functioning, general well-being and reduces pain^{10,11}. Also a healthy lifestyle, including habitual physical activity, has been shown to be beneficial for OA. Regular daily physical activity has preventive and therapeutic effects¹², while avoidance of activity predicts an increase of limitations in patients with knee OA¹³. Walking has also been found to be equally effective in managing knee OA as has home-based quadriceps exercise training¹⁴. In knee OA, obesity is one of the modifiable risk factors that also can be targeted by physical activity, preferably combined with dietary interventions^{15,16}.

Despite these positive findings, older adults with arthritis show low levels of maintaining exercise^{17,18} and low compliance with physical activity guidelines¹⁹. Moreover, inactivity rates are higher in OA patients than in the general older population²⁰. Also, greater adherence to recommended exercise programs predicts long term benefits^{14,21,22}. Therefore it is important to gain more insight into which factors determine physical activity behavior in older adults with OA²³. Several studies have found that socio-demographic (e.g. lower age, male gender, and higher education), health (e.g. normal weight, no physical limitations, pain or fatigue) and healthcare factors (i.e. having been advised by a health professional that physical activity benefits arthritis and having attended an arthritis education course) are associated with increased levels of physical activity²⁴⁻²⁷.

Individual behavioral aspects such as self-efficacy, attitude, and pain coping strategies are all considered possible determinants of physical activity behavior and thereby on the impact of OA on physical performance and disability²⁸⁻³². The Avoidance Model proposes that coping with pain in particular plays an important role as it may mediate the relationship between pain, avoidance of activity, reduced muscle strength, instability of joints, and subsequent disability^{33,34}.

A recent meta-analysis showed that behavioral interventions were more successful than cognitive interventions in increasing physical activity in healthy adults³⁵. More insight into how these factors interact with each other and predict physical activity behavior in older adults with chronic conditions is needed. This knowledge may help to improve the long-term

effectiveness of exercise programs and physical activity guidelines in older adults with OA.

Objective

The purpose of this study is to evaluate if the behavioral aspects self-efficacy, attitude, social norm and coping predict change in physical activity behavior in the shorter and longer term in older adults with osteoarthritis in the knee and/or hip.

Methods

Study design

Data from a randomized controlled trial of a self-management program for patients with OA of the knee and or hip were used ³⁶. Potential participants were recruited through advertisements in a local newspaper. Inclusion criteria were diagnosis of OA of the hip and/or knee according to firstly radiographic criteria and secondly to ACR clinical criteria, aged between 55 and 75 years and not being on a waiting list for joint replacement. In total, 120 eligible respondents were randomized into an experimental and a control group. Fifteen participants in whom a diagnosis of OA could not be confirmed during analysis were excluded, leaving 105 participants eligible for analysis.

The program, which consisted of 6 weekly sessions of 2 hours, consisted of health education (including physical activity) by a peer and physical exercises taught by a physical therapist. Both groups completed a questionnaire, and underwent interview and physical examination. Data were collected at baseline, at 6 weeks, and at 6-months follow-up. A more detailed study design is described elsewhere ³⁶. The study protocol was approved by the TNO Medical Ethics Committee.

In order to study factors that determine physical activity behavior, participants from the intervention and control groups were analyzed as one group, controlling for participation in the intervention.

Data collection

To measure changes in physical activity behavior, participants were asked: 'Has OA caused you to exercise more or less over the past 6 weeks/6 months?' Answers were given on a 5-point Likert scale ranging from 'much more' to 'much less' physical activity behavior and was dichotomized into more physical activity at 6 weeks versus the same amount or less physical activity (Model 1), and more physical activity in the past 6 months versus the same level or less physical activity (Model 2). In two participants answers on physical activity behavior outcomes were missing leaving 103 participants included in the analysis.

To assess physical activity levels, the Voorrips questionnaire was conducted by an interviewer at baseline and at 6 months ³⁷. The reliability (0.89) and validity (0.78) of the questionnaire are good. Respondents were asked to report habitual physical activities over

the past year. Questions cover three areas; household activities (mean score of 10 items ranging from 'very active' to 'inactive'), sport activities (type of activity, intensity, hours per week and months per year, for a maximum of two activities) and leisure time activities (type of activity, intensity, hours per week and months per year, for six activities maximum). Sport and leisure activity scores were calculated by an equation multiplying the intensity, hours per week and period of the year. Using tertiles this resulted in a total physical activity score according to which participants were finally classified as having a high, medium or low level of physical activity.

The baseline variables age, sex, marital status, education, income, work status (paid or voluntary work) were identified as demographic variables. There were five categories of marital status: married living together, not married living together, divorced, widowed, and single. Education was divided into three categories following the Dutch educational system: primary education (0-8 years), secondary education (9-16 years), and college/university (17 years and older). Income was classified into categories low, middle, and high income levels in euros (< € 908; €908 - €1360; > € 1360).

Duration of joint complaints was assessed by asking 'how many years ago did your first OA complaints arise?' Answer categories were <1 year, 1-3 years, 3-10 years, 10-20 years, and > 20 years ago. Self-reported joint complaints (right or left hip, right or left knee) were noted by participants if present.

Body mass index (BMI) was calculated as length and weight expressed as kg/m². Participants were classified as normal weight (BMI < 25), overweight (BMI 25-30), and obese (BMI ≥ 30). Comorbidity, including use of medication, was assessed during the interview by reading out a list of 25 chronic conditions to the participants and asking them if they had any of these disorders and if so what sort of medication they took for it. Pain severity, pain tolerance and fatigue over the previous month were measured on a 10 cm VAS scale ranging from 0-100. A higher score indicates more pain/fatigue. Disability was evaluated using the Sickness Impact Profile (SIP) subscale physical functioning which comprises self-reported statements on ability to carry out activities in the area of household management, body care and movement and mobility. Scores are summarized and presented as a percentage of maximum dysfunction, ranging from 0% to 100%. The higher the score the higher the level of disability³⁸.

Behavioral variables were based on the theoretical model of attitude, social norm and self-efficacy (ASE) of de Vries³⁹. The ASE model illustrates how factors contribute to intention to display a desired behavior. Attitude comprised two constructs: the expectations of consequences of certain behavior (e.g. beliefs) and the value given to those expectations (e.g. evaluations). Regarding beliefs, the participant was given a list of six activities and asked 'how much benefit do you think the following activities will have on your functioning in general?' The answering scales were 'a lot of benefit', 'a little benefit', and 'no benefit' The

same six questions were asked on evaluations; 'how important do you feel these benefits are to the following activities' with answering scales 'important', 'a little bit important', and 'not important'. Where one item was missing, participants (n=21) were given the statistical mean value. If more than one item was missing per construct, cases were excluded from analysis (n=19). A sum score of attitude to physical activity was calculated by multiplying the beliefs and evaluations of each question per respondent, followed by adding up the scores of the six questions⁴⁰. A higher score indicated a more positive attitude.

Social norm was operationalized as the perceived opinion of important others (e.g. normative beliefs) and the personal value given to these opinions (e.g. motivation to comply). Normative beliefs were assessed by asking 'how do you think your near environment would react if you were to undertake more physical activity?' with answers 'positive, negative, or neutral.' The motivation to comply was measured by asking 'how important is the opinion of your near environment' on a 5-point answer scale 'very important' to 'not important'. A social norm score was calculated by multiplying the normative beliefs of each participant with their motivation to comply⁴⁰. A higher score indicates a more positive social norm.

Self-efficacy is one's belief in being able to carry out a certain behavior. Self-efficacy was measured by asking 'do you believe you will succeed in exercising more?' on a 10 cm VAS scale, with a higher score indicating 'no, I will not succeed'. This scale was developed by Lorig et al.⁴¹ to measure perceived self-efficacy in patients with rheumatic disease.

Finally, intention was measured by asking 'do you intend to engage in more physical activity?' Answers 'definitely yes', 'probably yes', 'probably no', and 'definitely no' were dichotomized into 1=yes and 0=no.

Coping styles in general were assessed at baseline by the short version of the Utrecht Coping List (UCL) which views coping as a personality trait and measures how people deal with health and illness in general. Seventeen items were evaluated by respondents by reporting the frequency of responding to a given problem on a four-point scale from 'never' to 'very often'. Items were divided into four categories: active problem solving (5 items, such as 'seeking ways to solve the problem'), seeking support (5 items, e.g. 'asking someone for help'), avoidance (5 items, e.g. 'doing other things to avoid thinking about the problem') and a religious response (2 items, 'praying' and 'thinking the situation is inevitable because it comes from a higher power'). A higher score indicated more use of the coping style. The short version of the UCL has been found to be valid and reliable⁴².

The Pain Coping Inventory (PCI) is a Dutch pain-specific coping instrument developed by Kraaimaat & van Schevikhoven⁴³. The PCI assesses how people deal with pain. A four-point answering scale was used to identify how often a certain behavior is carried out ('never' to 'very often'). The 35 items were categorized into six pain coping scales: worrying about pain ('I think the pain will get worse'), distraction by engaging in pleasant activities (e.g. 'I seek distraction by diverting my attention to reading, music, watching television, or something similar'), resting (e.g. 'I restrict myself to simple activities'), pain transformation (e.g.

'I imagine the pain to be less severe than it really is'), retreating (e.g. 'I ensure I will not be disturbed by intrusive noise') and reducing demands (e.g. 'I make sure I don't get anxious'). A higher score indicated more use of a pain coping style.

Participation in the intervention program and baseline physical activity (continuous score as calculated by the Voorrips questionnaire) were included as confounders.

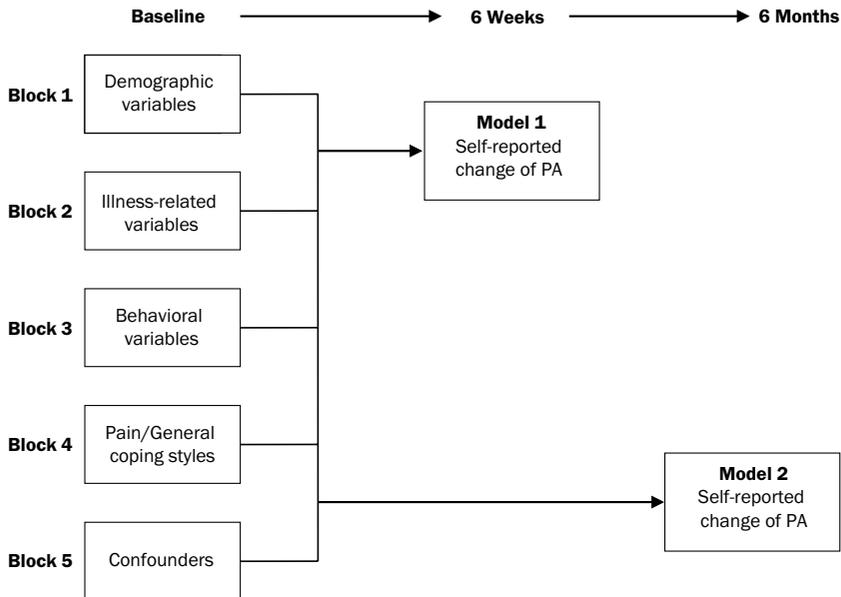


Figure 1: *Blocks of independent variables, time of measurement and two models of change in physical activity behavior used in multivariate stepwise backward logistic regression analyses*

Analysis

Descriptive statistics of all participants on baseline characteristics were calculated. Results for self-reported change in physical activity behavior and physical activity levels at 6 months are compared to see if participants' reports correspond.

To study which factors predicted self-reported change in physical activity behavior at 6 weeks and at 6 months, univariate comparisons were made between possible predictors and the two models using chi-square tests for categorical variables and t-tests for continuous variables. All participants were categorized as either carrying out less or the same physical activity or more physical activity. Univariate associations of $p < 0.20$ were required for entry into the multivariate model with the exception of pain severity which was added to the multivariate model due to its great impact on patients suffering from OA^{44,45}. Multivariate stepwise backward logistic regression analyses were first conducted

between independent predictors and more physical activity behavior at 6 weeks (Model 1) and at 6 months (Model 2). Predictors were tested in five blocks of variables (figure 1); demographic variables were tested in Block 1, followed by illness-related variables in Block 2, behavior variables in Block 3, pain coping styles and coping styles in general in Block 4 and confounders in Block 5. Confounders were entered into the last step of the model to reduce its effects on other variables. Intention was entered as an extra step after attitude to prevent obscuring the multivariate model, as the ASE model shows that attitude influences intention.

In analyzing the two models, changes in β , p-values and Nagelkerke R^2 were calculated. Hosmer and Lemeshow's goodness-of-fit tests were conducted to assess if non-significant chi-square goodness-of-fit value was present. This showed that the model had an adequate fit. Correlations between predictors were assessed to test for multicollinearity. Correlations higher than 0.50 were excluded to ensure stable regression analyses. Finally, missing analyses were conducted using chi-square tests and t-tests to assess if excluded participants were similar to valid participants on demographic variables age, sex, marital status, education, income and illness-related variable body mass index.

To check whether the results for self-reported change could be replicated for physical activity levels as measured with the Voorrips questionnaire at 6 months, possible predictors of these were tested with the same procedure. P-values less than 0.05 were considered statistically significant. Statistical analyses were performed using SPSS version 17.0.

Results

Baseline characteristics of the total study population (n=105; table 1) show that most participants were women, were married and living together, overweight or obese, and had completed secondary or higher education. Around one-third were engaged in paid work or voluntary work. Of participants reporting other chronic diseases, OA of the hands, severe back complaints and high blood pressure were most frequently reported. Almost all participants reported complaints in knee and/or hip joints, with 30% reporting complaints in three or four joints. Knee complaints were twice more prevalent than hip complaints. Radiological OA (ROA) of the knee was two to three times more prevalent than hip ROA. Disability in the domain of physical functioning was low, with participants indicating only 6% maximum dysfunction.

Table 1: *Baseline characteristics (n=105)*

Demographic variables	
Sex, % female	82.9
Age, years, mean (SD)	65.5 (5.5)
Marital status, %	
Married living together	66.7
Not married living together	2.9
Divorced	7.8
Widowed	7.8
Single	11.8
Education, %	
Primary	22.2
Secondary	52.5
College/university	25.3
Income, %	
< € 908	39.5
€ 908 to € 1360	34.9
> € 1360	25.6
% Paid work	14.0
% Voluntary work	34.7
Disease-related variables	
BMI, mean (SD)	27.5 (4.2)
% Normal weight	29.1
% Overweight	48.5
% Obese	22.3
Number of diseases, mean (SD)	2.5 (1.6)
% Prescribed medicine	45.5
% Non-prescribed medicine	29.4
Fatigue past month [†] , mean (SD)	40.4 (22.1)
PA-levels, mean (SD)	11.8 (7.2)
Disability (SIP-subscale physical functioning), mean (SD)	5.8 (7.0)
OA related variables	
Duration of complaints, %	
< 1 year ago	3.1
1 to 3 years ago	22.7
3 to 10 years ago	36.1
10-20 years ago	19.6
> 20 years ago	18.6

OA related variables	
Joints with complaints, %	
0 joints	2.0
1 joint	23.5
2 joints	45.1
3 joints	18.6
4 joints	10.8
Pain severity past month [¶] , mean (SD)	43.3 (24.4)
Pain tolerance past month [‡] , mean (SD)	31.4 (21.8)
Morning stiffness, %	11.4
Joints with self-reported complaints, %	
Hip, left	34.3
Hip, right	25.5
Knee, left	63.7
Knee, right	67.6
Joints with ROA, %	
Hip, left	21.6
Hip, right	15.4
Knee, left	46.6
Knee, right	46.6

BMI=body mass index; OA=osteoarthritis; ROA=radiological osteoarthritis

[†] Measured on a VAS scale, 0=not tired; [¶] Measured on a VAS scale, 0=not severe; [‡] Measured on a VAS scale, 0=tolerable.

Around 48% of respondents reported they had become more physically active after 6 weeks compared with baseline, 45% remained stable and 8% reported less physical activity (table 2). At follow-up, 6 months later, 38% reported that they had increased their physical activity behavior on comparison with baseline. A large proportion of all participants who reported more physical activity at 6 weeks also reported more physical activity at 6 months (n=28, 58%) or maintained the level (n=19, 40%). A few participants were doing less at 6 months than at 6 weeks (n=11). To assess the correspondence between self-reported change in physical activity behavior and self-reported physical activity levels, table 2 shows the mean change in physical activity level per change group at 6 months. Although only the 'more' group reported a rise in physical activity levels, compared to a minor decline for the 'same' and 'less' group, there was no statistically significant difference in mean change between the three groups (F=2.6; p=0.078).

Univariate associations between baseline characteristics and physical activity behavior are presented in table 3.

Table 2: Number of participants who reported change in physical activity behavior at 6 weeks and 6 months (n=101) and corresponding changes in self-reported physical activity levels (Voorrips)

Physical Activity Behavior - at 6 weeks	Physical Activity Behavior - at 6 months			Total
	More	Same	Less	
More	28	19	1	48
Same	7	31	7	45
Less	3	2	3	8
Total	38	52	11	101

Self-reported physical activity levels, mean (SD)				
Change from baseline	3.4 (9.5)	-0.6 (7.0)	-0.7 (12.7)	0.9 (9.3)

Table 3: Univariate chi-square and t-tests of baseline predictors with two groups of change in physical activity behavior at 6 weeks and 6 months (n=103)

	Physical Activity Behavior - at 6 weeks		Physical Activity Behavior - at 6 months	
	Less & Same	More	Less & Same	More
Number	53	50	65	38
Demographic variables				
Sex, % female	87	78	88	76 ^o
Age, years, mean (SD)	65.4 (5.5)	65.3 (5.6)	66.3 (5.2)	63.3** (5.2)
Min-max	54-75	54-75	55-75	54-74
Marital status % [†]				
Married living together	71	63*	68	68
Not married living together	2	4	2	3
Divorced	2	14	5	14
Widowed	6	10	8	5
Single	16	6	16	5
Education %				
Primary	24	19	20	24
Secondary	50	55	55	51
College/university	26	26	25	24
Income % [‡]				
< € 908	35	44	43	33 ^o
€ 908 to € 1360	33	21	31	22
> € 1360	33	35	26	44
% Paid work	16	12	10	22 ^o
% Voluntary work	39	30	28	44 ^o

	Physical Activity Behavior - at 6 weeks		Physical Activity Behavior - at 6 months	
	Less & Same	More	Less & Same	More
Disease-related variables				
BMI, mean (SD) †	27.0 (3.7)	28.1 (4.7) ^o	26.9 (4.3)	28.5 (3.8) ^{oo}
% normal weight	31	27	37	16†
% overweight	52	45	46	55
% obese	17	29	18	29
Number of diseases, mean (SD)	2.3 (1.7)	2.6 (1.5)	2.7 (1.6)	2.2 (1.6) ^o
% medicine past month, prescribed	51	40	49	39
% medicine past month, non-prescribed	35	25	27	35
Fatigue past month ‡, mean (SD)	38.9 (20.3)	42.5 (24.2)	41.3 (23.2)	40.3 (20.5)
OA-related symptoms				
Duration of complaints %				
< 1 year ago	4	2	3	3
1 to 3 years ago	21	26	23	24
3 to 10 years ago	35	34	34	41
10-20 years ago	23	17	21	18
> 20 years ago	17	21	18	15
Joints with complaints % †				
0 joints	2	2	2	3
1 joint	24	22	25	16
2 joints	41	51	43	51
3 joints	20	18	18	22
4 joints	14	6	13	8
Pain severity past month ‡, mean (SD)	46 (24.1)	41 (25.0)	45 (24.2)	41 (24.5)
Pain tolerance past month ‡, mean (SD)	32 (21.2)	31 (22.8)	30 (21.7)	32 (20.7)
Disability (SIP-subscale physical functioning), mean (SD)	5.2 (5.4)	6.4 (8.5)	5.7 (7.6)	5.6 (6.0)
Behavioral variables				
Attitude, mean (SD)	37.8 (10.5)	38.1 (11.7)	36.2 (11.7)	40.7 (9.8) ^{oo}
Social norm, mean (SD)	7.6 (4.0)	7.2 (4.3)	7.2 (3.9)	7.9 (4.4)
Self-efficacy, mean (SD)	45.5 (26.0)	39.1 (22.9)	40.3 (24.1)	43.8 (25.3)
Intention, % yes	51	81 ^{**}	58	77 [†]
Coping styles in general, mean (SD)				
1. Active problem solving	2.2 (0.7)	2.4 (0.6) ^o	2.3 (0.7)	2.2 (0.5)
2. Seeking support	1.7 (0.5)	1.8 (0.6)	1.7 (0.5)	1.9 (0.6)*
3. Avoidance	2.2 (0.5)	2.2 (0.4)	2.2 (0.5)	2.1 (0.4)
4. Reacting religious	1.5 (0.7)	1.5 (0.7)	1.5 (0.7)	1.4 (0.6)

Pain coping styles, mean (SD)				
1. Pain transformation	2.2 (0.6)	2.0 (0.6) ^o	2.0 (0.6)	2.1 (0.6)
2. Distraction	2.6 (0.6)	2.2 (0.5)**	2.4 (0.6)	2.4 (0.6)
3. Reducing demands	2.2 (0.6)	2.3 (0.6)	2.2 (0.6)	2.4 (0.6) ^{oo}
4. Retreating	1.5 (0.5)	1.7 (0.5) ^o	1.6 (0.5)	1.7 (0.5)
5. Worrying about pain	1.7 (0.5)	1.8 (0.5)	1.7 (0.5)	1.8 (0.5)
6. Resting	2.1 (0.5)	2.4 (0.6)*	2.2 (0.6)	2.4 (0.6) ^o
Participation intervention, % yes	34	76 **	45	68*
Physical activity, mean (SD)	13.0 (8.4)	10.6 (5.5) ^{oo}	12.5 (8.1)	10.6 (5.2) ^o

^o p<0.20 ^{oo} p<0.10 ⁺ p<0.05 ^{**} p<0.01

[†] Significant difference between more vs. less & same activity behavior at 6 weeks on all marital status variables; ^{*} Significant difference between more vs. less & same activity behavior at 6 months on all levels;

[‡] Measured on a VAS scale, 0=positive;

Predictors of change in physical activity at 6 weeks

The following variables were entered into the multivariate analysis based on associations with more physical activity behavior measured at 6 weeks: marital status, BMI, intention, general coping style 'active problem solving', pain coping styles: 'pain transformation', 'distraction', 'retreating', and 'resting', intervention status, baseline physical activity levels, and pain severity.

In the multivariate regression analysis (table 4), intention, use of the pain coping style 'resting', and participation in the intervention were positively associated with more physical activity behavior whereas being single, having more severe pain, and making less use of the pain coping style 'distraction' contributed to lower levels of physical activity behavior. Intention was the best predictor of change in physical activity behavior, followed closely by being single. The predictors explained 59% of the variance of more physical activity behavior. Demographic variables explained most of the variance together with intention and pain coping styles. No significant chi-square goodness-of-fit values were detected and no multicollinearity was present. Missing analysis showed there were no significant differences between missing and valid subjects on demographic variables and BMI.

Table 4: *Multivariate stepwise backward logistic regression of independent variables with 6 weeks change in activity behavior; β value (p value), n=70*

Independent variables	Step 1	Step 2	Step 3	Step 4	Step 5
1. Demographic variables Marital status 'single' [†]	-0.80 (0.28)	-0.85 (0.26)	-1.08 (0.18)	-2.06 (0.05)	-2.15 (0.05)
2. Illness-related variables Pain severity		-0.02 (0.09)	-0.02 (0.10)	-0.03 (0.06)	-0.03 (0.05)
3. Behavior variables Intention [‡]			1.98 (0.00)	2.39 (0.00)	2.17 (0.01)
4. Pain coping styles Distraction Resting				-2.00 (0.01) 1.46 (0.03)	-1.81 (0.02) 1.50 (0.05)
5. Confounder Intervention [‡]					1.31 (0.07)
Total R²	0.18	0.23	0.38	0.55	0.59
Incremental R²	0.18	0.05	0.15	0.17	0.04

[†]1=married and living together; [‡] 1=yes.

Predictors of change in physical activity at 6 months

Variables univariately associated with change in physical activity behavior at 6 months that were selected for multivariate analysis were sex, income, paid and voluntary work, age, BMI, co-morbidity, attitude, intention, general coping style 'seeking support', pain coping styles 'reducing demands' and 'resting', intervention status, and physical activity level at baseline. Again, pain severity was added.

Multivariate analysis showed that age was the only significant predictor (N=64; β =-0.14; p=0.02) of more physical activity behavior at 6 months and explained 40% of the variance (data not shown). In the model higher age was associated with less physical activity behavior. Missing analysis showed that valid participants had higher income levels (p=0.02) than those with missing data. No multicollinearity was present.

Self-reported physical activity levels categorized into high, medium and low tertiles showed univariate associations with age, paid work activities, attitude, intention, general coping style 'active problem solving', baseline physical activity and intervention status (data not shown). Stepwise backward logistic regression analysis showed age was the only significant predictor (n=70; β =-0.13; p=0.01). Again higher age was associated with lower physical activity levels. The results from the two models are summarized in table 5.

Discussion

This study explored the behavioral predictors of self-reported change in physical activity among older adults with knee or hip OA. Compared with baseline, about half of the participants indicated that they had increased their physical activity behavior at 6 weeks, but by 6 months this had declined to 37%. This finding is consistent with other studies, as

the effect of change in behavior is difficult to maintain over time^{17,18}. Even so, only a small percentage (10%) indicated that they had reduced their physical activity.

Of the behavioral aspect of the ASE model only the intention to become more physically active item predicted becoming more physically active at 6 weeks, although the variables influencing intention, i.e. attitude, self-efficacy, and social norm, were not associated. This result is contrasted to other studies which show that self-efficacy in particular plays a role in physical activity³¹.

Results on the pain coping styles 'resting' and 'distraction' seem to contradict other studies that used the same instrument (PCI), where active pain coping styles such as distraction were found to be cross-sectionally associated with more sporting activity, and passive coping styles such as resting with less sporting activity²⁸. The use of the pain coping style 'resting' also has been shown to be a predictor of future limitations in patients with knee and hip OA¹³. These studies used OA patients recruited through rehabilitation centers which might mean more pain and subsequent limitations in their study sample. Patients might use different coping strategies when faced with more serious symptoms.

Given the fact that pain severity also predicted physical activity at 6 months, the association with pain coping becomes more relevant. The interaction between these aspects makes the relationship between OA and physical activity complex. On the one hand strenuous occupational tasks and high-intensity competitive sports are risk factors for OA of the hand, hip, and knee^{46,47}, while longitudinal studies in older adults with knee or hip osteoarthritis show that higher physical activity levels have been associated with a slower decline in function¹². Examining how coping mechanisms play a role and using this information might help individuals to gain better control of the disease symptoms that influence physical activity and the pathway to disability⁴⁸.

In our sample being single and having more severe pain were also associated with less physical activity behavior at 6 weeks. Both factors are well known to negatively influence physical activity behavior^{25-27,45}.

At 6 months, the behavioral aspects showed only univariate associations with self-reported behavioral change and physical activity levels. When controlled for other demographic and health-related predictors, no relationship with behavioral aspects was found. Only higher age predicted less physical activity at 6 months. This outcome confirms other studies that have reported higher age being associated with less physical activity behavior²⁵. Nevertheless, it is striking that only one predictor remained to explain change in physical activity behavior as well as self-reported physical activity levels. From univariate results it can be seen that the more physically active group is on average 3 years younger, which is quite a large gap in an age-range of 20 years. In this group also twice as many participants were active in paid or voluntary work which contributes to higher baseline physical activity

levels⁴⁹ which could make it difficult to further increase PA levels in this group. Alternatively, age may stand for other variables that change with age but were not included in our set of predictors, or were not sufficiently specified, i.e. the variable for chronic disease which did not specify type of disease.

Other well-known predictors of change in physical activity identified in the literature such as BMI, number of chronic diseases, and disability were not significantly related to self-reported change in activity behavior^{50,51}. Differences between populations could explain this discrepancy. However, due to the fact that only one of the models studied showed significant multivariate associations, it is difficult to compare these data to our predictors. The high variance explained by our multivariate model might indicate that enough important variables were included for this study population.

Table 5: Summary results statistically significant associations between predictors and change in physical activity (PA)

	At 6 weeks	At 6 months
Univariate	Being single ↓	Age ↓
	Intention ↑	UCL seeking support ↑
	PCI distraction ↓	Intervention ↑
	PCI resting ↑	
	Intervention ↑ [†]	
Multivariate	Being single ↓	Age ↓
	Pain severity ↓	
	Intention ↑	
	PCI resting ↑	
	PCI distraction ↓	
	Intervention ↑ [†]	

PCI = pain coping inventory; UCL = Utrecht coping list

↑: positive association indicating higher value of predictor leads to more PA;

↓: negative association indicating higher value of predictor leads to less or same level of PA; † confounder

Limitations of this study

Certain limitations of this study should be considered. An important limitation of this study was the small study population, which decreased the statistical power meaning that long term multivariate associations of self-reported change in physical activity behavior could not be assessed. Even so, almost no multicollinearity was present and the models showed good fit. Identified univariate predictors should give a good indication of the variables to be used in other studies.

Another limitation is self-reported behavior, which may be unreliable in assessing change in behavior. Socially desirable answers could be given. In addition, levels of physical activity tend to be overestimated⁵². Comparison with physical activity levels as measured with a validated questionnaire in our study showed that subjective changes corresponded quite

well with reported physical activity levels. Also, similar results were shown for predictors of 6 months physical activity between the self-reported change and levels outcome.

For purposes of this analysis, we treated the participants of the intervention and control groups as one group, although half of them underwent an intervention that was in part aimed at and succeeded in addressing behavioral aspects such as self-efficacy. The association with participation in the intervention confirms this, but unfortunately the number of participants made it impossible to do separate analysis on both groups to look further into this effect. On the other hand some of the behavioral aspects such as coping style are viewed as a personality trait which may not change during an intervention, as was shown in the original effect evaluation³⁶.

Despite these limitations, univariate and multivariate findings of this study should be considered or taken in to account for future interventions. Higher age in particular was shown to be a high risk for lower physical activity behavior. Similar to other studies, the ASE model can be recommended to provide a background for interventions⁵³, or at least behavior-guided interventions³⁵. Due to the longitudinal nature of this part of our study, causality can be assigned to observed associations. Since osteoarthritis was diagnosed by radiographs and almost all participants reported complaints in at least one joint, we hope our population is representative of an older osteoarthritis population. Results should be generalized with caution as the analysis was conducted on a small sample.

It can be safely stated that these and other results show that the relationship between OA and physical activity is complicated and needs further study. The interplay in time between the disease and its symptoms, functional limitations and psychological reactions such as coping styles is complex and if left unattended to may lead to a downward spiral of avoidance, fear of activity and subsequent deterioration in function and disability³⁴. Attention to behavioral aspects and a positive attitude towards keeping physically active is necessary in prevention and care for OA patients^{23,54} and older adults in general⁵⁵.

Conclusion

In conclusion, a change in physical activity behavior in the short term was found to be related to behavioral factors such as intention and pain coping styles. This, together with other predictors of self-reported change, such as pain severity, should be addressed in designing more effective future interventions.

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General discussion

REDUCING
THE IMPACT OF
GERIATRIC
CONDITIONS BY
PHYSICAL
ACTIVITY

CHAPTER

8

Introduction

In 1981 James Fries and Lawrence Crapo published a book ¹ in which they argued that the process of aging is not fixed but plastic and modifiable, and that consequences of aging such as chronic disease or disability can be postponed to shortly before death. In order to delay the aging process, especially those reversible markers of aging such as strength, memory and social ability can be vitalized if an individual chooses to make an effort. Although they identify exercise and physical activity as important changeable markers of aging, in 1981 they also had to conclude that: “the influence of physical activity on aging and other important aspects of human aging have been bypassed as research topics” (p110) ¹. They also comment about the lack of longitudinal studies which look into these aspects, especially those including older adults with chronic diseases.

Since this publication thirty years ago a lot has changed. Demographically, developed countries are faced with an unprecedented aging population with a big increase in the oldest old ². Epidemiological evidence shows that these older adults have an increased risk of living with a chronic disease in old age ³ (and increasingly so with more than one disease at a time ⁴) which may threaten their independence ⁵. On reviewing the evidence on health trends, Christensen et al.⁴ reported that the increase in multimorbidity in older adults did not seem to be resulting in increased functional limitations or disability, although the evidence was not consistent. In general, studies of health trends are complex because indicators of functional limitations and disability have been applied inconsistently; study designs, participation rates and wording of questions have changed over time, and institutional populations are often excluded ⁴. Despite these methodological challenges Christensen et al.⁴ also concluded that aging processes are modifiable.

One of the most important outcomes of the aging process is loss of independence caused by disability. Recent studies into disability trends conclude that there has been a substantial reduction in disability in older adults over recent decades which is probably due to advances in medical science and changing socioeconomic factors ⁶. According to these and other authors, more research is needed on the influence of health behaviors and interventions that prevent - or substantially delay -functional decline ⁷. Physical activity has been identified as one of these behaviors and related to the prevention and reduction of disability ⁸⁻¹⁰.

The key question of this thesis is to identify if and how physical activity and exercise can be used to postpone the disabling consequences of an aging population. The framework of the Disablement Process Model (DPM) ¹⁰ helps the study of the effects of aging and disease on disability and how factors, including health behaviors, influence the pathway from aging and diseases to disability and subsequent loss of independence. Using the Disablement Process Model as the theoretical background, the aim of this thesis was to study the role

of physical activity in preventing or reducing the level of functional limitations and disability in older adults with geriatric conditions. Three separate research questions have been developed to address this issue:

- I. What is the association between physical activity and disability in older persons with and without geriatric conditions?
- II. Can the impact of geriatric conditions on functional limitations and disability be reduced by specifically designed exercise programs?
- III. What are the determinants of initiation, adherence to and maintenance of exercise programs in older persons with geriatric conditions?

Next, a short summary of the main findings related to these research questions will be presented, followed by an interpretation of these results and discussion of their main consequences. After a short look at some methodological issues of the studies, this general discussion and thesis concludes with implications and some recommendations of these results from a scientific, practical and policy point of view.

Summary of the main findings

To provide an answer on the *first research question*, the first two studies looked into the association between habitual physical activity and disability in older persons with and without geriatric conditions. It was found that:

- on comparison with low physical activity, a medium/high physical activity level reduced the risk of incident basic ADL disability by half; this result was no different in the older (75+) or younger age groups, length of follow-up, study quality and for differences in demographics, health status, functional limitations or lifestyle;
- the risk of progression of basic ADL in older adults with medium/high physical activity level compared with low physical activity level was also reduced although this was a slightly smaller reduction and based on fewer studies and participants meaning that no additional analysis could be done.

A second study explored the same association, only this time in a group of community dwelling older adults with generalized radiological osteoarthritis (GROA) which is known to increase the risk of becoming disabled. Although there was a univariate association between being physically active and a better disability outcome, this association disappeared when adjusted for other health factors such as BMI and number of chronic diseases. The impact of these factors surpassed that of a physically active lifestyle possibly by providing a barrier to being physically active. Therefore it is especially important to tailor physical activity in older adults with disabling geriatric conditions by introducing specifically designed exercise programs for instance.

This option was studied in more detail in the *second research question* by carrying out two clinical trials designed to actively intervene in the disablement process using specifically designed exercise programs. For this purpose two populations of older adults with a geriatric condition were recruited. These two trials show that it is feasible to improve physical performance in older adults with geriatric conditions by the use of specifically designed exercise programs. Achieving a reduction in disability seems more difficult as a decrease in disability was observed only after improved functional performance in community dwelling older adults with osteoarthritis. In frail institutionalized older women no improvement in disability was achieved, despite small improvements in functional performance. Last but not least, these results also indicate that adherence can be an important mediator in reaching improved function and reduced disability levels.

The importance of adherence was the objective of the *third research question* and last two studies of this thesis in which the determinants of initiation, adherence and maintenance to exercise programs for older adults with geriatric conditions were studied. These studies show that determinants for taking part in exercise programs for older adults with geriatric conditions are phase-specific, and that functional limitations and disease-specific symptoms, and how to cope with them, are important issues to address in order to increase adherence and maintain physically active behavior. It also shows that taking part in this type of specific program only increases habitual physical activity and specific exercise activity during the course of the program. The end of the program is a critical period for maintenance and risk factors for dropping out can and should be addressed.

Interpretation of the results

The Disablement Process Model offers a framework to interpret these results. However, this model is largely based on work in the field of disability research and might be less compatible with the field of physical activity research. Therefore, adaptations to the model were proposed to make it more compatible with physical activity research⁹. These include (figure 1):

1. the addition of disuse and physiological aging as key mechanisms which begin the disablement process;
2. the addition of symptoms as an important mechanism by which chronic disease affects functioning and disability;
3. the modification of definitions to incorporate positive levels;
4. the distinguishing of functional performance and physical functioning as separate steps in the pathway.

This joint theoretical framework and these adaptations will be used to discuss the results of the studies presented in this thesis.

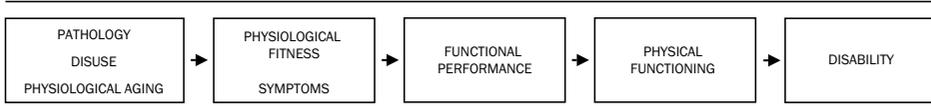


Figure 1: Suggested conceptual framework for linking physical activity and disability research⁹

It has been proposed that the disablement process starts not only with **pathological conditions** such as chronic disease but also with disuse and physiological aging.

Physical activity has been extensively associated with the prevention of major diseases and conditions such as cancer, hypertension, obesity and depression in older adults¹¹. As well as the primary prevention of chronic disease, physical activity slows down the deterioration of physiological and mental functioning associated with **aging** such as decreased cardiovascular fitness and aerobic capacity, reduced muscle mass and strength, increasing adiposity, reduced flexibility of joints, disturbed balance, reduced bone density, lowered immunity and increased chronic inflammation¹¹⁻¹⁴. It is difficult to distinguish the effect of aging from that of disease in most of these functions, as it is still not known which levels of physical functioning can be considered as normal or representative of each consecutive age. Nevertheless, by removing or reducing these risk factors, an increase in organ reserve is realized which helps to prevent disablement. This is particularly beneficial at older ages when the energy requirements of daily activities approach an individual's functional capacity. As long as this functional capacity exceeds the energy requirements functional ability and an independent lifestyle are feasible. Interventions that target different bodily systems (cardiopulmonary, musculoskeletal etc.) at the same time are preferable in order to increase functional capacity.

Besides the aging process, **disuse** or sedentary behavior has been identified as an important determinant of loss of physical capacity^{15,16}. According to Daley & Spinks¹⁷ half of the loss in functional capacity between ages 30-70 is related to the aging process and the other half to inactivity.

It is likely that the major influence of regular, habitual physical activity on disability is mainly through delaying the start of the disablement process as it prevents chronic disease, slows down the aging process and prevents disuse. As is concluded in Chapter 2, a medium/high level of physical activity would be sufficient to prevent or delay the progression to disability. A medium level would constitute regularly being physically active at least 1- 3 days a week. By removing some of these starting points of the disablement process with physical activity important benefits can be achieved in terms of the vitality and capacities of an individual to deal with threats. Even so, most older adults at some time during their life will be challenged by disease or traumatic life events which threaten their independence. The next step would be to slow down the disablement process by remaining physically active despite disease or aging, as dealt with in Chapters 6 and 7, and via specific exercise interventions as in

Chapters 4 and 5. The subsequent stages in the pathway between disease and disability help to identify where these interventions should be targeted.

The next stage of the adapted Disablement Process Model introduces **physiological fitness** as a positive connotation of impairments and adds symptoms to this stage. **Symptoms** such as pain and fatigue are not only known determinants of functional limitations and disability¹⁸ but also have been identified as mediators between physical activity and functional limitations for instance in osteoarthritis¹⁹. Fear of pain during activities can lead to avoidance of physical activity and thereby increasing the impact of OA on disability²⁰. In the osteoarthritis trial discussed in Chapter 5, the physical exercise intervention resulted in less symptoms i.e. pain which may have been an important factor in slowing down the disablement process. At the same time dropout was related to tolerance to pain which makes the relationship between exercise and pain in older adults with osteoarthritis more complex. Also in Chapter 3 joint complaints, including pain, were identified as important determinants of disability in older adults with generalized radiological osteoarthritis as well as being related to the amount of physical activity. Therefore, addressing pain management when providing exercise programs to these older adults is important.

In the next adaptation of the model, it is proposed that the original concept of functional limitation is renamed positively and divided into levels of 'functional performance' and 'physical functioning'. Functional performance loosely resembles performance-based measurement of **physical performance**, and as scores are projected onto a scale that is not maximized to 'having no limitations', thereby avoids ceiling effects. Nevertheless, as identified in Chapter 2, most of the instruments used in studies do not differentiate well between these stages as they incorporate items related to the impairment, limitation and/or disability level into one scale²¹. One way of clarifying this might be to use **physical functioning** as a stage which more closely reflects self-report measures or perceptions of functioning. Several studies have shown that performance-based and self-report measurements of functioning do not always match²²⁻²⁴ which might reflect distinct entities in the disablement pathway.

In the two trials discussed in Chapters 4 and 5, the exercise interventions were specifically targeted at the stage of physical performance (figure 2). In the incontinence trial discussed in Chapter 4 an improvement was observed in physical performance but not in self-reported function or disability. This might have been due to the small improvement which did not lead to a subjective improvement, and also underlines the need for clearly distinguishing these stages. Also, the post-test measurement that was carried out did not pick up any changes in physical functioning or disability that may have occurred later, although the intervention ran for 6 months. The 'Hop with the Hip' program in Chapter 5 aimed to improve both physical fitness (i.e. muscle strength) and the function of the hip joint by means of targeted exercises. Improvement in functional aspects was achieved and subsequently resulted in improvement in disability status as proposed by the model.

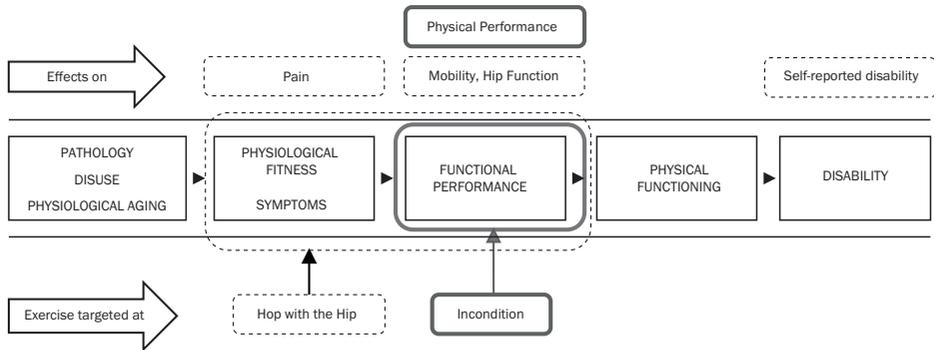


Figure 2: Targeted and effected stages of the adjusted disablement process model in two trials

Together these results show that preventing or delaying the transition between the different stages of the disablement process can be achieved by targeted exercise interventions. For instance, physical activity and exercise reduce functional limitations (such as lower extremity limitations, mobility limitations) which act as a mediator between impairments and disability²⁵⁻²⁷. One consequence of following this specific pathway would be that the effects of induced exercise would show up first in reduced functional limitations, only later to be followed by changes in level of disability²⁵. This was indeed the case in the osteoarthritis trial in Chapter 5 which used physical exercise to reduce symptoms (i.e. pain) and improve functional performance (i.e. hip function) at post-test. At follow-up this resulted in decreased disability (self-report scale). On comparison with other health promotion programs, a wide range of exercise programs have been shown to be more effective in improving physical functions related to disability²⁸. While both resistance and aerobic exercise training have been shown to be able to reduce the risk of ADL disability with 43%²⁹, recently developed functional or task-specific exercise programs show even more promise^{30,31}. These programs specifically target physical function in an ADL environment instead of only physiological fitness or performance such as muscle strength, and result in longer term maintenance of functional capacities³¹. As visualized in the adapted model, targeting more stages at once or closer to the final stage, could enhance both short and long term effects on disability. Nevertheless, alternative pathways of physical activity in the last stage of the disablement process, **disability**, cannot be ruled out as is discussed in Chapter 2. Even when adjusted for functional limitations, being physically active still resulted in a reduced risk of basic ADL disability. The results in Chapter 3 show the interplay between different determinants of disability is more complex than the chronological pathway of the disablement process projects. This might lead to alternative explanations of the effect of physical activity on disability.

Firstly, being physically active may serve as a proxy for a more broadly healthy lifestyle which leads to prevention of negative consequences. A lifelong history of physical activity may

have a stronger effect on delaying the disablement process than current physical activity status. One of the few studies that did follow older adults over a prolonged period of time (up to 21 years, The Runners Study)³², showed that progression of disability was slowed down even in those who started exercising later in life. Their level of physical activity resembled that of those who had been exercising for over twenty years. The disability progression rate was also similar between lifetime sedentary and exercise dropouts, even when corrected for higher levels of comorbidity.

Secondly, a lack of complete understanding of which confounding factors are related to disability may lead to overestimation of the contribution of factors currently known to be related to disability. The strongly reduced risk of disability associated with physical activity identified in Chapter 2 might be smaller if other factors are taken into account. Besides PA and the functional limitations already mentioned, currently identified factors include, demographic factors (age, gender, education, income, race, marital status), lifestyle factors (smoking, alcohol intake, diet, BMI, sleep, social network), and health-related factors (physical and mental comorbidity, self-rated health, health care utilization (including medication use)). Most of these factors are in some way associated with physical activity. Nevertheless the result of the meta-analysis of Chapter 2 remained present when adjusted for most of these factors indicating a unique effect of habitual physical activity.

Thirdly, older adults who suffer from chronic disease or disabling health conditions may already be restricted in their physical activity behavior³³ due to subclinical disability. Lack of exercise could thus be an indication of subclinical disability. Thorough adjustment of the subjective and objective health status is therefore necessary before drawing conclusions on the underlying mechanisms of disability. Nonetheless as discussed in Chapter 2, 4 and 5 and other studies^{34,35}, even in those older adults who have one or more diseases (chronic or otherwise) and are already disabled, increased levels of physical activity or specific exercises will still slow down the disablement process.

Fourthly, the effect of physical activity has also been shown to work through other, psychological, pathways such as depression and self-efficacy. Depression influences the level of physical activity and the subsequent risk of disability³⁶ whereas self-efficacy has been shown to play a mediating role between longitudinal changes in physical activity and functional limitations in older women³⁷. In Chapter 7 the role of self-efficacy in physical activity behavior in older adults with osteoarthritis is explored. No direct effect of self-efficacy was observed while coping styles did play a role in being physically active.

Fifthly, physical exercise has been related to reducing inflammatory markers associated with age-related decline, disability, and frailty^{7,38}.

In conclusion these results show that physical activity plays an important and versatile role in reducing the impact of geriatric conditions. It prevents or delays the start and the subsequent stages of the disablement process, but also slows down transitions between

these stages resulting in prevention or reduction of limitations and subsequent disability. As we have seen, a physically active lifestyle is not self-evident in older adults with geriatric conditions. Older adults are the least physically active age group³⁹⁻⁴¹, especially if suffering from chronic disease or physical limitations^{42,43}.

Therefore the last two studies focused on determinants of initiation, adherence, and maintenance to exercise programs and physical activity in older adults with chronic conditions. These results show that maintenance of exercise behavior is difficult especially in the long term but that there are factors - both interventional and behavioral - that can be changed.

Although the Disablement Process Model identifies external factors that influence the pathway, including risk factors, extra-individual (e.g. medical care) factors as well as intra-individual factors (e.g. lifestyle behaviors), it does not stipulate how these interact with the different stages of the model. Other behavioral models address the issue of physical activity behavior but do not integrate this with the disablement process. An attempt to integrate models addressing physical activity behavior and disability, resulted in the Physical Activity for people with a Disability model (PAD model)⁴⁴. This is a combination of the International Classification in Functioning (ICF) and an adjusted version of the Attitude, Social Influence and Self-Efficacy (ASE) model, as discussed in Chapter 7. The determinants are divided into environmental factors (social influence) and personal factors (self-efficacy, attitude, and health conditions). Both sets of determinants are also influenced by facilitators/barriers (e.g. availability and accessibility of built facilities, time, skills, age, gender). All these determine the central determinant of physical activity, the intention which interacts with levels of physical activity which is part of the levels of functioning described in the ICF model: body functions and structures, activities and participation. The stages of change of the Transtheoretical model are also thought to be compatible with the ASE and PAD models. In this sense, 'contemplators' and 'ready for action' can be characterized as those who have the intention to be active, those exerting 'action' as physically active, 'maintenance' as those who stay active. All of these models, separately or combined into one, offer possibilities to interpret the results of the last two Chapters 6 and 7.

In the study with older adults with osteoarthritis of the knee and/or hip, several behavioral aspects of the ASE model showed associations with self-reported change in physical activity behavior, but when controlled for other predictors, only 'intention' to become more physically active predicted more physical activity at 6 weeks. 'Intention' leading to more physical activity behavior, is supported by the ASE model, although the variables influencing intention, namely attitude, self-efficacy and social influence, were not associated. A concept which is not prominently featured in the above mentioned theories, but is especially relevant in a population with geriatric conditions, is how individuals cope with disease-related symptoms, such as pain in particular. The use of differing pain coping styles may result in different outcomes regarding maintenance and physically active behavior and should

therefore be more prominently addressed in theoretical models. Although pain coping styles play a role they are usually personal and difficult to change. For these reasons those aspects mentioned in the models that are prone to change should be of especial interest for future interventions. As identified in these two studies these include, self-efficacy, practical barriers and quality of intervention. Aspects that need to be addressed when developing an intervention include symptoms, especially severe pain but also other health complaints, and being single. Recent systematic reviews have identified determinants to physical activity and exercise in older adults⁴⁵ as well as common barriers and motivators to physical activity in the oldest old⁴⁶ that should be taken into account when developing interventions.

Another important result was the fact that determinants of exercise behavior are phase-specific and different strategies need to be addressed for the initiation, adherence and maintenance of behavior, which is in line with other results^{47,48}. For instance Rothman describes a framework in which it is stated that decisions regarding behavioral initiation are predicted to depend on favorable expectations regarding future outcomes, whereas decisions regarding behavioral maintenance are predicted to depend on perceived satisfaction with received outcomes⁴⁸. As described earlier, the stages of change of the Trans Theoretical Model also distinguish different stages and suggests that persons in each stage of change should be approached in a different stage-specific way⁴⁹.

Methodological consideration

Despite the growing population of older adults and the fact that physical activity and exercise have been identified as an important factor in the aging process for more than 30 years, older adults are underrepresented in intervention studies. In 72% of trials reported between 1994-2006 in 9 major journals, older adults were excluded⁵⁰ while in 2004 only 5% of RCTs were designed specifically for older adults⁵¹. Also, there is a lack of studies reporting on barriers and motivators exclusively for the oldest old, making it difficult to design promotion efforts for this population⁴⁶. The main reason for excluding older adults is the use of co-morbidity as an exclusion criterion. This clearly shows that more studies into the role of physical activity to reduce the impact of geriatric conditions are necessary, but also present methodological and practical challenges.

These can be distinguished/categorized as:

- design of exercise interventions;
- recruitment, adherence and dropout of participants;
- outcome measurements.

Table 1 presents the challenges faced and solutions used in the studies described in this thesis, which will be discussed more extensively below.

Table 1: *Challenges and solutions to methodological and practical issues*

	Challenges	(Possible) Solution	Consequence
Exercise design	Reduced capacity or tolerance to perform exercises	1. Adaptation of intervention 2. Feasibility pilot	1. Longer duration-> increased risk of dropout
	Heterogeneity in older population	1. Tailored intervention 2. Individual guidance	1. Comparability 2. Increased resources
Adherence	Difficult recruitment	Multistage process	Time consuming
	Loss of power due to selective dropout and missing data	1. Dropout analysis 2. Imputation of missing data 3. Extent measurement period/ brief assessment	1. Adjust generalizability 2. - 3. Time consuming
	Lack of adherence	Per protocol analysis	Also include intention to treat
Measurements	Lack of suitable objective instruments (reliable, feasible)	1. Self-report 2. Use of proxy or observer	1. Subjective and less reliable 2. Increased workload and recruitment
	Choice of relevant instruments for different stages in DPM	Restrict self-report to disability	International standard
	Lack of comparability	Use higher level comparisons (low, moderate, high)	No insight in dose-response Loss of information

Design of exercise interventions

Designing interventions for older adults with geriatric conditions is challenging due to their reduced physical fitness and performance and the increasing variability with age of function and heterogeneity of this population. The intensity of the exercises in particular usually needs to be reduced which may affect their effectiveness. This can be compensated by prolonging the intervention period but this will increase the chance of dropout. A second important adaption could be to individually tailor interventions to the functional level of participants. This has been proven to be an effective strategy in reducing incontinence^{52,53}. Some negative consequences of this approach are the higher costs of this type of intervention (increased workload for instructors) which might prohibit future implementation and reduce comparability of interventions. On the other hand, studies of group treatments have some methodological consequences that need to be addressed such as adapted treatment allocation, power calculation and the analysis methods involved⁵⁴.

Nevertheless, to increase the effectiveness and feasibility of exercise intervention trials the following suggestions have been made^{55,56}:

- individually tailored (to disability, intensity levels);
- multimodal (aerobic, strength, balance, functional tasks);
- multifocal (co-morbidity);
- designed around important goals for participants (i.e. independence);
- focused on prevention or delay of progressive disability.

Recruitment, adherence and dropout

In three intervention studies discussed in this thesis (Chapters 4, 5, and 6) recruitment was difficult; eligible participants withdrew, sometimes after formal inclusion and baseline measurement. The main consequence was a loss of power which may have resulted in lack of statistically significant findings. Reasons for withdrawal were diverse but as discussed in Chapter 6, practical aspects (time and location of the intervention) and expectations about the type of intervention were the reasons most mentioned. During the trials, selective dropout occurred, related to relevant factors such as tolerance to pain, age (Chapter 5), lack of motivation or dissatisfaction with the intervention or instructor (Chapter 4). The latter factors also influenced the level of adherence during the trial which resulted in per protocol analysis being carried out in order to identify the effect in a motivated and compliant subgroup. Dropout also affected the longitudinal studies synthesized in Chapter 2. Most reports of these studies did not account for the loss of participants during follow-up measurements or lack of participation during the recruitment phase. In all publications where this was mentioned, selective dropout was reported. This may have led to an overestimation of the preventive effect of physical activity on disability. Even when there are no differences at baseline between participants and those who refuse to participate or drop out, studies that did look at follow-up data reported a higher mortality and nursing home admission rate among refuser⁵⁷.

The incontinence trial also suffered from missing data due to lack of compliance in measurements (in both participants and caregivers). Therefore imputation of data was used to enhance the dataset.

Outcome measurements

With respect to the measurement of physical activity in longitudinal studies (as discussed in Chapters 2 and 3), most studies use either single questions or, in some cases, validated questionnaires. Yet reliable and usable objective alternatives do exist⁵⁸, although less practical in large cohort studies. In general, use of self-report measures leads to overestimation of activity levels. Also most measures used focus on frequency without evaluating intensity or type of activity. A major consequence is the lack of comparability of these studies and classification of participants into low, moderate or high levels of physical

activity which may have resulted in overestimating or underestimating the level of physical activity in some studies. Also, terms such as vigorous, high etc. were hardly specified by authors. These limitations made it impossible to look into dose-response relationships. Alternatives might be to promote use of validated instruments (either questionnaires or objective measures) or increase comparability between physical activity scales, such as response conversion techniques⁵⁹.

Another important issue regarding measurement is making a clear distinction between definition and instruments to measure the various stages of the disablement process model²¹. Consequently the distinction between impairments, functional limitations and disability is not consistently applied. One reason is that most standard instruments incorporate items containing more than one concept, such as the Physical Performance Test⁶⁰ (Chapter 4) which combines items of functional limitation with items measuring disability (eating, clothing). Also the latter stages of the Disablement Process Model can either be assessed by objective measurements or self-report and are not comparable. Both of these approaches are potentially valid but reasoned choices should be made and not just practical ones. In order to overcome these issues, standardization of definitions and measurement of different stages should be implemented. This should also address aspects of clinically relevant cut-points and meaningful change scores, cross-national and cultural comparisons²¹. A number of definitions of disablement are in use, leading to different interpretations of results. Interesting work has been done by the European Network for Action on Aging and Physical Activity (EUNAAPA, www.eunaapa.org), which has published a series of systematic reviews on measurement of physical activity and physical performance instruments for older adults⁶¹⁻⁶³. Although these reviews focus on psychometric qualities such as validity and reliability, they can serve as a starting point for future standardization efforts.

Most of the abovementioned methodological and practical issues can be addressed. In order to overcome some of these challenges *The Interventions on Frailty Work Group*⁵⁶ published a set of recommendations which guide the design and execution of intervention studies with frail older adults. Most of these also relate to older adults in general and include using a multistage selection process, avoiding co-morbidity as an exclusion criterion, ascertaining the level of cognitive impairment incompatible with participation in certain interventions, limiting self-report measurements to measures of disability and using objective measures for physical function and including secondary measures that are in the theoretical pathway between the intervention target and the disability outcome⁵⁶.

Implications and recommendations

In addition to the recommendations concerning designing exercise interventions and methodological issues discussed above, on the basis of the results described in this thesis the following implications and considerations should be taken into account.

From a scientific point of view

In order to gain a full understanding of how physical activity influences the development of disability, the research fields of physical activity and disability need to be combined. The proposed clarification of the various steps in the Disablement Process Model that is proposed by Stewart seems appropriate in order to get a clearer understanding of the way exercise interventions can be directed at improving function and decreasing disability. It may also help to more clearly distinguish the various proposed concepts and improve operationalization in physical activity and disability research²¹. The systematic review (Chapter 2) showed that functional impairment and disability were not always clearly distinguished from one another which leads to difficulty in synthesizing the evidence. Naming concepts positively has the advantage of being able to use a broader scale and therefore might help to more accurately identify the effects of interventions. For instance, having a 'high level of physical fitness' instead of having 'no impairments' can identify those adults with a large capacity to deal with negative events such as trauma or disease and maintain natural function and independence for longer⁶⁴. This is also closely linked to the new definitions of health which have been put forward⁶⁵ which focus on the ability to deal with consequences of disease such as functional limitations, disability and participation. Nevertheless, other models such as the International Classification in Functioning (ICF) developed by the World Health Organization are increasingly being used in disability research. In order to prevent confusion, some authors propose that the ICF should be chosen as the main model⁶⁶. For scientific purposes, i.e., efforts to further elucidate the mechanisms of disablement and how physical activity acts on this process, the disablement process model seems to be better equipped as it was developed and validated by scientific research^{10,67,68} while the ICF is based on a consensus-building process. One important consequence is that the concepts of the Disablement Process Model have been more clearly operationalized in instruments, although improvements are still necessary²¹ and there is progress on instruments for the ICF model⁶⁹.

One important step which could further develop and improve prevention of disability would be to identify which older adults with geriatric conditions have an increased risk of becoming disabled and who would benefit from exercise interventions. As clarified by the Disablement Process Model, loss of physiological fitness or functional performance is one of the first signs of progress to disability. Screening instruments which focus on these stages could be useful in detecting high risk older adults. Several predictors of functional decline have

been identified which increase the risk of disability in activities of daily living. These include vision and hearing problems, overweight and malnutrition, low levels of physical activity, reduced physical fitness, mobility problems, balance problems, muscle strength, cognitive impairment, bad subjective health and limited social network^{70,71}. Objective measured physical predictors seem particularly relevant for implementing early detection programs and can be measured reliably⁷². Effective interventions are available for most of these impairments and functional limitations⁷³ which makes it relevant to screen as improvement and reduction of risk can be achieved. Examples of reliable instruments that can be used includes the Short Physical Performance Battery (SPPB)⁷⁴, hand grip strength measurement and the Short Nutritional Assessment Questionnaire for the elderly (SNAQ65+)⁷⁵. The SPPB has recently been identified as the most reliable and valid instrument to measure overall function in older adults⁶³. It can be easily administered and provides clear cut-off points for classification of high risk older adults. Interestingly, a recent assessment of the appropriateness of screening community dwelling older people to prevent functional decline, based on the criteria of Wilson & Junger and by expert opinions, revealed that insufficient physical activity was considered appropriate as one of three (besides smoking and cardiovascular risk factors)⁷⁶. Identifying older adults who are low in level of physical activity can therefore also be regarded as a valid screening tool for increased risk of functional decline.

From a practical point of view

With reference to promoting **habitual physical activity**, both a moderate level of habitual physical activity as well as participation in specific exercise interventions are important measures to prevent or slow down the disablement process in older adults with geriatric conditions. In addition to those recommendations for physical activity and exercise programs already made, several aspects such as type and level of physical activity are important to mention.

Considering the optimal type of activity for older adults it would be good to promote accessible, popular and everyday activities such as walking and transport to increase habitual PA levels^{41,77,78}. Various studies have shown that moderate but regular levels of physical activity are enough to reduce the impact of geriatric conditions. It has been proposed that daily activities such as walking 1 mile at least once a week²⁶ are sufficient to prevent disability. Vigorous levels of activity such as running can increase the risk of injuries and might predispose to decline in function⁷⁹ although the incidence of sport-related injuries reduces with age⁸⁰. Dose-responses relationships have been reported between the level of exercise and functional limitations or disability⁸¹ although ceiling effects have been reported⁸². These different results might be due to population differences between the different countries as well as methodological differences. There does not seem to be an effect of intensity level on disability⁸². With reference to **physical activity programs**,

discussed in Chapter 6 and described in other studies⁸³ the quality of physical activity programs plays an important role in the effectiveness of promoting physically active behavior. EUNAAPA has published recommendations on designing high quality physical activity programs, based on inventories of guidelines and current practice in Europe⁸⁴ which can be found on their website (www.eunaapa.org).

Out of the results in Chapters 4 to 7 it can be assumed that different strategies are needed for different behavioral phases. These include:

- Distinguishing initiation from maintenance behavior;
- Using an individually tailored approach focusing on the functional limitations and preferences of older adults^{85,86} which specifically address behavioral aspects (self-efficacy, attitude, social aspects, coping strategies)^{85,87-91};
- Addressing outcome expectations and providing regular feedback on achievements^{48,90,92,93};
- Addressing barriers that can be overcome, in particular health-related symptoms such as overweight, pain, tiredness, shortness of breath, depression, with adaptations in the type, intensity and frequency of exercise^{86,89,91};
- The provision of qualified and motivated instructors, regular feedback and alternated exercises⁹⁴ and make it feel like fun!⁹⁵

From a policy point of view

In health policy-making the focus has shifted towards the concept of 'healthy and active aging' which does not only include maintaining good health or preventing disease but also focuses on the goals of independence and participation of older adults. For example, this has led to promoting function-oriented prevention as well as more classical disease prevention (i.e. by early detection of risk for functional decline⁹⁶). As we have seen, physical activity promotion can accommodate this shift in health policies as identified in a silver paper on the future of health promotion and preventive actions of age-related disease⁹⁷.

The Behavioral Epidemiology Framework⁹⁸ identifies various phases in linking physical activity with health as described in a recent position stand of the ECSS⁹⁹:

1. Identify the link between physical activity and health;
2. Develop methods for the accurate assessment of physical activity;
3. Identify factors associated with different levels of physical activity;
4. Evaluate interventions designed to promote physical activity;
5. Translate findings from research into practice.

Most of these steps have been taken in relation to older adults. As we have seen, regular physical activity is associated with enhanced health and prevention of disability¹¹ (and Chapter 2), accurate methods of assessment are available although not yet used extensively⁵⁸, determinants of physical activity initiation and maintenance are known

(this thesis) and guidelines are available ^{100,101}, interventions have also been developed and evaluated ⁷³. One of the remaining key issues is how to translate all this scientific knowledge into practice and policy. An interesting approach might be to let scientists take an active role in this process of policy development for health promotion. An inventory of the organizational policies of a number of sectors concluded that the sports sector has the most favorable perceptions of goals and resources for promotion of physical activity while the health sector was the most negative on these aspects but the most positive on obligations towards physical activity promotion ¹⁰². Therefore physical activity promotion policies might advance more rapidly if collaboration between these sectors is fostered.

In a recent European funded project, this approach was used to strengthen capacities for the promotion of health through physical activity among sedentary older people in 15 European nations. It used an intersectoral approach which helped organizations from different sectors related to aging and or physical activity to strengthen their intra-organizational capacities to promote physical activity. An evaluation showed that capacities of the participating organizations had indeed increased ¹⁰³. Also the project resulted in 12 national intersectoral alliances, including organizations from the health sector (physical therapy), social sector (senior representative organizations), sports sector (Olympic committees), science/education (universities), environment sector (nature organizations), policy sector (municipalities, ministries) and media (broadcasting organizations). The alliances drew up action plans to promote physical activity in older adults based on the input of scientific evidence. The advantage of addressing separate policy fields is that different kinds of settings that influence population physical activity levels can be combined such as individual factors (health care), social factors (social care, sport) and environmental factors (planning). A multidisciplinary approach offers the best opportunity for change in increasing the physical activity levels of aging populations. This could be organized by national platforms as described above. Good examples are the Fit for Life initiatives originated in Finland and followed by the Netherlands.

In conclusion

As stated more than 30 years ago, the goal of research into aging should be to study patterns of aging that may be altered resulting in an increased period of vitality. Although our lifespan is fixed, many aspects of aging are modifiable and with this thesis, the role that physical activity can play in attaining lifelong vitality and preventing or delaying disability has become a little clearer. More than anything it stresses the need for older adults to stay physically engaged throughout life, even in old age and when misfortune crosses their path. The upside of this would be that aging is not something inevitable but something that can be actively challenged by initiating or maintaining a physically active lifestyle.

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Summary

Nederlandse samenvatting

REDUCING
THE IMPACT OF
GERIATRIC
CONDITIONS BY
PHYSICAL
ACTIVITY

CHAPTER

9

Reducing the impact of geriatric conditions by physical activity

Due to the increase in the number of people aged 65 and older and the fact that diseases that were formerly fatal can now be better treated and managed, the number of older adults with chronic disease is rising. As well as diagnosed diseases, the so-called geriatric conditions are common. These can be described as a collection of symptoms and signs common in older and vulnerable adults and which are not necessarily related to a specific disease. These include cognitive impairment, incontinence and immobility. One important consequence of multiple chronic disease or conditions in older adults is the increased risk of becoming disabled - as described by the disablement process model of Verbrugge & Jette in 1994. This model describes the pathway that runs from aging and pathology via impairments and functional limitations towards disability which threatens the quality of life and participation of older adults in society. Physical activity has been identified as one of the factors that can speed up or slow down this process and which affects its direction.

Theoretically physical activity can influence all stages along this pathway, but there is discussion about what is the most effective physical activity or exercise intervention to prevent or slow down this process, particularly in those older adults who are already impaired. Paradoxically, those groups that would benefit most from an active lifestyle are also those known to be the least active, i.e. older persons and those with disabilities or chronic conditions. There is a need for better understanding of how to surmount these barriers and increase adherence and maintenance to physical activity in this growing group. The aim of this thesis is to study the role of physical activity in preventing or reducing the level of functional limitations and disability in older adults with geriatric conditions.

Three separate research questions have been developed to address this issue:

- I. What is the association between habitual physical activity and disability in older persons both with and without geriatric conditions?
- II. Can the impact of geriatric conditions on functional limitations and disability be reduced by specifically designed exercise programs?
- III. What are determinants of initiation, adherence to and maintenance of exercise programs in older persons with geriatric conditions?

In order to answer the first question, two studies using observational data were carried out. The first was a meta-analysis of the association between physical activity and the incidence and progression of basic ADL disability (**Chapter 2**). By means of an electronic literature search and cross-referencing, thirteen prospective longitudinal studies on physical activity and basic ADL disability in community-dwelling older adults (50+) with baseline and follow-up measurements were selected. Results of the meta-analysis show that compared with a low physical activity level, a medium/high physical activity level reduced the risk of

incident basic ADL disability by 0.51 (95% CI: 0.38, 0.68; $p < .001$). This is based on nine longitudinal studies involving 17,000 participants followed up for 3 to 10 years. The result was independent of age, length of follow-up, study quality, differences in demographics, health status, functional limitations, and lifestyle. The risk of progression of basic ADL disability in older adults with a medium/high level of physical activity compared with those with a low physical activity level was 0.55 (95%CI: 0.42, 0.71; $p < .001$), based on four studies involving 8,500 participants.

The second study (**Chapter 3**) studied the same association but this time in community-dwelling older adults with generalized radiological osteoarthritis (GROA in hand, knee and/or hip) and disability. A good outcome at follow-up was defined as improved or mild disability, and a poor outcome as worsened or severe disability. Factors potentially associated with outcome were demographics, joint complaints, chronic health problems or limitations and level of different types of PA.

The results show that in the 309 community dwelling older adults (75+) with GROA that were identified in the cohort of the Rotterdam Study, the level of disability at baseline was classified as mild to moderate with minor increases in 5 years. At baseline physical activity decreased with increasing disability, particularly in sport and walking. Physical activity was univariately associated with a better outcome at follow-up, but when adjusted for other factors only higher age and having more than two other chronic conditions were associated with negative changes in general and lower limb disability, but not with upper limb disability. This means that the results of the meta-analysis could not be replicated within this group of older adults with GROA, which might be due to the complex relationship between physical activity and symptomatic OA. This leaves the question on function can be improved and disability reduced in older adults who are frail or suffer from multiple geriatric conditions that have great impact on daily life and activities?

To answer this second research question, two randomized controlled trials (RCT) were conducted in which the effect of exercise on reducing functional impairment and disability was studied. The first multicenter RCT (**Chapter 4**) was carried out among women living in homes for the elderly in whom urinary incontinence (UI) is highly prevalent. Management is usually restricted to dealing with the consequences instead of treating underlying causes such as bladder dysfunction or reduced mobility. The aim of this study was to compare a group-based behavioral exercise program to prevent or reduce UI, with usual care. This study was done by recruiting, matching and randomizing Dutch homes into intervention or control homes. These homes recruited older women, with or without UI, with sufficient cognitive and physical function to participate in the program. This program addressed behavioral aspects of continence and used physical exercises to improve PFM, bladder and physical performance. It consisted of a weekly group training session and homework exercises and ran for 6 months during which time the control group participants received care as usual.

In total a 102 participants were allocated to the program and 90 to care as usual. Intention to treat analysis, based on an imputed data set (n=85 intervention, n=70 control) showed improvement of physical performance as measured with the Physical Performance Test (intervention +8%; control -7%) and no differences on other primary and secondary outcome measures. Per protocol analysis, including all participants who completed the study and intervention (n=51 intervention, n=60 control) showed a reduction in participants with self-reported UI (intervention -40%; control -28%) and in frequency of self-reported episodes (intervention -51%; control -42%) in both groups. The observed improvement of physical performance (intervention + 13%; control -4%) was related to participation in the exercise program. Based on these results it was concluded that improving physical performance by exercise is feasible in institutionalized older women. The reductions in UI were not related to the intervention.

The second trial (**Chapter 5**) was aimed at evaluating an 8-week exercise program with strength training and lifestyle advice for community-dwelling older adults with osteoarthritis (OA) of the hip. Although there is no cure for OA, disease-related factors, such as impaired muscle function and fitness, are potentially amenable to exercise intervention. However, unlike in OA of the knee there is little evidence to support the efficacy of such programs in OA of the hip, and few studies have evaluated the long-term effects of such programs.

The program 'Hop with the Hip' consists of eight 1-hour weekly group sessions of strength training using fitness equipment under the supervision of a physical therapist. Participants were also offered a home exercise program, personal ergonomic advice from an occupational therapist and dietary advice from a dietician. A total of 109 participants (55 experimental, 54 controls) were included in the trial. They had to be 55 years or older, have clinical OA diagnosed in accordance with the ACR criteria, and live independently. Fifteen participants dropped out due to lower pain tolerance and younger age. The results show that the program had a positive effect on pain (VAS scales; moderate effect at post-test and small effect at follow-up), hip function (Harris Hip Score; small effect at post-test), self-reported disability (GARS; small effect at follow-up), and the timed Up & Go test (small effect at follow-up). It did not affect QOL, other measures of observed disability or BMI.

Based on this it was concluded that the exercise program had positive effects on pain and hip function, which the disablement process model shows to be important mediators of disability.

These two trials show that it is feasible to improve physical performance in older adults with geriatric conditions by using specifically designed exercise programs, and that reduction in disability takes more time and follows improvement in functional performance. In frail institutionalized older women improvement in disability was not achieved, at least not at post-test, despite small improvements in functional performance. Finally, these results also indicate that compliance can be an important mediator in achieving improved function and reduced disability levels.

The third and final research question looks into the issue of compliance and was studied by two observational studies that looked at determinants of maintenance of physical activity behavior after exercise trials in community-dwelling older adults. The first study (**Chapter 6**) was conducted after an RCT showing that improvement in some aspects of cognitive function was related to adherence to an exercise program. To address patterns of adherence and determinants of maintenance older adults with mild cognitive impairment were contacted by telephone for an interview six months after the end of their exercise program. Mean adherence during the trial was 53%. About one-third of participants had lapses during the trial but completed it, one-third had no lapses, and one-third dropped out or never started. Practical barriers (time, location) were related to not starting, functional limitations to dropout. After the trial 25% of participants continued with the programs, 14% reported an intention to continue, and 61% quit. Maintenance was determined by fewer health complaints, higher levels of satisfaction with the programs and better adherence during the programs. Although maintenance was low, this study identified motivators and barriers to adherence and maintenance that can be addressed.

The final study (**Chapter 7**) evaluated whether behavioral aspects of self-efficacy, attitude, social norm and coping predict change in physical activity in older adults with OA in the knee and/or hip. A total of 105 participants of a RCT (self-management intervention) were followed up to 6 months. Results show that forty-eight percent of participants had a self-reported increase of physical activity at 6 weeks and 37% at 6 months which corresponds with PA levels measured with the Voorrips questionnaire. At 6 weeks, univariately as well as multivariately, use of the pain coping style 'resting', intention to and participation in the intervention were positively associated with more physical activity behavior whereas being single and less use of the pain coping style 'distraction' predicted more self-reported physical activity. More severe pain only predicted less physical activity multivariately. At 6 months, univariate associations were found for age, general coping style 'seeking support' and participation in the intervention; multivariately, higher age was associated with less self-reported physical activity. It was concluded that a self-reported change of physical activity at post-test was predicted by the behavioral factors 'intention' and several pain coping styles. Together with other predictors of self-reported change (pain severity, higher age, being single), these can be addressed in future interventions to enhance physical activity at the end of an exercise program which is a critical period for maintenance.

The final chapter of this thesis (**Chapter 8**) discusses the results from these six studies, using a conceptual framework for linking physical activity and disability research based on the disablement process model. According to this enhanced model physical activity can prevent the start of the disablement process by preventing disease, physiological aging and disuse. Secondly, specifically designed exercise may lead to a reduction in symptoms such as pain or fatigue which can cause disablement. This was shown in the second trial (Chapter

5), aimed at older adults with hip osteoarthritis which reduced pain levels. Thirdly, exercise programs such as the hip program or Incondition program (Chapter 4) aim to improve the functional performance, even in frail institutionalized women, as well as physical functioning. These improvements in symptoms, performance and functioning may delay or prevent the end stage of the disablement process, disability in daily life. Nevertheless alternative pathways cannot yet be ruled out. The results from the meta-analysis (Chapter 2) show that being physically active also has an effect on disability when controlled for functional limitations. Other explanations are discussed, such as physical activity being a proxy for a general healthy lifestyle, missing of relevant confounding factors in the disablement pathway, selection effect (those already disabled are limited in their physical activity) and other, non-physiological pathways such as via psychological mechanisms.

Next a possible link between the disablement process and behavioral aspects as studied in Chapters 6 and 7 is discussed. Various behavioral models such as the ASE model and phase -specific models such as the Trans Theoretical Model do not integrate relevant aspects such as symptoms or coping into their models which have been shown to be relevant in older adults with geriatric conditions. Also the different stages of physical activity behavior, initiation, adherence and maintenance and their specific determinants need to be taken into account.

Several methodological issues that are challenging in doing research with older adults with geriatric conditions are discussed: loss of statistical power (due to lack of participation and compliance) and valid outcome measurements (due to lack of suitable objective instruments, choice of stage specific instruments, lack of comparability between PA instruments). Other challenges include the design of exercise interventions (regarding the reduced capacity and heterogeneity of the target group), recruitment, increasing adherence and minimalizing dropout. Most of these issues can be solved but have negative consequences. Finding the right balance is necessary and guidelines addressing these problems are presented and discussed. One important recommendation is that interventions and studies should be better tailored to the heterogenic older population.

Finally implications and recommendations from a scientific, practical and policy point of view are discussed. These include better theoretical combination of the fields of physical activity and disability, designing and using better instruments for tailoring interventions, developing additional physical activity guidelines including optimal type of physical activity and threshold levels, improving physical activity programs on theoretical, practical and quality level. Finally translating the results from this thesis, and aging and physical activity research in general needs to be our next priority. On a European level there are platforms, such as the EUNAAPA network, that can help to disseminate knowledge between scientists, practitioners and policy makers.

Together all these activities should improve the life of older adults and make clear that the impact of aging is not something inevitable but something that can be actively challenged by initiating and maintaining a physically active lifestyle.

Verminderen van de impact van geriatrische aandoeningen door fysieke activiteit

Eén van de belangrijkste gevolgen van veroudering en geriatrische aandoeningen is het ontstaan van beperkingen. De weg van aandoening naar beperking in het dagelijks leven verloopt volgens bestaande modellen in verschillende stappen en wordt, in theorie, beïnvloed door verschillende factoren. Fysieke activiteit wordt gezien als één van de factoren die dit traject kan vertragen, stoppen of zelfs omkeren. Maar hoe werkt dit bij ouderen die geriatrische aandoeningen hebben? Aan de hand van drie onderzoeksvragen en 6 studies wordt dit nader onderzocht.

Onderzoeksvraag I:

Wat is de associatie tussen (dagelijkse) fysieke activiteit en beperkingen in het dagelijks leven van ouderen met en zonder geriatrische aandoening?

In hoofdstuk 2 zijn 13 studies samengevat waarin ouderen (50+) zijn gevolgd om de relatie te onderzoeken tussen hun mate van fysieke activiteit (laag, medium of hoog) en beperkingen in basale activiteiten van het dagelijks leven (ADL) zoals persoonlijke verzorging op latere leeftijd. Vergeleken met ouderen met een laag niveau van fysieke activiteit verminderen ouderen met een medium/hog niveau het risico op het ontstaan van basale ADL beperkingen in de daarop volgende 3 tot 10 jaar met de helft. Bij ouderen die al beperkingen hadden bij het begin van het onderzoek werd een risico vermindering van 45% gevonden op het erger worden van de beperkingen.

In de tweede studie (Hoofdstuk 3) is dezelfde relatie onderzocht maar dan toegespitst op zelfstandig wonende ouderen (55+) met gegeneraliseerde radiologische artrose (GRA; radiologisch zichtbare artrose in meerdere gewrichten). De resultaten laten zien dat bij 309 ouderen met GRA het niveau van beperkingen in het dagelijks leven als mild tot matig kan worden omschreven met daarbij een kleine toename na 5 jaar. Bij het begin van de studie blijkt dat ouderen met meer beperkingen in het dagelijks leven, minder actief zijn met name in sport en wandelen/fietsen. Vijf jaar later is meer fysieke activiteit geassocieerd met een positieve uitkomst (minder ernstige of milde beperkingen). Indien echter wordt gecorrigeerd voor andere factoren, blijken alleen leeftijd en het aantal chronische aandoeningen het verergeren van beperkingen te beïnvloeden bij deze specifieke groep.

Op basis van deze twee studies kan **geconcludeerd** worden dat dagelijkse fysieke activiteit een duidelijke positieve associatie heeft met het voorkómen van of vertragen van beperkingen in het dagelijks leven, maar dat met name bij ouderen met geriatrische aandoeningen ook andere factoren hierop van invloed zijn. De vraag rijst dan hoe fysieke activiteit doelgericht ingezet kan worden om de impact van geriatrische aandoeningen te verminderen in deze groep ouderen.

Onderzoeksvraag II:

Kan de impact van geriatrische aandoeningen op functionele beperkingen en beperkingen in het dagelijks leven verminderd worden door speciaal ontwikkelde beweegprogramma's?

Om deze tweede onderzoeksvraag te beantwoorden, zijn er twee gerandomiseerde klinische trials (RCT's) uitgevoerd waarin het effect van een fysiek oefenprogramma op het verminderen van beperkingen is onderzocht. De eerste RCT (hoofdstuk 4) werd uitgevoerd in 18 Nederlandse verzorgingshuizen. Oudere vrouwen met of zonder urine incontinentie werden gevraagd om deel te nemen, waarbij de helft een speciaal ontworpen oefenprogramma volgde (totaal 102 deelnemers) terwijl de andere helft reguliere zorg kreeg (totaal 90 deelnemers). Het oefenprogramma bestond uit het aanleren van beter toiletgedrag en fysieke oefeningen om de bekkenbodemspieren, blaas en het fysiek functioneren te trainen. De resultaten van verschillende analyses lieten zien dat het fysiek functioneren inderdaad als gevolg van deelname aan het oefenprogramma licht verbeterd (maximaal 13% toename), maar niet het urine verlies. In de groep deelnemers die het hele onderzoek en oefenprogramma hadden afgemaakt, verminderde het ongewild urine verlies echter wel (maximaal 40% minder deelnemers met urine verlies), maar ongeacht of ze het oefenprogramma kregen of reguliere zorg.

De tweede RCT (hoofdstuk 5) had als doel het evalueren van een oefenprogramma bestaande uit krachttraining en leefstijl advies voor zelfstandig wonende ouderen van 55 jaar of ouder met een klinische diagnose van heupartrose. Het ontwikkelde programma, 'Hup met de Heup' duurde 8 weken, opgebouwd uit groep sessies met krachttraining op fitness apparatuur onder supervisie van een fysiotherapeut. Vijf en vijftig deelnemers volgden dit programma en 54 niet maar werden allen wel voor en na gemeten. De resultaten lieten zien dat deelname aan het programma direct na afloop een positief effect had op pijn, heupfunctie, mobiliteit én 3 maanden na afloop ook op zelf gerapporteerde beperkingen.

In **antwoord op de onderzoeksvraag** laten deze twee onderzoeken zien dat het inderdaad mogelijk is de impact van geriatrische aandoeningen te verminderen door speciaal ontwikkelde beweegprogramma's. In het proces van aandoening naar dagelijkse beperking werden functionele beperkingen (b.v. heupfunctie of fysiek functioneren) verminderd, zelfs in kwetsbare geïnstitutionaliseerde oudere vrouwen. Minder functionele beperkingen leidden vervolgens ook tot minder dagelijkse beperkingen, hoewel dit niet aangetoond kon worden bij de vrouwen in de verzorgingshuizen. Deze resultaten lieten tevens zien dat ook deelname en behoud van deelname een belangrijke rol speelt in het reduceren van de impact van geriatrische aandoeningen op dagelijkse beperkingen.

Onderzoeksvraag III:

Wat bepaalt deelname en behoud van deelname aan beweegprogramma's in ouderen met geriatrische aandoeningen?

In twee beschrijvende studies is onderzocht welke factoren (z.g. determinanten) van invloed zijn op het starten met, deelnemen aan en behoud van deelname aan beweegprogramma's door zelfstandig wonende ouderen met geriatrische aandoeningen. Het eerste onderzoek (hoofdstuk 6) is uitgevoerd 6 maanden na afloop van een RCT naar het effect van een sportief wandelprogramma op cognitief functioneren. Het gemiddelde niveau van deelname tijdens het programma was 53%. Ongeveer 1/3 van de deelnemers volgde vrijwel het hele programma, 1/3 viel een aantal weken uit maar maakte het programma wel af, en 1/3 ging niet van start of viel tussentijds uit. Praktische barrières (tijd, locatie) waren vooral gerelateerd aan het niet van start gaan; uitval werd meestal door functionele beperkingen veroorzaakt. Na het onderzoek ging 25% van de oorspronkelijke deelnemers door met het programma, 14% had de intentie om dit te gaan doen en 61% hield er voorgoed mee op. Doorgaan na afloop was gerelateerd aan het hebben van minder gezondheidsklachten, hogere tevredenheid met het programma en betere therapietrouw tijdens het programma. De laatste studie (hoofdstuk 7) onderzocht of gedrag gerelateerde aspecten zoals zelf-effectiviteit, attitude, sociale norm en coping verandering in beweeggedrag kunnen voorspellen in ouderen met artrose in de heup en/of knie. Honderd en vijf deelnemers aan een RCT (evaluatie van een zelfmanagement beweegprogramma) werden tot 6 maanden na afloop gevolgd. De resultaten laten zien dat 48% van de deelnemers een zelf gerapporteerde toename had in beweeggedrag na 6 weken en 37% na 6 maanden. Na 6 weken bleek het gebruik van de pijn coping stijl 'rusten', een intentie tot verandering en deelname aan het beweegprogramma te leiden tot meer bewegen. Ouderen die geen partner hadden, minder gebruik maakten van de pijn coping stijl 'afleiding' of meer pijn hadden waren juist minder gaan bewegen. Na 6 maanden beïnvloedden een lagere leeftijd, gebruik van de algemene coping stijl 'steun zoeken' en deelname aan het beweegprogramma beweeggedrag positief. **Geconcludeerd** kan worden dat het aflopen van een beweegprogramma een kritisch moment is waarop veel deelnemers stoppen maar deze twee studies hebben factoren kunnen identificeren waar rekening mee kan worden gehouden (leeftijd, wel of geen partner hebben) en die deels ook te beïnvloeden zijn (functionele beperkingen en tevredenheid met het programma). De rol van pijn en hoe ouderen hiermee om gaan verdient speciale aandacht, vooral bij ouderen met artrose.

In het laatste hoofdstuk van dit proefschrift (hoofdstuk 8) worden de resultaten van deze 6 studies bediscussieerd aan de hand van een conceptueel kader waarbij onderzoek naar fysieke activiteit wordt geïntegreerd met onderzoek naar beperkingen zoals beschreven in het 'Disablement Proces Model': veroudering en (geriatrische) aandoeningen leiden via symptomen, verminderde functionele prestatie en problemen in fysiek functioneren uiteindelijk tot beperkingen in het dagelijks leven.

Volgens dit model, en zoals onderzocht in de zes studies, kan fysieke activiteit op verschillende manieren het ontstaan en verergeren van beperkingen beïnvloeden: (1) de start van het proces voorkómen door (primaire) preventie van aandoeningen, vertragen van de fysiologische veroudering en verminderen van sedentair gedrag; (2) door middel van speciaal ontwikkelde beweegprogramma's kan een reductie in symptomen zoals pijn of vermoeidheid bewerkstelligd worden zoals aangetoond in de tweede RCT (hoofdstuk 5) gericht op ouderen met heup artrose; (3) tevens kunnen beweegprogramma's zoals 'INCOnditie' (hoofdstuk 4) het fysiek functioneren, zelfs bij kwetsbare geïnstitutionaliseerde vrouwen, verbeteren en fysieke beperkingen voorkomen. Deze verbetering in symptomen, fysieke prestatie en functioneren zorgen samen voor een vertraging in het ontstaan van of zelfs preventie van beperkingen in het dagelijks leven. Alternatieve paden voor de in dit proefschrift gevonden gunstige associatie tussen fysieke activiteit en beperkingen in het dagelijks leven kunnen echter niet uitgesloten worden. De resultaten uit hoofdstuk 2 bijvoorbeeld laten ook zien dat een fysiek actieve leefstijl ook een gunstig effect heeft op dagelijkse beperkingen ongeacht functionele beperkingen. Andere mogelijke verklaringen die worden besproken zijn (1) een selectie effect: ouderen met geriatrische aandoeningen zijn al te beperkt om nog fysiek actief te zijn; (2) het feit dat fysieke activiteit onderdeel is van een bredere gezonde leefstijl welke een gunstige invloed heeft; (3) andere niet fysiologische paden zoals psychologische mechanismen.

Vervolgens wordt getracht een link te leggen tussen het Disablement Proces Model en beweeggedrag (hoofdstukken 6 en 7) in bestaande gedragstheorieën. De verschillende gevonden determinanten van bewegen waaronder symptomen en coping worden vaak (nog) niet in deze theorieën meegenomen, terwijl zoals uit hoofdstuk 7 bleek, ze wel degelijk een belangrijke rol spelen.

Er zijn diverse methodologische beperkingen en uitdagingen waar in dit proefschrift en in onderzoek met ouderen met geriatrische aandoeningen in het algemeen tegen aan is gelopen: (1) uitval van vaak kwetsbare ouderen leidt o.a. tot statistische beperkingen; (2) het valide meten van uitkomstmaten: door het ontbreken van geschikte objectieve instrumenten, het niet kunnen onderscheiden van verschillende stadia van achteruitgang en gebrekkige vergelijkbaarheid van instrumenten om fysieke activiteiten te meten; (3) het ontwikkelen van geschikte beweeginterventies die rekening houden met de verminderde

capaciteit en heterogeniteit van de onderzoeksgroep; (4) de werving van deelnemers en het verhogen van de therapietrouw. De meeste van deze uitdagingen kunnen aangegaan worden maar hebben vaak andere nadelige consequenties. Het vinden van de juiste balans is nodig en enkele beschikbare richtlijnen hiervoor worden vermeld en bediscussieerd. Een belangrijk advies is om interventies én studies beter op maat te maken en te personaliseren voor een heterogene oudere populatie.

Tenslotte worden implicaties vanuit een wetenschappelijk, praktisch en beleidsstandpunt bediscussieerd zoals: (1) een betere theoretische integratie van het onderzoeksgebied van fysieke activiteit en dat van beperkingen; (2) ontwikkeling en beter gebruik van instrumenten voor verschillende stadia van achteruitgang; (3) op maat maken van interventies; (4) ontwikkelen van aanvullende richtlijnen voor fysieke activiteit voor deze doelgroepen inclusief optimale typen en drempelwaarden; (5) verbetering van beweegprogramma's op theoretisch, praktisch en kwalitatief gebied. Tenslotte, het vertalen en toepassen van resultaten van beweegonderzoek, zoals uit dit proefschrift, zou een eerste prioriteit moeten zijn. Op Europees niveau bestaan er platformen, zoals het European Network for Action on Aging and Physical Activity (EUNAAPA) die verspreiding van kennis tussen wetenschappers, uitvoerenden en beleidsmakers op het gebied van fysieke activiteit voor ouderen met geriatrische aandoeningen kunnen faciliteren.

Al deze inspanningen zullen moeten leiden tot een verbetering van het dagelijks leven van ouderen en laten zien dat de impact van het ouder worden niet iets is dat ons overkomt maar waar we actief richting aan kunnen geven door het initiëren en onderhouden van een fysiek actieve leefstijl.

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Dankwoord
About the author
Publications

REDUCING
THE IMPACT OF
GERIATRIC
CONDITIONS BY
PHYSICAL
ACTIVITY

CHAPTER

10

Acknowledgements

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Part of these results (the Per Protocol results) have been published in the Dutch Journal for Physiotherapy, (A.T.H. Van Hespén, E.C.P.M. Tak, P. Van Dommelen, M. Hopman-Rock, *Evaluatie van het incontinentie programma incondition voor vrouwen in verzorgingshuizen* [Evaluation of the incontinence programme incondition for women in homes for the elderly]. *NTvF*, 2006;116(6):136-142) and are republished with permission (data in table 1 and 2). For the current publication the Intention To Treat analysis has been added and expanded with imputed data (table 3).

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Chapter 5: Based on the study, 'Hup met de Heup', een advies- en trainingsprogramma voor mensen met heupartrose. ['Hop with the Hip', an advise and training program for people with osteoarthritis of the hip], carried out between 1996-1999. Thanks to dr. Mai Chin A Paw and drs. Marja Westhoff for their help in carrying out and evaluating the study. Supported by a grant from the Netherlands Health Research and Development Council (Praeventiefonds).

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Over de auteur



Erwin Cornelis Petrus Maria Tak is geboren en opgegroeid in Oud-Gastel. In 1991 behaalde hij zijn VWO diploma op het Thomas More College in Oudenbosch. In datzelfde jaar startte hij met de studie Psychologie aan de Universiteit Leiden. Voor zijn afstudeerstage kwam hij terecht bij TNO Preventie en Gezondheid in Leiden op het onderzoek 'Omgaan met artrose van de knie en/of heup; de evaluatie van een leefstijlprogramma', onder begeleiding van Marijke Hopman-Rock. In 1997 studeerde hij af in de Klinische en Gezondheidspsychologie.

Na eerst als tijdelijke kracht gewerkt te hebben kwam hij in 1999 vast in dienst bij TNO Preventie en Gezondheid in Leiden op de afdeling Volwassen. In 2004-5 volgden er de eerste gesprekken over en activiteiten rond een promotietraject met Marijke Hopman-Rock, welke deels in eigen tijd plaatsvonden. Na een onderbreking in verband met inzet in de lokale Leidse politiek, o.a. als bestuurs- en gemeenteraadslid, hervatte hij eind 2008 zijn werkzaamheden aan het proefschrift, inmiddels onder vlag van Body@Work, Onderzoekscentrum Bewegen, Arbeid en Gezondheid, TNO-VUmc.

Op dit moment is hij werkzaam bij TNO op de afdeling Lifestyle als onderzoeker en projectleider bij het team 'Active Aging'. Zijn werkzaamheden hebben vooral betrekking op het gebied van de preventieve gezondheidszorg voor ouderen zoals vroegsignalering van functionele achteruitgang en verminderen van de impact van chronische aandoeningen. Hierbinnen heeft hij bijzondere aandacht voor onderzoek naar en toepassing van kennis over bewegen en ouderen zowel in de Nederlandse context als in diverse Europese projecten, o.a. als coördinator van het European Network for Action on Aging and Physical Activity (EUNAAPA).

About the author

Erwin Cornelis Petrus Maria Tak was born and raised in Oud-Gastel, in the southern part of the Netherlands. In 1991 he graduated from high school at the Thomas More College in Oudenbosch. In the same year he began to study Psychology at the Leiden University. At the end he did his internship at TNO Prevention and Health in Leiden on the study 'Coping with osteoarthritis of the knee and/or hip; evaluation of a lifestyle programme', under supervision of Marijke Hopman-Rock. In 1997 he received his master's degree in Clinical and Health Psychology.

After a temporary contract, he got a permanent position in 1999 at TNO Prevention and Health in Leiden at the department 'Adults'. Around 2004-5 he discussed writing a thesis

for the first time with Marijke Hopman-Rock and started with preparing the first chapters, part of which he did in his spare time. After an interruption due to his activities with local politics at the Leiden City Council, he picked up work on his thesis at the end of 2008, this time within Body@Work, Research Center on Physical Activity, Work and Health, TNO-VU University Medical Center.

Currently he works at the TNO department Lifestyle in Leiden as researcher and project leader in the team Active Aging. His work focuses mainly on preventive health care for older adults such as early detection of functional decline and reducing the impact of chronic diseases. He has a special interest in research on and implementation of physical activity in older adults within the Dutch context as in well as in several European projects such as coordinating the European Network for Action on Aging and Physical Activity (EUNAAPA).

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