# The GALM effect study




## Changes in physical activity, health and fitness of sedentary and underactive older adults aged 55-65

Johan de Jong

# The GALM effect study:

## changes in physical activity, health, and fitness of sedentary and underactive older adults aged 55-65 years

Johan de Jong

This research was financially supported by ZonMw
(grant number 2200.0074)

The publication of this thesis was generously supported by:

Graduate School for Health Research SHARE
Zorg Onderzoek Nederland (ZonMw)
Hanzehogeschool Groningen (HG)

Printed by: Zalsman Groningen bv

De Jong, Johan. The GALM effect study: changes in physical activity, health, and fitness of sedentary and underactive older adults aged 55-65 years.

Thesis University of Groningen, The Netherlands – With ref. –With summary in Dutch.

ISBN: 978 90 77113 738

RIJKSUNIVERSITEIT GRONINGEN

The GALM effect study:
changes in physical activity, health, and fitness in sedentary and underactive older adults aged 55-65

**Proefschrift**

ter verkrijging van het doctoraat in de
Medische Wetenschappen
aan de Rijksuniversiteit Groningen
op gezag van de
Rector Magnificus, dr. F. Kuipers
in het openbaar te verdedigen op
woensdag 11 maart 2009
om 16.15

door

**Johan de Jong**
geboren op 3 mei 1970
te Bergum

| | |
|---|---|
| Promotor: | Prof. dr. E.J.A. Scherder |
| Copromotores: | Dr. K.A.P.M. Lemmink<br>Dr. M. Stevens |
| Beoordelingscommissie: | Prof. dr. R.L. Diercks<br>Prof. dr. J.W. Groothoff<br>Prof. dr. W. van Mechelen |

Paranimfen: Drs. K. Leibbrand
Drs. O. Dorrestijn

Cover photos: G. Verhoeven

Printed by: Zalsman Groningen bv

ISBN: 978 90 77113 738

## Voorwoord

Het Groninger Actief Leven Model (GALM) is in 1994 ontwikkeld door het Instituut voor Bewegingswetenschappen van de Rijksuniversiteit Groningen in samenwerking met de Landelijke Stichting Meer Bewegen voor Ouderen (MbvO) dat opgegaan is in het huidige Nederlands Instituut voor Sport en Bewegen (NISB). In de periode 1994-1995 is een pilot uitgevoerd in de provincies Drenthe en Groningen naar de uitvoerbaarheid van GALM. Op basis van een succesvolle pilot fase en de daaruit voortkomende verbeteringen is de uiteindelijke GALM strategie beschreven in een handboek. Dit handboek diende als blauwdruk voor de landelijke implementatie die vanaf 1997 tot hedentendage plaatsvindt en mede mogelijk is gemaakt door subsidies van onder andere de Nederlandse Hartstichting (NHS), fonds zomerpostzegels, VWS en Zorg Onderzoek Nederland (ZonMw).

Parallel aan de ontwikkeling en uitvoering van de landelijke implementatie van GALM werd gewerkt aan de ontwikkeling en validering van een gedragsveranderingsmodel dat geresulteerd heeft in het proefschrift met als titel: "Groningen Active Living Model (GALM): development and initial validation" door Martin Stevens (2001).

Als vervolg op deze studie is een tweede grootschalig onderzoek opgezet en uitgevoerd met als doel het in kaart brengen van de effecten van deelname aan GALM op lichamelijke activiteit, fitheid en gezondheid van sedentaire en onvoldoende lichamelijk actieve ouderen. Deze dissertatie beschrijft de resultaten van de longitudinale studie naar de effecten van deelname aan GALM.

## Contents

# General introduction

## Chapter 1

## 1. Introduction

In Western society, older adults form a population segment that is growing in numbers but also in age. In 2004, the mean percentage of people over 65 years in Europe and The Netherlands was 17% vs. 14%, respectively. Although The Netherlands demonstrate a lower mean percentage of older adults compared with other European countries, this percentage will increase with 50% in the year 2025.[1] Also the mean age of the older adults is still growing. From 1980 to 2004, the life expectancy after the age of 65 has developed from 15.53-18.36 and 16.51-18.37 years in Europe and The Netherlands, respectively.[2]

With this in mind reducing and postponing disability, diseases, and functional loss that go along with aging is an essential public health goal in which physical activity can play an important role. Scientific evidence demonstrates that participation in regular exercise programs can reduce or prevent a number of functional declines associated with aging.[3-6] Older adults are trainable and able to adapt to endurance as well as strength training. Endurance training can result in maintaining or improving various aspect of cardiovascular function (e.g., $VO_2$max, cardiac output), as well as enhance submaximal performance. Strength training can help the offset of the loss in muscle mass and strength associated with normal aging.

Moreover, health status can be improved through reduction in risk factors associated with disease states (e.g., cardiovascular disease, non-insulin dependent diabetes mellitus, hypertension, colon cancer, obesity, etc.) and thereby increase life expectancy. Additional benefits from regular exercise include improvement of bone health and thus reduce the risk of osteoporosis, stability and risk of falling, and an increase in flexibility. Finally, regular exercise also seems to provide a number of psychological benefits related to preserved cognitive function, alleviation in depression symptoms and behavior. In conclusion, the benefits associated with regular exercise and physical activity contribute to a more health lifestyle, improving the functional capacity and quality of life of older adults.[3-6]

Despite all these benefits, many older adults are still sedentary or underactive. At the start of the development of the Groningen Active Living Model (GALM) in the late nineties of the past century, actual data with respect to physical inactivity among older adults was scarce. Depending on the measurement methods used, physical inactivity percentages varied between 35-80% of the Dutch older adults.[7,8]

## 1.1 Physical activity, fitness, and health

A conceptual model that illustrates the interrelationships between physical activity, fitness, and health was described by Bouchard and Shephard et al. (1994) (Figure 1).[3] In this model the three key concepts are physical activity, health-related fitness and health. Physical activity is defined as "any body movement produced by skeletal muscles that results in a substantial increase over the resting energy expenditure."[3] It covers leisure-time physical activity, occupational physical activity as well as household and other cores (e.g., nursing relatives).

With respect to the definition of fitness, no universal definition is available. In present day Western societies fitness is operationalized with a focus on two goals: performance and health.[3] Performance-based refers to those components of fitness that are necessary for optimal work or sport performance. Regarding older adults, performance-based fitness refers to components necessary to optimally perform activities in daily living.[3] Performance-based fitness depend heavily on motor skills, cardiorespiratory power and capacity, muscular strength, power or endurance, body size, body composition, motivation, and nutritional status.[3]

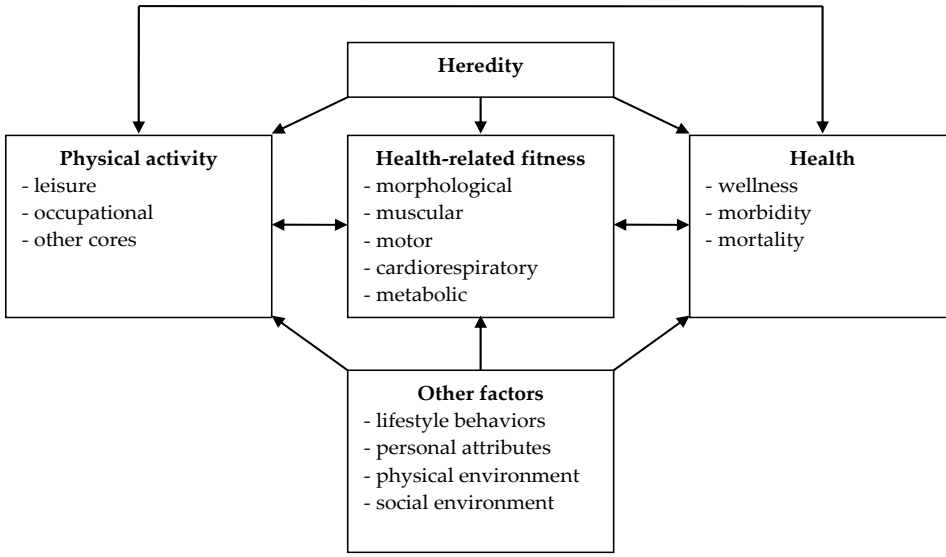



**Figure 1.** The Bouchard model.[3]

Health-related fitness is about those fitness components that are affected favorably or unfavorably by habitual physical activity and relate to health status. Important components of health-related fitness includes morphological (e.g., body composition, flexibility), muscular (e.g., power, strength, endurance), motor (e.g., balance, coordination), cardiorespiratory (e.g., maximum aerobic capacity, long function) and metabolic aspects (e.g., glucose tolerance, insulin sensitivity). Pate (1988) defined health-related fitness as: a) the ability to perform daily activities with vigor; b) demonstration of traits and capacities associated with low risk of premature development of inactivity-related diseases.[9]

From the aforementioned definitions of performance-based and and health-related fitness, a major point of criticism on the Bouchard model appears. Within the Bouchard model there is unclarity with respect to the distinction between both aspects of fitness, performance vs. health related. This overlap together with the fact that performance-based as well as health-related components of fitness play an important role in older adults' functioning and performance in daily living made that both components are relevant and will be assessed in this study. In the progress of this thesis the terms performance-based fitness and health indicators will be used refering to the performance and health focus within fitness, respectively.

Health is defined as a condition with physical, social, and psychological dimensions, each characterized on a continuum with positive and negative poles. Health includes measures of wellness (positive health), and morbidity and mortality (negative health). The Bouchard model summarizes the interrelationships that appear between physical activity, fitness, and health. Furthermore, other factors (lifestyle e.g., smoking, diet; personal attributes e.g., age, gender; physical environment e.g., temperature, altitude; social environment e.g., political, economic circumstances) and heredity are also of influence on the three key concepts and their interrelationships.

In the perspective of public health, the Bouchard model shows that physical activity through influencing fitness can influence health and vice versa. Additionally, there is also an independent relationship possible between physical activity and health and back, apart from fitness. In this thesis the relationships between physical activity and health-related as well as performance-based fitness measures will be studied.

In the following paragraph the focus will be on these two relationships through briefly describing the development of the physical activity recommendations for health and/or fitness in older adults.

## 1.2 Physical activity recommendations for improving fitness and health in older adults

Recommendations on quantity and quality of physical activity necessary to improve fitness and health differ. Major general recommendations on fitness and health were published in 1990, 1995 and 1998 by the American College of Sports Medicine (ACSM) together with the Centers for Disease Control (CDC).[5,10-12]

The 1990 ACSM recommendations on the enhancement of fitness can be considered as the most commonly accepted standard.[10] These guidelines focused on developing and maintaining cardiorespiratory and muscular fitness in healthy adults. The guidelines recommend an exercise training frequency of 3-5 sessions per week, a training intensity of 60-90% of heart rate maximum (equivalent to 50-85% of maximum oxygen uptake or heart rate reserve), a duration of 20-60 minutes per session and rhythmical and aerobic use of large muscle groups. To develop and maintain muscular strength and endurance, moderate intensity resistance training (one set of 8-12 repetitions if 8-10 different exercises at least twice a week) is suggested. Beside these guidelines primarily focusing on cardiorespiratory and muscular fitness, they also recognized the potential health benefits of more frequent regular exercise at lower intensity, for longer duration independent of cardiorespiratory fitness. The 1990 recommendations stated that lower levels of physical activity than recommended may reduce the risk for certain chronic disease states without improving cardiorespiratory fitness (e.g., maximum oxygen uptake).

In 1995 the ASCM together with the CDC published new recommendations in addition to the 1990 ACSM recommendations in which a shift occurred that led to the primary focus on the relationship between physical activity and health-related benefits instead of the development and maintenance of cardiorespiratory and muscular fitness.[11] The 1995 guidelines recommended that all adults perform 30 minutes of physical activity of moderate intensity (e.g. brisk walking) on most, and preferably all days of the week. These 30 minutes could be performed in one 30-minute session or accumulated throughout the day in multiple bouts of 8-10 minutes. It was also acknowledged that, for most people, greater health benefits can be obtained by performing physical activity of more vigorous intensity and of longer duration.

In 1998 the ACSM beside the recommendations for adults,[12] published specific recommendations for older adults.[5] These guidelines recognized

that in addition to the health benefits of physical activity, that are important for all adults, important objectives especially for older adults are maintaining and improving cardiorespiratory fitness and the ability to perform activities of daily living independently and thus quality of life. Therefore it was stated that physical activity programs for older adults should not only focus on improving or maintaining health but also in improving cardiorespiratory fitness, strength, coordination and flexibility. To reach these objectives, the 1998 recommendations promote in order to enhance not only health but also the cardiorespiratory fitness and the ability to perform daily activities independently, physical activities with longer duration and higher intensity than recommended by the 1995 ACSM/CDC guidelines. Based on the 1995 and 1998 recommendations, in 1998 a Dutch recommendation entitled "de Nederlandse Norm voor Gezond Bewegen (NNGB)" was developed.[13]

### 1.3 Effects of multi-modal/multi-component/multi-dimensional physical activity programs for older adults

From the aforementioned recommendations it can be concluded that physical activity programs for older adults should pay attention to several components of fitness (cardiorespiratory, strength, coordination, and flexibility). Such programs can be characterized as multi-modal/multi-component/multi-dimensional programs. Compared with the amount of studies reporting on the effects of one or two dimensional exercise based physical activity (training) programs, evidence on multi-modal physical activity programs remains scarce. These multi-modal program can be characterized by simultaneously prescribed doses and intensities of strength, aerobic, balance training, and are feasible and capable of eliciting changes in physical functioning and quality of life remains.

Baker et al. (2007) conducted a systematic review after the effects of multi-modal exercise programs for older adults and finally included 15 studies that satisfied the following inclusion criteria: a) only randomized controlled trials; b) only involving studies with older adults with a mean age over 60 years; c) studies with single clinical diagnosis as entry criteria (e.g. stroke, multiple sclerosis etc.) were excluded; d) the exercise intervention should at least contain three modalities of strength/resistance training, aerobic/cardiovascular endurance training, and balance/stability training, and might include flexibility exercises.[14]

Five studies administered home-based interventions and the others had supervised centre-based programs in class format of small groups.

Two studies had a combination of home- and centre-based exercise. The mean intervention duration was 8.8 (± 3.6) months with a range of 3 to 12 months. In general the frequency of exercise was 3 days per week, with one study reporting a frequency of twice and one study once per week. Most commonly the control groups received no treatment, advice or other control activities (e.g., low intensity/flexibility exercises, education, nurse visit, etc.). The overall results suggest that multi-modal exercise has a positive effect on fall prevention. The limited data available suggested that multi-modal exercise may have a smaller effect on physical, functional and quality of life outcomes than single-modality programs. Aerobic fitness was only reported in one study and the direct measure of $VO_2$ demonstrated a significant effect of training on aerobic fitness. Despite this limited evidence of multi-modal exercise, it may be seen as an effective treatment in fall prevention but further investigation was recommended.[14]

## 1.4 The Groningen Active Living Model (GALM)

The increase in number and age of older adults together with the aforementioned role that physical activity can play in enhancing health and fitness led to the development of a new strategy that aimed at stimulating leisure-time physical activity in sedentary and underactive older adults entitled the Groningen Active Living Model (GALM). After the development and pilot phase of GALM, the strategy was described in a manual and implemented from 1997 till nowadays in The Netherlands.[15,16] Furthermore, five projects have been started in Belgium and based on the principles of GALM the Canberra Active Living Model (CALM) was successfully implemented in Australia.[17]

GALM is a behavioral change strategy and is based on a process model in which behavioral change is seen as a multidimensional and dynamic process.[16] The strategy starts with a special recruitment phase followed by a fitness test and continues with participation in a recreational sports program.

The recruitment phase consists of three steps: 1) direct mailing; 2) door-to-door visits; 3) program invitation. By means of these steps, sedentary and underactive older adults were screened and invited to participate in a fitness test and subsequently the GALM recreational sports program.[15,16,18]

The content of the recreational sport program is primarily based on an evolutionary-biological play theory,[19] and insights from social cognitive theory.[20] The evolutionary-biological play theory suggests that programs

that are in accordance with the genetic potential are most likely to succeed in developing a lifelong, physically active lifestyle. From social cognitive theory self-efficacy, social support, and perceived fitness are manipulated in order to enhance enjoyment in physical activity.[16,20] To assist the maintenance of physical activity, it was assumed that the GALM sessions should be tailored to the individual's wishes, preferences, and needs.[21-24] This ultimately led to the versatile content of the GALM recreational sports program containing physical activities like ball games, swimming, athletics, fitness etc.

Compared with other more exercise based physical activity (training) programs, the GALM recreational sports program differs on several points: 1) the content of the GALM program is primarily based on behavioral change theories; 2) for reasons of compliance to the program, the GALM program is versatile and sessions are held once per week; 3) the GALM recreational sports program offers different modes of activities aiming at diverse components of performance-based fitness (strength, aerobic endurance, coordination, and flexibility).

### 1.5 Objective of the thesis

Based on the aforementioned considerations, GALM can be characterized as a multi-modal physical activity program. However, GALM differs from other multi-modal exercise programs in that it consists of recreational sports activities. To our knowledge, no study so far reported on the effects of physical activity, health, and fitness after participating in a recreational sport program of older adults.

Based on several mechanisms it is assumed that participation in the GALM recreational sports program will lead to favorable changes in physical activity, health, and/or fitness outcomes. First, based on the low initial fitness level of the target group together with the fact that people with the lowest levels can gain the most,[11,25] it is expected that GALM may enhance health, and/or fitness even though it does not meet all key exercise variables (e.g. type, intensity, and volume).[11,12] Second, by means of the versatile nature of the GALM recreational sports program participants can develop preferences towards one or more physical activity modes which they may conduct additional to GALM. If this transfer occurs the increase in physical activity can lead to increases in health and/or fitness outcomes.[26] Third, since the GALM recreational sports program addresses all components of fitness, effects can occur in several performance-based fitness measures.[11]

Based on these assumptions, the objective of this thesis is to determine the effect of participation in GALM on physical activity, health, and fitness outcomes in sedentary and underactive older adults.

## 1.6 Outline of thesis

In *chapter 2* we describe the recruitment phase of GALM and its efficiency in selecting and including sedentary and underactive older adults in the age category of 55-65 years.

In *chapter 3* the background and intensity of the GALM physical activity program is described. The theories on which the GALM physical activity program is based and the translation to practice are elaborated. Furthermore the intensity of the program is measured objectively based on heart rate monitoring.

In *chapter 4* the six-month effects of participation in the GALM program on physical activity, health, and fitness outcomes are presented. In addition *chapter 5* provides the longitudinal results after twelve months of participation in the GALM program on physical activity, health, and fitness outcomes.

In *chapter 6* the longitudinal changes in heart rate during submaximal exercise as an indicator of cardiovascular function after 18 months of participation in the GALM program are described.

In *chapter 7* we discuss the major findings of the study and the overall effects of participation in the GALM on physical activity, health, and fitness outcomes.

## References


1. Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2007. Available from http://www.rivm.nl/tv/object_document/o4671n16911.html.
2. World Health Organization (WHO) Regional Office for Europe: European Health for all database (HFA-DB), 2007. Available from http://www.euro.who.int/hfadb.
3. Bouchard C, Shephard RJ, Stephens TS, editors. Physical activity, fitness, and health. International proceeding and consensus statement. Champaign (IL): Human Kinetics, 1994.
4. US Department of Health and Human Services. Physical activity and health: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996.
5. American College of Sports Medicine Position Stand. Exercise and physical activity for older adults. Med Sci Sports Exerc 1998;30:992-1008.
6. Paterson DH, Jones GR, Rice CL. Ageing and physical activity: evidence to develop exercise recommendations for older adults. Appl Physiol Nutr Metab 2007;32:S69-S108.
7. Hildebrandt VH, Ooijendijk WTM, Stiggelbout M, Hopman-Rock M. Trendrapport bewegen en gezondheid 2002/2003. Hoofddorp/Leiden: TNO, 2004.
8. Centraal Bureau voor de Statistiek (CBS). Persbericht PB06-034. Voorburg, NL: CBS, 2006.
9. Pate RR. The evolving definition of fitness. Quest 1988;40:174-79.
10. American College of Sports Medicine. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. Med Sci Sports Exerc 1990;22:235-74.
11. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health: a recommendation from the Centers for Disease control and Prevention and the American College of Sports Medicine. J Am Med Assoc 1995;273:402-7.

12. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc 1998;30:975-91.
13. Kemper HCG, Ooijendijk WMT, Stiggelbout M, Hildebrandt VH, Backx FJG, Bol E, et al. Nederlandse Norm voor Gezond Bewegen: trendrapport bewegen en gezondheid. Lelystad NL: Koninklijke Vermande, 1999.
14. Baker MK, Atlantis E, Fiatarone Singh MA. Multi-modal exercise programs for older adults: systematic review. Age and Ageing 2007;35:375-81.
15. De Greef MHG, Stevens M, Bult P, Lemmink KAPM, Rispens P. Groningen Active Living Model: manual. Haarlem (NL): De Vrieseborch, 1997.
16. Stevens M, Bult P, de Greef MHG, Lemmink KAPM, Rispens P. GALM: stimulating physical activity in sedentary older adults. Prev Med 1999;29:267-76.
17. Canberra Active Living Model (CALM). Available from http://www.canberra.ymca.org.au/index.php?content=content/rymemoverscalm.htm
18. Lemmink KAPM, Kemper H, de Greef MHG, Rispens P, Stevens M. Reliability of the Groningen fitness test for the elderly. J Aging Physical Act 2001;9:194-212.
19. Bult P, Rispens P. Learning to move: acquiring versatility in move ment through upbringing and education. Maastricht, The Netherlands: Shaker Publishing B.V., 1999, 29-42.
20. Bandura A. Social foundation of thought and action. Englewood Cliffs, NJ: Prentice Hall, 1986, 399-409.
21. Dishman RK, Buckworth J. Increasing physical activity: a quantitative synthesis. Med Sci Sports Exerc 1996;28(6):706-19.
22. Ecclestone NA, Myers AM, Paterson DH. Tracking older participants of twelve physical activity classes over a three year period. J Aging Phys Activity 1998;6:70-82.
23. King AC. Interventions to promote physical activity by older adults. J Gerontol A Biol Sci Med Sci 2001;56A(2):36-46.

24. Van der Bij AK, Laurent MGH, Wensing M. Effectiveness of physical activity interventions for older adults: a review. Am J Prev Med 2002;22(2):120-33.
25. Blair SN, Cheng Y, Holder JS. Is physical activity or physical fitness more important in defining health benefits? Med Sci Sports Exerc 2001;33(6):S379-99.
26. Stewart AL, Verboncoeur CJ, McClelland BY, Gillis DE, Rush S, Mills KM, et al. Physical activity outcomes of CHAMPS II: a physical activity program for older adults. J Gerontol A Biol Sci Med Sci 2001;56(8):465-70.

# The Groningen active living Model, an example of successful recruitment of sedentary and underactive older adults

## Chapter 2

Martin Stevens
Johan de Jong
Koen APM Lemmink

*Preventive Medicine 2008;47:398-401*

**Abstract**

**Objective**
Many physical activity interventions do not reach those people who would benefit the most from them. The Groningen Active Living Model (GALM) was successful in recruiting sedentary and underactive older adults.

**Method**
In the fall of 2000 older adults in three municipalities in The Netherlands received written information, were visited at home and, if eligible according to the GALM recruitment criteria, filled in the Stages of Change questionnaire and the Voorrips physical activity questionnaire.

**Results**
By using the strategy we succeeded in including 12.3% of the older adults (315 of the 2,551 qualifying participants), 79.4% of whom could be indeed regarded as sedentary or underactive. These results can be considered in line with results described in the literature. The cost of successfully recruiting an older adult was estimated at $84.

**Conclusion**
The GALM recruitment strategy is a potentially useful and effective method for reaching community-dwelling sedentary and underactive older adults.

## Introduction

Despite proven benefits, many physical activity interventions do not reach those people who would benefit the most. The Groningen Active Living Model (GALM) originated from this need for a more tailored approach. GALM is a behavioral change strategy for stimulating physical activity in sedentary and underactive older adults aged 55-65, and consists of a recruitment strategy and a recreational sports activity program.[1] Until 2005, 552,094 persons were approached in 424 projects. However, reports on effective means of recruiting participants for programs like GALM remain scarce. Most research emphasizes outcome, with little attention given to which recruitment strategies are most successful.[2] This paper reports on the effectiveness of the GALM strategy to recruit sedentary and underactive older adults.

## Methods

### Participants

This study was part of research into effects of participation in GALM on health and fitness. The recruitment took place in three Dutch municipalities, in four neighborhoods that were assigned as intervention or control neighborhoods (fall 2000). Intervention neighborhoods underwent a recreational sports activity program. Control neighborhoods underwent the program after being placed on a waiting-list (6 months). In the context of reporting about effectiveness of the strategy, both groups were put together.

### Recruitment strategy

The approach comprised a population and network strategy. In the population strategy about 700 older adults in a selected municipal area received a written invitation (based on the municipality's population data) and were visited at home by a trained employee. When older adults could not be reached, a second visit was planned during dinnertime the same day. If this attempt was unsuccessful, a reminder card was left behind asking to respond by mail or telephone. As attending by oneself is often a barrier, potential participants were invited to bring someone along even if that person was not sedentary or underactive.

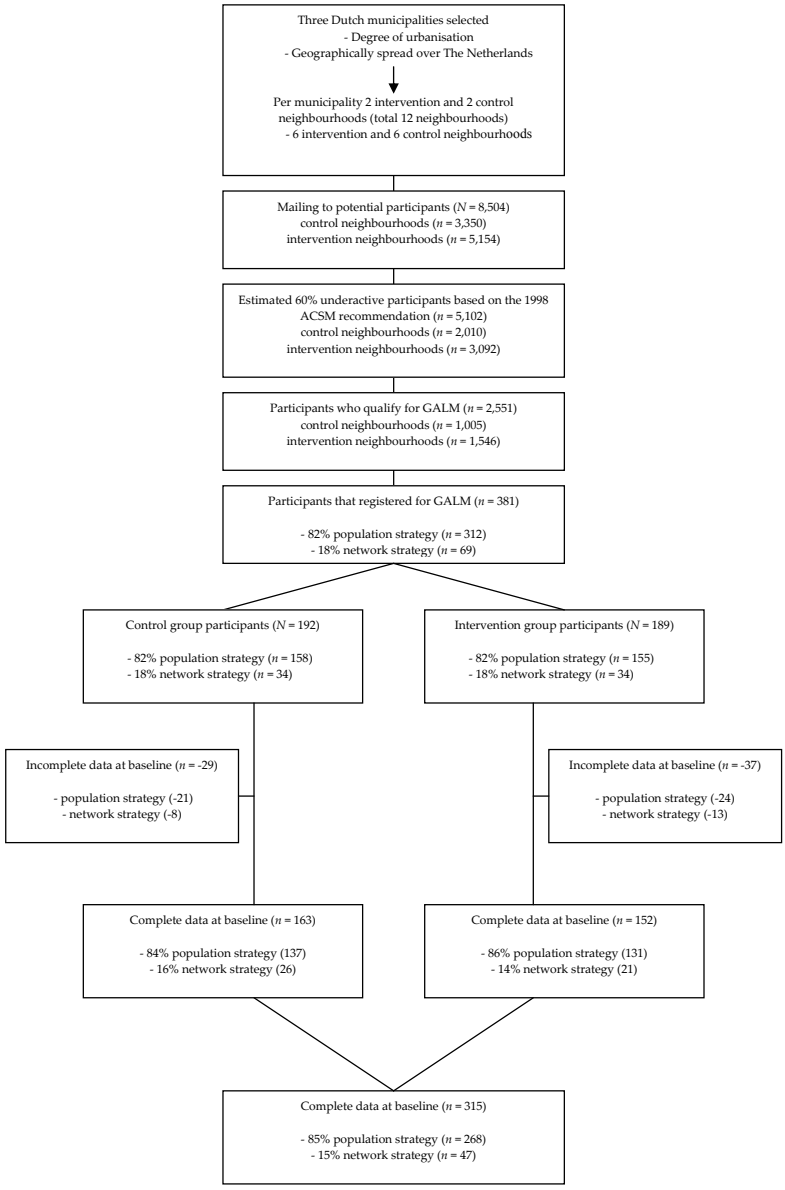



**Figure 1**. Results of the GALM recruitment strategy (Fall 2000, The Netherlands)

This was the network strategy. During these visits, potential participants (population and network strategy) were screened using the GALM recruitment questionnaire,[3] which is based on the ACSM recommendations on exercise and physical activity for older adults (Appendix 1).[4]

**Measurements**

To get an impression of the effectiveness of the strategy potential participants filled in a questionnaire (demographics, stages of change and energy expenditure). Stage of change was measured with a Dutch version of the Stages of Change questionnaire.[5] The five stages were reduced to three: (1) pre-contemplation; (2) contemplation/preparation; (3) action/maintenance.

Energy expenditure was measured with the Voorrips physical activity questionnaire.[6] Intensity of recreational sports activities (e.g., swimming, volleyball) and leisure-time physical activities (e.g., gardening, walking, and cycling for transportation purposes) was based on the compendium of physical activities.[7] The study was conducted in accordance with regulations of the local Medical Ethical Committee.

**Statistical analyses**

Participants were categorized according to stage of change. Between-stages-of-change and intervention-versus-control-group differences were assessed with chi-square and general linear model (GLM) procedures.

## Results

In total, 8,504 persons were visited. About 60% ($n$ = 5,102) could be considered underactive according to ACSM recommendations. Based on a pilot study of the recruitment strategy it was considered that approximately half of the 60% ($n$ = 2,551) qualified for GALM. The other half was not interested or unable to participate (personal circumstances, i.e., illness, work, nursing). Ultimately 381 were registered and 315 participated in the measurements (Figure 1). Mean age was 59 years, 46% men and 54% women. Costs of recruitment for one subject was estimated at $84, the total cost amounted $26,570 (postage $17,600; door-to-door visits $6,900; staff time $2,070).

**Stages of change and energy expenditure for physical activity**

A total of 79.4% of the participants reported being in the pre-contemplation (5.4%) or contemplation/preparation (74.0%) stages.

**Table 1.** Comparison between intervention and control group regarding stages of change and energy expenditure for physical activity for men, women and total group (December, 2000 The Netherlands)

| | Intervention vs. control group | | | | | | | | | Between-stage differences | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Stage 1 | | | Stage 2 | | | Stage 3 | | | | | |
| | IG | CG | Total | IG | CG | Total | IG | CG | Total | *p*-value[a] | | |
| **Participants** | | | | | | | | | | | | |
| Men (%) | 1.4 | 5.5 | 3.5 | 80.6 | 74.0 | 77.2 | 18.1 | 20.5 | 19.3 | - | | |
| (*n*) | (1) | (4) | (5) | (58) | (54) | (112) | (13) | (15) | (28) | | | |
| Women (%) | 3.3 | 11.4 | 7.0 | 81.3 | 59.5 | 71.2 | 15.4 | 29.1 | 21.8 | $\chi^2$=10.42, $p$< 0.01 | | |
| (*n*) | (3) | (9) | (12) | (74) | (47) | (121) | (14) | (23) | (37) | | | |
| Total (%) | 2.5 | 8.6 | 5.4 | 81.0 | 66.4 | 74.0 | 16.6 | 25.0 | 20.6 | $\chi^2$=10.38, $p$<0.01 | | |
| (*n*) | (4) | (13) | (17) | (132) | (101) | (233) | (27) | (38) | (65) | | | |
| **Estimated energy expenditure for physical activity** | | | | | | | | | | | Effects[a] | |
| Mean (*SD*) | | | | | | | | | | group | stage | stage x group |
| $EE_{RECSPORT}$ | 676 | 101 | 236 | 489 | 477 | 484 | 1479 | 1399 | 1432 | - | $F$=39.02, | - |
| (kcal/week) | (663) | (132) | (398) | (696) | (577) | (646) | (914) | (1309) | (1154) | | $p$<0.001 | |
| $EE_{LTPA}$ | 359 | 1573 | 1287 | 2387 | 1500 | 2001 | 2310 | 1810 | 2017 | - | | - |
| (kcal/week) | (718) | (1631) | (1541) | (2725) | (1447) | (2298) | (2786) | (1773) | (2243) | | | |
| $EE_{TOTAL}$ | 1035 | 1674 | 1523 | 2876 | 1977 | 2485 | 3789 | 3209 | 3449 | - | $F$=6.75, | - |
| (kcal/week) | (1013) | (1559) | (1447) | (2790) | (1608) | (2387) | (3172) | (2246) | (2662) | | $p$<0.01 | |

*Stage 1 (pre-contemplation) "I am not active in recreational sports activities and not planning to be".*

*Stage 2 (contemplation/preparation): "I am not active in recreational sports activities but am thinking about starting within 6 months" or "I am not regularly active in recreational sports activities" (less then once a week or less than 60 minutes per session).*

*Stage 3 (action/maintenance):"I have been regularly active in recreational sports activities in the past 6 months" (at least once a week and at least 60 minutes per session) or "I have been regularly active in recreational sports activities for more than 6 months" (at least once a week and at least 60 minutes per session).*

*IG, intervention group.*

*CG, control group.*

[a] *Not significant (p > 0.05, 2-tailed) unless otherwise noted.*

*SD, standard deviation.*

$EE_{RECSPORT}$, *energy expenditure for recreational sports activities.*

$EE_{LTPA}$, *energy expenditure for leisure-time physical activities.*

$EE_{TOTAL}$, *total energy expenditure for physical activities:* $EE_{TOTAL} = EE_{RECSPORT} + EE_{LTPA}$.

Significant differences existed between the intervention and control groups for women and total group in the different stage groups (Table 1). For women, lowest percentages were found in stage 1 (3.3% versus 11.4%), and highest and greatest difference in stage 2 (81.3% versus 59.5%) ($\chi^2 = 10.42$, $p < 0.01$). For total group, lowest percentages were found in stage 1 (2.5% versus 8.6%) and greatest difference in stage 2 (81.0% versus 66.4%) ($\chi^2 = 10.38$, $p < 0.01$).

For $EE_{RECSPORT}$ and $EE_{TOTAL}$, there were significant main effects for stage ($F = 39.02$, $p < 0.001$ and $F = 6.75$, $p < 0.01$), in that stage-3 participants showed higher energy expenditure values than participants in stages 1 and 2. No main effects were found for group or stage x group ($p > 0.05$).

## Discussion

We succeeded in including 12.3% of potential participants, 79.4% of whom could be considered sedentary or underactive. Although there were significant differences for women and total group between stage groups, this was concluded to be of no influence to the effectiveness of the strategy.

In the Lifestyle Interventions and Independence for Elders pilot (LIFE-P) a recruitment rate of 13.5% is reported.[8] In the Perth Active Living Seniors Project (PALS) rates are reported of 12.6% and 14.5% for intervention and control groups.[9] GALM results can be considered in line with these studies, although GALM focuses on "younger" older adults. Recruitment rates between intervention and control neighborhoods in GALM were 16.2% (163/1005 x 100%) and 9.8% (152/1546 x 100%), respectively. This lower percentage for the control group can be explained by the fact that, in absolute numbers, control neighborhoods consisted of more persons to anticipate on a lower response, as these were placed on a waiting list first.

Compared with PALS, GALM showed a more equal distribution of 46% men and 54% women vs. 37% men and 63% women, respectively. Explanation for this may be that PALS recruited with the perspective of joining a walking program that was found to be more appealing to women, while GALM offered a versatile recreational sports activity program that attracted both sexes.[1]

In LIFE-P and PALS, the estimated cost of recruiting one person was $439 and $30, respectively. Costs in GALM were estimated at $84. GALM and PALS include project staff time, which was not the case in LIFE-P. It can be concluded that GALM is an inexpensive way to enroll participants relative to other screening approaches.[10]

Based on results of the Stages of Change and Voorrips questionnaires, it can be concluded that the strategy was effective. A total of 79.4% of the participants reported being in the pre-contemplation or contemplation/preparation stage. The remaining 20.6% were in the action/maintenance stage, and approximately half of them were recruited by means of the network strategy (intervention group 57%, control group 44%). The other half can be the result of not filling out the recruitment or the Stages of Change questionnaires correctly, therefore being miscategorized. This may also apply to the pre-contemplation stage, which can be considered a limitation of the strategy.

With respect to estimated energy expenditure, it is concluded that contemplation/preparation stage participants had significantly lower $EE_{RECSPORT}$ than action/maintenance stage participants. Significant differences were found for $EE_{LTPA}$. This does not contradict our expectations, since GALM makes a distinction between active and sedentary or underactive based on recreational sports activity behavior. These results confirmed that the main target group of GALM, the contemplation/preparation stage participants, can indeed be considered as less active.

**Conclusions**

The GALM recruitment strategy is a potentially useful and effective method for reaching community-dwelling sedentary and underactive older adults.

## Appendix 1.

**The GALM recruitment questionnaire**

1. Are you engaged in one or more of the recreational sports activities described in the list provided on the right side?

   0 No (please proceed with question 5)
   0 Yes (please proceed with question 2)

2. Are you engaged in one of these recreational sports activities every month of the year?

   0 No (please proceed with question 5)
   0 Yes (please proceed with question 3)

3. Are you engaged in recreational sports activities (added together) at least thrice a week (i.e., jogging twice a week and aerobics once a week)?

   0 No (please proceed with question 5)
   0 Yes (please proceed with question 4)

4. Are you engaged for at least 30 minutes per session?

   0 No (please proceed with question 5)
   0 Yes You are considered physically active and are now ready filling in the questionnaire. Thank you for your cooperation!

5. You are considered a target group member of GALM. Would you like to participate in the GALM recreational sports program?

   0 No You are now ready filling in this questionnaire. Thank you for your cooperation!
   0 Yes Please fill in the GALM registration form below.

1. Aerobics
2. Athletics
3. Ball games
4. Ballet
5. Leisure bicycling
6. Stationary bicycling
7. Body building
8. Calisthenics
9. Circuit training
10. Canoeing
11. Cross-country skiing
12. Dancing
13. Fencing
14. Fitness
15. Golf
16. Gymnastics
17. Health club exercise
18. Hiking
19. Hunting
20. Jogging
21. Marching band
22. Martial arts
23. Racket games
24. Running
25. Self-defense
26. Skating
27. Roller-skating
28. Pre-ski training
29. Step-treadmill ergometer
30. Swimming laps
31. Leisure-swimming
32. Triathlon
33. Pleasure walking
34. Water aerobics
35. Water skiing

---

**By filling in this form, I register in the GALM recreational sport program:**

Name: …….. Address: …….
Telephone: ……..… Postal code: ……
Date of birth: …….-……..-……. Sex: 0 male 0 female

You are invited to bring someone along. If you do so, please fill out the form below for your partner/friend:

Name:…… Address: …….
Telephone: ……..… Postal code: ……
Date of birth: …….-……..-……. Sex: 0 male 0 female

## References


1. Stevens M, Bult P, Greef de MHG, Lemmink KAPM, Rispens P. GALM: stimulating physical activity in sedentary older adults. Prev Med 1999;29:267-76.
2. Rowland RM, Fisher K, Green M, Dunn AM, Pickering MA, Fuzhong L. Recruiting inactive older adults to a neighborhood walking trial: The SHAPE project. J Aging Stud 2004;18:353-68.
3. De Jong J, Stevens M, de Greef MHG, Dirks CJ, Haitsma J, Lemmink KAPM, et al. GALM questionnaire to select sedentary seniors: reliability and validity. Med Sci Sports Exerc 1999;31:S379.
4. American College of Sports Medicine Position Stand. Exercise and physical activity for older adults. Med Sci Sports Exerc 1998;30:992-1008.
5. Marcus BH, Owen N. Motivational readiness, self-efficacy and decision-making for exercise. J Appl Soc Psychol 1992;22:3-16.
6. Voorrips LE, Ravelli AC, Dongelmans PC, Deurenberg P, van Staveren WA. A physical activity questionnaire for the elderly. Med Sci Sports Exerc 1991;23:974-79.
7. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity coded and MET intensities. Med Sci Sports Exerc 2000;32:S498-504.
8. Katula JA, Kritchevsky SB, Guralnik JM, Glynn NW, Pruitt L, Wallace K, et al. Lifestyle interventions and independence for elders pilot study: recruitment and baseline characteristics. J Am Geriatr Soc 2007;55:674-83.
9. Jancey J, Howat P, Lee A, Clarke A, Shilton T, Fisher J, et al. Effective recuitment and retention of older adults in physical activity research: PALS study. Am J Health Behav 2006;30:626-35.
10. Ory MG, Darby Lipman P, Karlen PL, Gerety MB, Stevens VJ, Fiatarone Singh MA, et al. Recruitment of older participants in frailty/injury prevention studies. Prev Sci 2002;1:1-22.

# Background and intensity of the GALM physical activity program

## Chapter 3

Johan de Jong
Martin Stevens
Koen APM Lemmink
Piet Rispens
Mathieu HG de Greef
Theo Mulder

*Journal of Physical Activity and Health, 2005;2:51-62*

**Background**
The Groningen Active Living Model (GALM) was developed to stimulate physical activity in sedentary and underactive older adults. The GALM physical activity program was primarily based on an evolutionary-biological play theory and insights from social cognitive theory. The purpose of this study was to assess the intensity of the GALM program

**Methods**
Data from 15 GALM sessions were obtained by means of heart rate monitors.

**Results**
Data of 97 program participants (mean age: 60.1 y) were analyzed. The overall mean intensity for the GALM program was 73.7% of the predicted heart rate maximum and 6% of the monitored heart rate time could be classified as light, 33% as moderate and 61% as hard.

**Conclusions**
The GALM program met the intensity guidelines to increase cardiorespiratory fitness. The intensity and attractiveness of this physical activity program make it an interesting alternative for stimulating physical activity in sedentary and underactive older adults.

## Introduction

As in other Western countries, the prevalence of physical inactivity among older adults constitutes a potential health burden for Dutch society.[1-3] Although many community-based physical activity stimulation strategies have been conducted, only a few focus specifically on enhancing physical activity in sedentary and underactive older adults, a group that could benefit most from such strategies.[4-6] To meet this need for more tailored approaches, a novel strategy termed the Groningen Active Living Model (GALM) was developed.

GALM is a behavioral change strategy for stimulating leisure-time physical activity participation in sedentary and underactive older adults 55 to 65 years of age. The strategy aims at stimulating and monitoring adults who are willing to participate (or resume participation) in leisure-time physical activity. The GALM strategy lasts 1.5 y and has been described in detail elsewhere.[7,8] Part of the GALM strategy is the physical activity program which can be characterized as a leisure-time physical activity program with an emphasis on recreational sports activities (e.g., softball, dance, self-defense, swimming, and athletics).[9] The goal of the GALM program is to stimulate sedentary and underactive older adults to become and remain active in leisure-time physical activity once a week. We hypothesize that, by providing a versatile leisure-time physical activity program of moderate intensity that is, on average, of moderate intensity, participants will gain or regain enjoyment during leisure-time physical activities and develop preferences toward certain activities. When the GALM program succeeds in its role as a "trigger", it can cause a transfer in participants becoming physically active more frequently outside the GALM program.[10,11] When this transfer occurs, former sedentary or underactive older adults might increase their frequency of moderate to vigorous physical activity and finally meeting the recommendations for enhancement of health and fitness.[12]

To change the participants' sedentary or underactive behavior, the attractiveness of the physical activity program was an important starting point of GALM. Many interventions have been set up to enhance physical activity among older adults and improve their health status and functional performance. Although scientific evidence shows that these interventions can indeed be successful in enhancing the health and fitness levels of the participants,[13] persuading older adults to become and continue to be physically active remains a difficult task.

To assist the maintenance of physical activity in the GALM groups, it was assumed that interventions should be tailored to the individual's wishes, preferences and needs.[6,14-16] To this end, the versatile sport and leisure-time activities of the GALM program[14,15] were based on the evolutionary-biological play theory[17] and insights of social cognitive theory.[18]

The evolutionary-biological play theory suggests that programs that are in accordance with the genetic potential of humans are most likely to succeed in developing a lifelong, physically active lifestyle. Therefore, this theory states that motor systems could be optimally developed and maintained if the motor qualities of strength, speed, endurance, flexibility, and coordination were trained using motor actions such as walking, running, jumping, batting, throwing, and catching that were integrated into games, sports, and activities of daily living. This type of programs would also have to meet three conditions: a) safe environments would have to be created in which participants do not experience feelings of fear; b) the activities conducted should be slightly ambivalent, which means that exciting situations should be included without being too exciting; and c) curiosity should be stimulated or the desire to explore new activities.[17] When these three conditions are met, a situation is created under which self-efficacy, social support, and perceived fitness could be manipulated and ultimately lead to increased enjoyment in physical activity.[7] In the GALM program, self-efficacy was developed by offering activities designed to provide successful mastery experiences. For example, the program had a low starting level with respect to the intensity and difficulty of the activities presented to participants, therefore making almost everyone feel at ease about their ability to participate. In addition, game rules and materials needed (e.g., balls) were adjusted to participants' capabilities when necessary.[7,18] Social support and social interaction were stimulated by support of other GALM group members, feedback from the instructor, and the moment of social interaction that was planned at the end of each session. Finally, feelings of perceived fitness were influenced by letting the participants experience that they were capable of being physically active for longer periods of time at a higher intensity in the course of the GALM program.

Another reason for the versatility of the GALM was that in this way the program also addressed several dimensions of motor fitness such as cardiorespiratory and muscular fitness as well as flexibility, all of which are crucial for older adults living independently.[19,20]

To enhance health and fitness outcomes, physical activity interventions should meet a certain amount and quality level of exercise. According to the 1998 American College of Sports Medicine (ACSM) recommendations, exercise to increase cardiorespiratory fitness should be conducted 3 to 5 days per week with an intensity of 55 to 65% to 90% of maximum heart rate, or 40-50% to 85% of heart rate reserve, or maximum oxygen uptake with a duration of 20 to 60 min. The lower intensity values are most applicable to individuals who are quite unfit.[12] The purpose of the present study was to investigate whether the GALM physical activity program, which was primarily based on an evolutionary-biological play theory and insights of social cognitive theory, was able to meet the physiological intensity guidelines to enhance cardiorespiratory fitness of sedentary or underactive older adults.

## Methods

### Participants and procedures

Subjects in three Dutch municipalities were included in this study. The three municipalities were selected based on the degree of urbanization. All participants had been recruited using the specific recruitment method of the GALM strategy,[7,21] and started with the GALM program at the same time. The participants in this study were from five different GALM groups in three municipalities. A total of 4 to 6 different GALM sessions were monitored per municipality, resulting in data of all 15 sessions. During each of the 15 sessions, heart data was obtained of 5 to 10 randomly selected participants. Subjects who used medication that influenced heart rate (e.g., beta blockers) were excluded from participation. In this way, a total of 114 older adults were measured in the 6-month period the GALM sessions were conducted. Mean heart rate data will be presented per session. The main characteristics of the subjects were gathered and body fat was predicted using leg-to-leg bioelectrical impedance analysis (Tanita model TBF-300, Tokyo, Japan). This method proved to be reliable in measuring body fat percentage and results correlated highly with body fat percentages as measured with underwater weighing and dual energy X-ray absorptiometry.[22] Before the measurements took place, each subject read and signed an informed consent approved by the Medical Ethical Board of Groningen University Hospital.

**Heart rate monitoring**

Heart rate monitoring of the participants was conducted and analyzed to assess the intensity of the GALM program. Heart rate monitoring has been commonly employed as an objective method of assessing intensity of physical activity.[23-26] The use of heart rate as a measure of physical activity is promising because it is a physiological parameter known to have a strong positive association with energy expenditure during large-muscle dynamic exercise.[27] Heart rate monitoring has been shown to be valid, and within-subject reproducibility to submaximal upper and lower body exercise is quite high (intraclass correlation coeffients 0.23 to 0.89 and 0.91 to 0.95, respectively).[28,29]

The net time we monitored heart rate of the participants ranged from 54 to 60 minutes per session, which had a maximum duration of 60 min. A 15-s interval period was used for the heart rate recording, and the data were obtained by means of Polar heart rate monitoring devices (Accurex and Vantage models, Polar Electro, Tampere, Finland). The data were transferred from the Polar receiver to a computer by means of an interface for further analysis.

**Structure of the GALM program**

The GALM program consisted of 15 sixty-min sessions, at a frequency of once a week. The selected leisure-time sport activities of the GALM program were based on national survey results on preferences of older adults towards certain leisure-time sport activities. The favorite leisure-time sport activities were incorporated into the GALM program (Table 1).

Each GALM session was structured as follows: a) a warming-up period of 5-10 min in which activities such as walking, exercise-to-music routines and introductory activities were linked to exercises to be conducted later in the session; b) 20-25 min of skills practice in which the offered exercises were tailored to the level and needs of the participants, and, if necessary, adapted materials were used (e.g. foam balls); c) 20-25 min of playing in which the learned and practiced skills were conducted in the context of a game or other activities; d) 5-10 min of cooling-down consisting of flexibility and relaxation activities. After each session, 15 min moment of socializing was incorporated in order to strengthen the social interaction and cohesion of the group. During this brief period, the instructor evaluated the session with the participants and gave answers to specific questions and the participants were able to engage in informal conversations with each other while having

**Table 1.** Recreational sports activities of the GALM program in chronological order

| Session | Recreational sports activities | Examples of exercises |
|---|---|---|
| 1 | **Introductory/ball game** | Introduction of instructor, participants and GALM program. Warming-up with walking, running exercises in small groups to learn each other's names. Ball-throwing and catching, playing introductory game of softball. |
| 2 | **Softball** | Warming-up on music, rhythmical walking, running, arm swinging and jump exercises. Ball-throwing and catching combined with running and batting with small groups. Playing adapted form of indoor softball. |
| 3 | **Dance** | Warming-up on music with increased intensity like arm and leg swings. Learning some steps and moves (e.g. V-step, side-step, step-tap) followed by more intensified exercises like jumping, tripling, skipping, muscle-strengthening exercises for abdomen, buttock and legs, ending with stretching. |
| 4 | **Volleyball** | Warming-up individually throwing and catching volleyball or foam ball, pair-wise exercises. Playing mini-volleyball with adjusted rules. |
| 5 | **Self-defense** | Warming-up on music, exercises with wooden stick like swinging, jumping, balancing the stick on fingers, pulling and pushing, stick wrestling, defense and attack combinations (cautiously). |
| 6 | **Badminton** | Warming-up on music, low-impact exercises and stretching. Teaching badminton skills and playing badminton with partner of same level. |
| 7 | **Basketball** | Warming-up with a basketball dribbling and scoring on basket. Circuit of basketball exercises (set shot, lay-up, chest pass) and playing mini-basketball. |
| 8 | **Swimming** | Aqua jogging, wet-belt exercises and swimming. |
| 9 | **Soccer** | Warming-up exercises with ball, dribbling. Soccer circuit with shooting, dribbling and passing. Playing mini-soccer with special rules. |
| 10 | **Indoor hockey** | Warming-up by means of simple hockey skills, pushing and stopping the ball, playing mini-hockey (adapted rules and materials, e.g. longer hockey sticks, lighter/soft ball). |
| 11 | **Games circuit** | Warming-up on music, introduction of game skills. Playing the circuit with exercises like throwing, catching, walking, running, kicking, jumping. |
| 12 | **Fitness (in a gym)** | Warming-up on music with low-impact and stretching exercises. Introduction of fitness equipment and exercises. Circuit of exercises with light weights. Relaxation and stretching on music. |
| 13 | **Tennis** | Warming-up on music doing dynamic flexibility exercises like swinging of arms and legs, walking/running and throwing/catching tennis ball with partner. Tennis skills individually like bouncing on racket, with walking with tennis ball/foam ball/balloon. Playing tennis with adjusted rules. |
| 14 | **Korfball**[a] | Warming-up with ball together with partner throwing, catching during walking and running. Scoring on a basket. Playing an adapted form of mini korfball. |
| 15 | **Athletics** | Warming-up with walking, running, stretching and dynamic flexibility exercises. Interval running, javelin throwing/tennis ball. Aiming and throwing javelin/ball on targets (e.g. balloons). Team relay running. |

[a] *Korfball is a traditional mixed-team ball game that aims at scoring on the basket of the opposite team that is positioned on a pole about 11 ft high. The ball has to be played by hand and no physical contact is allowed.*

a drink. All the sessions were conducted in groups consisting of 15 to 24 participants. The sessions were led by a trained instructor who, besides being a professional sports educator, had to complete a three-day course to learn how to teach the GALM sessions.

The GALM program was conducted at a local gymnasium in or near the neighborhoods in which the participants lived. By means of this neighborhood-oriented approach, GALM tried to make use of participants' social networks. Another bonus of this approach is that participants often lived within walking or cycling distance of the gymnasium, which lowers a barrier for participation.

**Statistical analysis**

All data were analyzed with SPSS version 10.0 (SPSS, Inc., Chicago, IL). The first screening for abnormalities in the heart rate curves showed that data of 17 participants (15%) were too damaged; these files were excluded from further analysis. Criterion for exclusion was more than 10 consecutive missing or unusable heart rates. Finally, heart rate data for 97 older adults were eligible for analysis in this study.

Descriptive statistics were used to analyze the main characteristics of the subject and the heart rate data. The heart rate data were categorized as light, moderate, or hard according to the ACSM 1998 classification, which was based on the percentage of maximum heart rate (HRmax). The HRmax was predicted by the formula HRmax = 220 - age (in y).[30] The "light" category was defined as ≤ 54% of HRmax, "moderate was 55 to 69% of HRmax and "hard" was ≥ 70% of HRmax.[12]

## Results

The 97 study participants (47% men and 53% women) had a mean age of 60.1 years (*SD* = 3.7). The main characteristics of the study sample are shown in Table 2.

Results of the heart rate monitoring show an overall mean heart rate for the introductory program of 117.8 beats/min (*SD* = 8.2). Heart rates varied between a minimum mean of 103.3 beats/min (*SD* = 8.3) for the fitness session and a maximum mean of 132.9 beats/min (*SD* = 11.8) for the korfball session. Overall mean percentage of HRmax was 73.7% (*SD* = 5.1). Mean percentages of HRmax varied as low as 64.6% (*SD* = 5.2) for fitness and as high as 83.1% (*SD* = 7.4) for korfball (Table 3).

**Table 2.** Main characteristics of the study sample by sex and for the total sample.

| | Men ($n$ = 46) | | Women ($n$ = 51) | | Total ($N$ = 97) | |
|---|---|---|---|---|---|---|
| **Main characteristics** | **Mean** | ***SD*** | **Mean** | ***SD*** | **Mean** | ***SD*** |
| Age (yr) | 61.0 | 3.9 | 59.4 | 3.5 | 60.1 | 3.7 |
| Weight (kg) | 83.9 | 11.6 | 74.4 | 10.7 | 78.9 | 12.1 |
| Height (cm) | 176 | 5.8 | 165 | 5.6 | 171 | 7.8 |
| BMI (kg/m²) | 27.0 | 3.6 | 27.3 | 4.2 | 27.2 | 3.9 |
| Body fat (%) | 25.6 | 4.9 | 38.1 | 5.7 | 32.1 | 8.2 |

*SD, standard deviation.*
*BMI, body mass index.*

Results of the heart rate monitoring show an overall mean heart rate for the introductory program of 117.8 beats/min (*SD* = 8.2). Heart rates varied between a minimum mean of 103.3 beats/min (*SD* = 8.3) for the fitness session and a maximum mean of 132.9 beats/min (*SD* = 11.8) for the korfball session. Overall mean percentage of HRmax was 73.7% (*SD* = 5.1). Mean percentages of HRmax varied from as low as 64.6% (*SD* = 5.2) for fitness to as high as 83.1% (*SD* = 7.4) for korfball (Table 3).

For the overall GALM program, 6% (*SD* = 5) of monitored heart rate time could be classified as light, 33% (*SD* = 13) as moderate and 61% (*SD* = 16) as hard. The korfball session had the highest mean percentage (88%, *SD* = 16) of time spent in the "hard" category. The badminton session showed the highest mean percentage (21%, *SD* = 30) of time in the "light" category.

## Discussion

This article describes the background and results of a study to evaluate the intensity of GALM, a versatile physical activity program that is primarily based on a play theory and insights of social cognitive theory.

The mean age of participants (60.1 y, *SD* = 3.7) and the proportion of men (47%) and women (53%) in this study demonstrated that the study sample was a reasonably representative cross section of the GALM participants in general.[8] Furthermore, for purposes of representativeness, five different GALM groups with five different GALM instructors were monitored to assess the intensity of the GALM program. In this way, our measures were not unduly influenced by the personal teaching style of an individual instructor. A disadvantage of having monitored sessions led by five different instructors was the standardization of the GALM program, which could limit the generalizability of the study results. To minimize this variability between GALM sessions and instructors, the described structure

**Table 3.** Recreational sports activity, mean heart rate, percentages of monitored heart-rate time classified according to the categories light, moderate, and hard,[12] and percentage of predicted HRmax of the 15 GALM sessions.

| | Heart rate monitoring | | | | | |
|---|---|---|---|---|---|---|
| **Recreational sports activity** | **Mean HR (*SD*)** | **% $HR_{max}$ (*SD*)** | **Light (*SD*)** | **Moderate (*SD*)** | **Hard (*SD*)** | ***n*** |
| 1 Introductory/ball game | 114.3 (11.9) | 71.5 (7.4) | 10 (11) | 36 (34) | 54 (42) | 4 |
| 2 Softball | 120.3 (8.7) | 75.2 (5.4) | 1 (1) | 36 (33) | 63 (34) | 4 |
| 3 Dance | 128.0 (9.4) | 80.0 (5.9) | 1 (1) | 17 (17) | 82 (17) | 5 |
| 4 Volleyball | 121.5 (8.7) | 76.0 (5.4) | 1 (2) | 30 (33) | 69 (34) | 9 |
| 5 Self-defense | 118.9 (9.0) | 74.4 (5.6) | 4 (5) | 38 (31) | 58 (34) | 8 |
| 6 Badminton | 104.0 (10.5) | 65 (6.6) | 21 (30) | 40 (26) | 39 (36) | 8 |
| 7 Basketball | 121.6 (10.2) | 76.1 (6.4) | 5 (10) | 22 (21) | 73 (30) | 6 |
| 8 Swimming | 111.6 (8.2) | 69.8 (5.1) | 6 (12) | 47 (25) | 47 (32) | 6 |
| 9 Soccer | 119.6 (13.2) | 74.8 (8.2) | 3 (2) | 31 (15) | 66 (17) | 9 |
| 10 Indoor hockey | 116.0 (10.5) | 72.5 (6.6) | 7 (8) | 37 (28) | 56 (34) | 8 |
| 11 Games circuit | 126.6 (9.6) | 79.2 (6.0) | 2 (1) | 20 (19) | 78 (20) | 9 |
| 12 Fitness | 103.3 (8.3) | 64.6 (5.2) | 8 (9) | 66 (12) | 26 (16) | 4 |
| 13 Tennis | 116.1 (12.0) | 72.6 (7.5) | 5 (4) | 39 (25) | 56 (27) | 8 |
| 14 Korfball | 132.9 (11.8) | 83.1 (7.4) | 1 (1) | 11 (15) | 88 (16) | 8 |
| 15 Athletics | 117.6 (7.4) | 73.5 (4.6) | 9 (14) | 25 (20) | 66 (30) | 6 |
| Overall mean HR | 118.1 (8.0) | 73.9 (5.0) | 6 (5) | 33 (13) | 61 (16) | |

*SD, standard deviation.*

*Mean HR, mean heart rate.*

*% HRmax, percentage of predicted heart rate maximum.*

*Light, ≤ 54% of HRmax.*[12]

*Moderate 55-69% of HRmax.*[12]

*Hard, ≥70 of HRmax.*[12]

and leisure-time sport activity scheme (Table 1) had to be adhered to strictly, and all instructors completed a 3-d GALM training course. The main characteristics of the subjects, together with the standardization procedures used, increased the likelihood of our results providing a realistic indication of the intensity of the GALM physical activity program despite our study group being only a small sample of all Dutch GALM participants.

In our study, 17 heart rate files (15%) were excluded from analysis because of abnormalities in or missing heart rate data. In one of the few studies that report on failures in heart rate assessment in a field setting, Treiber et al.[25] reported that less than 1.2% of the registrations with the Sport heart rate tester were lost because of malfunction. In that study, children were engaged in six 3-min activities: standing, walking, jogging, throwing, batting and playing in a jungle gym. Electrode detachments resulting from sweating and body movement were cited as reasons for malfunction. A possible explanation for the higher percentage of nonrepairable heart rate files in our study could be the fact that we monitored older people, who are generally more obese than younger people and could have disturbed the transmission of heart rate signals because of subcutaneous fat. Secondly, we monitored for longer periods of time (54-60 min per session). Finally, the activities conducted in our study showed a much greater variety of bodily movement, which in turn could increase the risk of unintentional detachment of the transmitters attached to the participants' chests. The highest percentages of nonrepairable files were reported during the fitness lesson, the introductory/ball game and the dance lesson.

The overall mean intensity of the GALM program was 73.7% (*SD* = 5.1) of HRmax with a variation between 64.6% (*SD* = 5.2) and 83.1% (*SD* = 7.4) of the HRmax. From the relationship found between HRmax and % $VO_2$ max it can be concluded that the overall mean intensity of the GALM program was about 60% of $VO_2$max or heart rate reserve with a variation between 50% and about 72% of $VO_2$max.[31,32] In the present study, however, the age-predicted HRmax equation, HRmax = 220-age (in y) was used as the basis for describing the intensity of the GALM program. Tanaka, Monahan, and Seals[33] argue that this equation was never validated in studies that included sufficient numbers of older adults. They conclude that the traditionally used equation underestimates HRmax in older adults, and that this would cause an underestimation of the appropriate intensity of prescribed exercise programs. Robergs and Landwehr[34] also emphasize that currently there is no acceptable method to estimate HRmax and that

there is no scientific merit to using the rule 220-age formula. If HRmax needs to be estimated, however, the most accurate equation is that of Inbar et al.:[35] HRmax = 205.8-0.685*age (Sxy = 6.4 beats/min). In the context of the debate on the 220-age formula, we conclude that the intensity of the GALM physical activity program is probably overestimated in this study. With this in mind, we still conclude that the overall mean intensity of the GALM program could be best classified as moderately intense (55 to 69% of HRmax).

The classification of the heart rate data into light, moderate and hard intensity was based on the ACSM 1998 guidelines for developing and maintaining cardiorespiratory fitness in healthy adults.[12] The results show that, most of the time, participants were physically active in the moderate (33%, *SD* = 13) or hard (61%, *SD* = 16) intensity zone. Still, considerable standard deviations are reported, indicating major interpersonal differences from which it can be concluded that the intensity of the sessions varied greatly between individuals. Another consideration is the small number of participants that were measured per session ranging from 4 to 9. This variability together with the number of cases per session makes it difficult to draw hard conclusions on the intensity of the program as assessed in this study. Although the results look promising with respect to the intensity of the GALM program, more and better-controlled studies should be conducted to gather more information on the intensity of versatile physical activity programs like GALM.

A disadvantage of our study was that the measurements took place in a time period of 6 months. This meant that GALM participants who were monitored during the first sessions of the GALM program could be indeed considered sedentary or underactive. By contrast, the participants measured in the last GALM sessions had already been physically active in the GALM program for several months. One could argue that this may have led to an underestimation of the assessed intensity results of the latter GALM sessions as a consequence of a probable heart rate-lowering training response. However, the lowering of heart rate during submaximal exercise was only reported as an effect of prolonged participation in aerobic exercise training.[9,19] Therefore, we think the difference in the amount of GALM sessions participated in at the time of heart rate monitoring did not affect the study results.

In sum, this study provides information on the background and structure of the GALM program. The results of the intensity study are an indication that an attractive versatile physical activity program like the GALM is able to meet the intensity criteria set by the ACSM. In the context

of health promotion this can be considered as an encouragement, given the fact that programs offering different physical activity options may be particularly appealing to older adults.[14,15]

## References


1. Backx FJG, Swinkels H, Bol E. How physically (in)active are Dutch adults in their leisure-time? [Eng. Trans]. CBS maandschrift 1994;3: 4-11.
2. Powell KE, Blair SN. Public health burdens of sedentary living habits: theoretical but realistic estimates. Med Sci Sports Exerc 1994;26:851-56.
3. Urlings IJM, Douwes M, Hildebrandt VH, Stiggelbout M, Ooijendijk WTM. Relative validity of a physical activity questionnaire regarding the activity guidelines [Eng. Trans.]. Geneeskunde en Sport 2000;33:17-22.
4. Shephard RJ. What is the optimal type of physical activity to enhance health? Br J Sports Med 1997;31:277-84.
5. King AC, Rejeski WJ, Buchner DM. Physical activity interventions targeting older adults: a critical review and recommendations. Am J Prev Med 1998;15:316-33.
6. Bij van der AK, Laurant MGH, Wensing M. Effectiveness of physical activity interventions for older adults: a review. Am J Prev Med 2002;22:120-33.
7. Stevens M, Bult P, de Greef MHG, Lemmink KAPM, Rispens P. Groningen Active Living Model (GALM): stimulating physical activity in sedentary older adults. Prev Med 1999;29:267-76.
8. Stevens M, Lemmink KAPM, de Greef MHG, Rispens P. Groningen Active Living Model (GALM): stimulating physical activity in sedentary older adults; first results. Prev Med 2000;31:547-53.
9. Department of Health and Human Services. Physical Activity and Health: a report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996:11-80.
10. Stewart AL, Verboncoeur CJ, McLellan BY, Gillis DE, Rush S, Mills KM, et al. Physical activity outcomes of CHAMPS II: a physical activity program for older adults. J Gerontol A Biol Sci Med Sci 2001;56A:465-70.

11. De Jong J, Leibbrand K, Stevens M, De Greef MHG, Lemmink KAPM. The effects of the GALM program on physical activity and other lifestyle characteristics, fitness, health and daily functioning of sedentary and underactive older adults [Eng. Trans.]. Groningen, NL: University of Groningen, 2004, 49-67.
12. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc 1998;30:975-91.
13. Physical activity, fitness and health: international proceedings and consensus statement. Champaign, IL: Human Kinetics, 1994, 993-1005.
14. Ecclestone NA, Myers AM, Paterson DH. Tracking older participants of twelve physical activity classes over a three year period. J Aging Phys Activity 1998;6:70-82.
15. King AC. Interventions to promote physical activity by older adults. J Gerontol A Biol Sci Med Sci 2001;56A:36-46.
16. Dishman RK, Buckworth J. Increasing physical activity: a quantitative synthesis. Med Sci Sports Exerc 1996;28:706-19.
17. Bult P, Rispens P. Learning to move: acquiring versatility in movement through upbringing and education. Maastricht, The Netherlands: Shaker Publishing B.V., 1999, 29-42.
18. Bandura A. Social foundations of thought and action. Englewood Cliffs, NJ: Prentice Hall, 1986, 399-409.
19. American College of Sports Medicine Position Stand. Exercise and physical activity for older adults. Med Sci Sports Exerc 1998;30:992-1008.
20. Hurley BF, Hagberg JM. Optimizing health in older persons: aerobic or strength training. Exerc Sport Sci Rev 1998;26:61-89.
21. De Jong J, Stevens M, de Greef MHG, Dirks CJ, Haitsma J, Lemmink KAPM, et al. GALM questionnaire to select sedentary seniors: reliability and validity. Med Sci Sports Exerc 1999;31:S379.
22. Nuñez C, Gallagher D, Visser M, Pi-Sunyer FX, Wang Z, Heymsfield SB. Bioimpedance analysis: evaluation of leg-to-leg system based on pressure contact foot-pad electrodes. Med Sci Sports Exerc 1997;29:524-31.

23. Washburn RA, Montoye HJ. Validity of heart rate as a measure of mean daily energy expenditure. Exerc Physiol 1986;2:161-72.
24. Leger L, Thivierge M. Heart rate monitors: validity, stability, and functionality. Physiol Sports Med 1988;16:143-51.
25. Treiber FA, Musante L, Hartdagan S, Davis H, Levy M, Strong WB. Validation of a heart rate monitor with children in laboratory and field setting. Med Sci Sports Exerc 1989;21:338-42.
26. Eston RGA, Rowlands V, Ingledew DK. Validity of heart rate, pedometry, and accelerometry for predicting the energy cost of children's activities. J Appl Physiol 1998;84:362-71.
27. Goldsmith R, Miller DS, Mumford R, Stock MJ. The use of energy long-term measurements of heart rate to assess energy expenditure. J Physiol 1967;189.
28. Strath SJ, Swartz AM, Bassett DR, O'Brien WL, King GA, Ainsworth BE. Evaluation of heart rate as a method for assessing moderate intensity physical activity. Med Sci Sports Exerc 2000;32:S465-70.
29. Washburn RA, Montoye HJ. Reliability of the heart rate response to submaximal upper and lower body exercise. Res Q Exerc Sports 1985;56:166-69.
30. Wasserman K, Hansen JE, Sue DY, Whipp BJ, Casaburi R. Principles of exercise testing and interpretation. Philadelphia: Williams & Wilkins, 1994:112-31.
31. Londeree BR, Ames SA. Trend analysis of the %$VO_2$max-HR regression. Med Sci Sports Exerc 1976;8:123-25.
32. Swain DP, Abernathy KS, Smith CS, Lee SJ, Bunn SA. Target heart rates for the development of cardiorespiratory fitness. Med Sci Sports Exerc 1994;26:112-16.
33. Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revisited. J Am Coll Cardiol 2001;37:153-56.
34. Robergs RA, Landwehr R. The surprising history of the HRmax = 220-age equation. J Exerc Physiol online 2002;5:1-10.
35. Inbar O, Oren A, Scheinowitz M, Rotstein A, Dlin R, Casaburi R. Normal cardiopulmonary responses during incremental exercise in 20-70-yr-old men. Med Sci Sports Exerc 1994;26:538-46.

# Six-month effects of the Groningen Active Living Model (GALM)on physical activity, health and fitness outcomes in sedentary and underactive older adults aged 55-65

## Chapter 4

Johan de Jong
Koen APM Lemmink
Martin Stevens
Mathieu HG de Greef
Piet Rispens
Abby C King
Theo Mulder

*Patient Education and Counselling, 2006:62;132-141*

## Abstract

**Objective**
To determine the effects on energy expenditure, health and fitness outcomes in sedentary older adults aged 55-65 after 6-month participation in the GALM program.

**Methods**
In three Dutch communities, subjects from matched neighbourhoods were assigned to an intervention ($n$ = 79) or a waiting-list control group ($n$ = 102). The GALM program consisted of fifteen 60-minute sessions once a week emphasising moderate-intensity recreational sports activities.

**Results**
The intervention group showed significant increases in energy expenditure for recreational sports activities, other leisure-time physical activity, health indicators, and perceived and performance-based fitness. Contrary to our expectations, the same increases were found for the control group. Consequently, only significant between-group differences, favouring the intervention group, were obtained for sleep, diastolic blood pressure, perceived fitness score and grip strength.

**Conclusion**
The increases in energy expenditure for physical activity from the GALM program, especially for the more intensive recreational sports activities, look promising and are in line with the expected amounts necessary to improve health. Further research is needed to evaluate long-term effects of participation in the GALM program.

**Practice implications**
These results underline that GALM can be considered successful in stimulating leisure-time physical activity and improving health and fitness in older adults.

## Introduction

Despite evidence that regular physical activity contributes substantially to health, functioning and quality of life of older adults,[1-3] a large segment of the Dutch older adult population does not participate regularly in leisure-time physical activity.[4,5] Approximately 60% of Dutch adults aged 55-65 can be considered physically inactive, according to the 1998 American College of Sport Medicine (ACSM) recommendations for exercise and physical activity for older adults.[3]

The Groningen Active Living Model (GALM) was designed to recruit and stimulate leisure-time physical activity in sedentary and underactive older adults aged 55-65.[6] After the recruitment phase, participants start with what can be characterised as a leisure-time physical activity program with an emphasis on recreational sports activities.[2] To assist the maintenance of physical activity in the GALM groups, it was assumed that the activities conducted should be tailored to participants' preferences and needs.[7-9] To this end, the GALM physical activity program was based on insights from social cognitive theory,[10] and evolutionary-biological play theory.[11] The social cognitive mediating variables of self-efficacy, social support, perceived fitness and enjoyment were influenced through the structure and versatile content of the GALM program and the instructors' actions.[6,12,13] Evolutionary-biological play theory suggests that programs that fit the genetic potential of humans are most likely to succeed in developing a lifelong, physically active lifestyle.

Another reason for the versatility of the GALM program was that in this way several dimensions of fitness — like cardiorespiratory, muscular fitness and flexibility, all of which are important to older adults living independently — were addressed.[3,14] We assumed that by providing a versatile leisure-time physical activity program of moderate intensity on average,[15] participants would gain or regain enjoyment during leisure-time physical activities and develop preferences towards certain activities. When the GALM program succeeds in its role as a trigger, it can cause a transfer in participants becoming physically active more frequently outside the program.[16,17]

Many studies have focused on the impact of physical activity programs on indicators of health and fitness in older adults, resulting in a large variety of reported effects.[1,18] Several factors that may account for this variation are diversity of program and subject characteristics, outcome measures and methodological issues.

The purpose of this study was to determine the effects of 6-month participation in the GALM program on physical activity level and indicators of health and fitness in sedentary older adults aged 55-65. Based on the low initial levels of physical activity of the GALM participants,[19] together with the characteristics of the GALM leisure-time physical activity program, we hypothesised that increased physical activity could lead to significant improvements in health and fitness outcomes.[20,21]

## Method

### Study design and subjects

A group-randomised trial was used. Based on urbanisation degree, number of persons in the 55-65 age category and population distribution, three municipalities were selected. In every municipality, the recruitment phase took place in four neighbourhoods that were assigned as intervention or control neighbourhoods. These twelve neighbourhoods were matched on number of older adults aged 55-65 living in that neighbourhood and socioeconomic status, and randomly assigned to study condition within matched pairs. Older adults from the six intervention neighbourhoods automatically became intervention group participants (IG). Correspondingly, older adults from the six control neighbourhood became control group participants (CG). The IG received the regular GALM strategy[6] and the CG started with the intervention after being placed on a waiting list for six months.

The trial was designed to include 144 and 192 subjects in the intervention and control groups respectively, taking into account corresponding expected dropout percentages of 20% and 40% with an alpha of 5% and a power of 80%. Based on experiences from former GALM projects, a total of 8,504 potential participants were recruited using a special strategy to reach the calculated numbers of subjects in the IG and CG. All older adults received a written invitation and were visited at home by trained personnel. During this visit, potential participants were screened using a short questionnaire based on the 1998 ACSM recommendations on exercise and physical activity for older adults.[3,22] Older adults who were not sufficiently active according to these criteria were invited to participate in the study. Based on estimates of available demographic data, about 60% ($n$ = 5,102) of the older adults invited could be considered underactive according to the 1998 ACSM recommendations.[3]

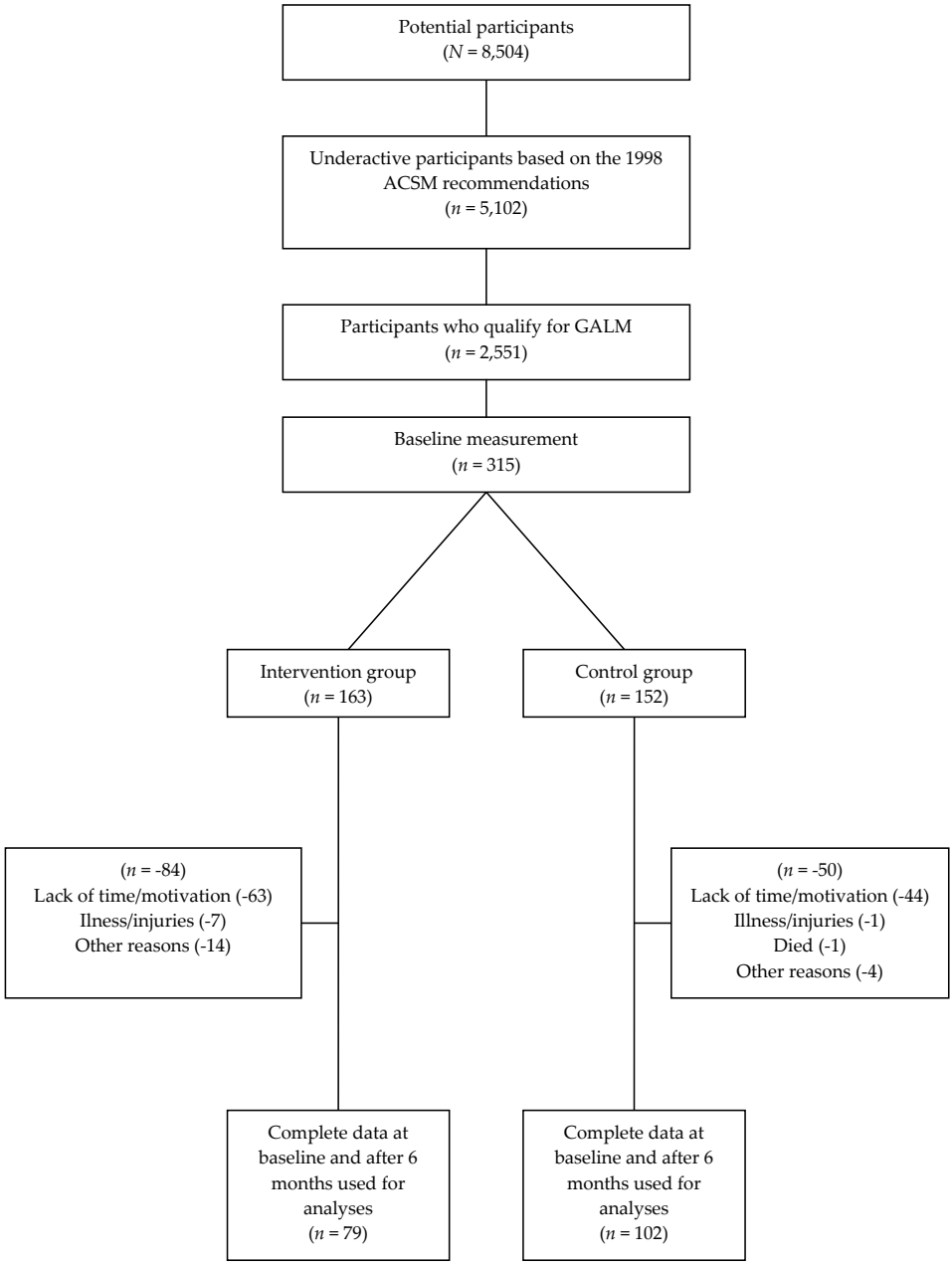



**Figure 1.** Participants flow.

Half of this 60% ($n$ = 2,551) qualified for GALM. The other half was not interested in leisure-time physical activity or was unable to participate for reasons that included illness and personal circumstances.[6]

A total of 315 older adults aged 55-65, i.e., 12% of the qualified individuals, participated in the baseline measurement; 181 of them (57%) also participated in the 6-month follow-up measurement (Figure 1). Intervention group participants were distributed over 12 different GALM groups led by 6 different GALM instructors. Before starting measurements, a written informed consent was obtained from each participant. The study protocol was approved by the Medical Ethics Committee of Groningen University Hospital.

**The GALM program**

The GALM program can be characterised as a leisure-time physical activity program emphasising moderate-intensity recreational sports activities and consists of fifteen 60-minute sessions at a frequency of once a week.[15] After the first 15 sessions participants are able to continue with a subsequent series of 15 GALM sessions.

The recreational sports activities of the GALM program are based on national survey results on preferences of older adults towards certain recreational sports activities. The 15 most favourite recreational sport activities were incorporated into the GALM program (e.g. softball, dance, self-defence, swimming and athletics). The physical activities conducted were tailored by type, format, intensity and frequency to meet the wishes and needs of participants.[6] The structure of each GALM session was as follows: (1) a 5-10 minute warm-up period; (2) 20-25 minutes of skills-practicing in which the exercises offered were differentiated for the level and needs of the participants, using adapted materials when necessary (e.g., foam balls); (3) 20-25 minutes of playing in which the skills learned and practiced were applied in the context of a game or other activities; (4) 5-10 minutes of cooling-down consisting of flexibility and relaxation activities. All sessions were conducted in groups of 15-24 participants and held in a gymnasium located in or near neighbourhoods participants lived in to avoid barriers like travelling distance. For reasons of convenience, the GALM sessions were scheduled at different times and days so participants could choose among the options offered. Once the participants made their choice, they were obligated to join that group for the rest of the program.

The sessions were led by trained instructors who, besides having a professional sports education, completed a three-day course to learn to teach the GALM sessions.

**Measures**
Baseline and follow-up measurements consisted of a questionnaire that had to be completed at home and a fitness test session. By way of the questionnaire, information about indicators of energy expenditure for physical activity, perceived health and perceived fitness was collected. The questionnaire data were collected at the end of the GALM program. Within one week after the participants finished their last GALM session, the fitness test sessions were held which took place in a local sports accommodation. During the test session indicators of health and performance-based fitness were assessed objectively. All test examiners were students and personnel with a medical or scientific background who completed a one-day course on administering the correct test procedures.

**Estimated energy expenditure**
Two categories of the Voorrips physical activity questionnaire[23] combined with the compendium of physical activities by Ainsworth[24] were used to estimate the energy expenditure for recreational sports activities ($EE_{RECSPORT}$: i.e., swimming, volleyball, cycling, brisk walking, etc.) and other leisure-time physical activities ($EE_{LTPA}$: i.e. gardening, doing odd jobs, walking, and cycling for transportation purposes). Spearman's correlation coefficient between the Voorrips questionnaire and 24-hour physical activity recall and a pedometer (Fitty, Kasper & Richter, Uttenreuth, Germany) was 0.78 and 0.72, respectively. Test-retest reliability coefficient for the questionnaire was 0.89.[23,24]

**Perceived health**
Perceived health was measured with a Dutch translation of the Vitality Plus Scale (VPS),[25] and the TNO-AZL Adult Quality of Life Questionnaire (TAAQOL).[26] The VPS was assessed to measure potential health-related benefits of exercise. The reliability of the scale (test-retest reliability: ICC = 0.87, 95% confidence interval [CI] = 0.76 to 0.93) and convergent and discriminant validity were reported to be sufficient.[25] The TAAQOL was used to measure quality of life and originally consisted of 12 sub-scales. We used nine sub-scales that were related mostly to physical activity.

Scale reliability was reported to range from 0.72 to 0.90. Convergent validity between the TAAQOL and corresponding SF-36 scales showed correlations from 0.50 to 0.70.[26]

**Perceived fitness**

Two measures of the perceived fitness questionnaire of the Groningen Fitness Test for the Elderly (GFE) were used: a perceived fitness score and a comparative fitness rating using peers as a frame of reference entitled comparative fitness rating.[27,28] The original test-retest reliability of the perceived fitness score was satisfactory for older men and older women (ICC = 0.76, 95% CI = 0.57 to 0.87 vs. ICC = 0.78, 95% CI = 0.66 to 0.86). The test-retest reliability coefficient of the comparative fitness rating was reported to be 0.94 for older men (95% CI = 0.88 to 0.97) and 0.84 for older women (95% CI = 0.76 to 0.90).[27]

**Health Indicators**

Prior to the test session, all participants had their blood pressure measured and completed a modified version of the Physical Activity Readiness Questionnaire (PAR-Q).[29] Participants who had a systolic blood pressure >160 mmHg and/or a diastolic blood pressure >100 mmHg, and/or who answered one or more questions of the PAR-Q affirmatively, had to consult the attending physician. Systolic and diastolic blood pressure were assessed electronically (Omron M4, Omron Corporation, Tokyo, Japan).[30] Body fat was predicted using leg-to-leg bioelectrical impedance analysis (Tanita TBF-300, Tanita Corporation, Tokyo, Japan). This method proved to be reliable to measure body fat percentage, and results correlated highly with body fat percentages as measured with underwater weighing and dual-energy X-ray absorptiometry in healthy adults.[31] Body Mass Index (BMI) was calculated by dividing body mass in kilograms by height in meters.[1]

**Performance-based fitness**

Six test items of the Groningen Fitness Test for the Elderly were used.[27] Manual dexterity was measured using the block transfer test. Reaction time was assessed by measuring simple reaction time. The grip strength test was used to measure maximum isometric strength of hand and arm muscles. The sit-and-reach test was conducted to measure flexibility of the hamstrings and lower back. The circumduction test measured shoulder flexibility. The walking test with increasing speed measured

aerobic endurance. All test items have proven to be reliable and valid.[27,32-34] Additionally, the functional reach and the timed chair-stand test were administered to measure dynamic balance and leg strength, respectively. Both tests have also proven to be reliable and valid.[35-37]

**Analysis**

Data were analysed using SPSS version 10.0 (SPSS Inc., Chicago IL., 1999) and MLwiN (2004, 2.01). Analysis of variance (ANOVA) and chi-square procedures were used to evaluate between-group differences for the general characteristics and main outcomes at baseline. To assess effectiveness of GALM after 6 months, we first checked if neighbourhood and municipality were of influence using a multilevel analysis. Since the results of this multilevel analysis demonstrated there was no such influence, repeated measure analysis of covariance (ANCOVA) procedures were used with baseline values, sex and age as covariates. The analyses were conducted by intention-to-treat, with participants analysed according to the initial randomised assignment.

Secondary analyses were performed including only those subjects who attended at least 50% of the GALM sessions. For both analyses, a one-tailed test of significance was applied for the between-group differences because we had directional hypotheses for the change in these outcomes. Adjusted change scores for each outcome measure and 95% confidence intervals were reported. To determine whether the calculated within-group changes over time were significant, paired t-test procedures were conducted. For all test procedures a probability value of less than 0.05 was considered statistically significant.

## Results

One hundred and eighty-one out of 315 participants at baseline also completed all measurements after 6 months, producing an overall dropout rate of 43% (IG, 52% vs. 33%, CG). Main characteristics of the 181 participants who completed all measures at baseline and after 6 months are shown in table 1. The study participants who dropped out were not significantly different with respect to sex, age, stage of change, $EE_{RECSPORT}$, $EE_{LTPA}$, and all health and fitness outcomes measures. The percentages of women in the IG (54.4%) and CG (56.9%) were nearly the same. The IG subjects demonstrated an average attendance to the GALM program of 12 of the 15 GALM sessions (80%, standard deviation = 19).

**Table 1.** Main characteristics at baseline.

| Characteristics | Intervention group ($n$ = 79) | Control group ($n$ = 102) | $F/\chi^2$ | $p$ |
|---|---|---|---|---|
| Age (year) | | | | |
| Mean (*SD*) | 59.6 (2.4) | 58.8 (2.7) | 4.02 | 0.05 |
| Range | 55-65 | 55-65 | | |
| BMI (kg/m²) | | | | |
| Mean (*SD*) | 26.9 (3.2) | 26.8 (3.6) | 0.03 | 0.86 |
| Range | 19.9-35.9 | 20.2-35.8 | | |
| Women (%) | 54.4 | 56.9 | 0.11 | 0.74 |
| Living alone (%)[a] | 17.7 | 19.8 | 0.13 | 0.72 |
| Educational Level (%)[b] | | | | |
| Elementary | 43.6 | 33.7 | 5.02 | 0.08 |
| Secondary | 28.2 | 44.5 | | |
| Higher/University | 28.2 | 21.8 | | |
| Number of chronic diseases (%) | | | | |
| 0 | 37.2 | 30.4 | 2.04 | 0.36 |
| 1 or 2 | 34.6 | 45.1 | | |
| >2 | 28.2 | 24.5 | | |
| Smoker (%) | 19.0 | 14.9 | 0.55 | 0.46 |
| Glasses of alcohol per day (%) | | | | |
| 0 | 20.3 | 19.6 | 1.21 | 0.55 |
| 1 or 2 | 72.2 | 76.5 | | |
| ≥ 3 | 7.5 | 3.9 | | |

[a] Missing $n$ = 1 in control group.
[b] Missing $n$ = 1 in intervention group.

## Baseline characteristics

Table 2 shows the results of the ANOVA for between-group differences for outcome measures at baseline, and demonstrates that energy expenditure, health and fitness of the IG were not significantly different from the CG except for two measures in the performance-based fitness domain.

The mean scores on the functional reach test showed a significant difference between the IG in favour of the IG (38.6 cm, $SD$ = 5.5 vs. 36.8 cm, $SD$ = 5.8) ($F$ = 4.93, $p < 0.05$). The IG also demonstrated a significantly higher score on the sit-and-reach test than the CG (29.3 cm, $SD$ = 9.5 vs. 26.1 cm, $SD$ = 10.7) ($F$ = 4.53, $p < 0.05$).

## Intention-to-treat analysis

IG as well as CG participants show many positive changes in energy expenditure for physical activity and health and fitness outcomes after 6 months. Especially the health and fitness outcomes as measured objectively changed positively (i.e. health indicators and performance-based fitness). The mean change for $EE_{RECSPORT}$ in the IG was larger than in the CG (325 kcal/week vs. 151 kcal/week), but did not reach statistical significance. Similar increases in $EE_{LTPA}$ (664 kcal/week vs. 662 kcal/week) occurred in both groups (table 3). For the indicators of perceived health, the sleep subscale of the TAAQOL demonstrated a significant difference between the IG and the CG

**Table 2.** Estimated energy expenditure, perceived health, perceived fitness, health indicators, and performance-based fitness per study group at baseline.

| | Intervention group ($n$ = 79) | Control group ($n$ = 102) | | |
|---|---|---|---|---|
| **Characteristics** | **Mean (*SD*)** | **Mean (SD)** | ***F*-value** | ***p*** |
| **Estimated energy expenditure for physical activity** | | | | |
| $EE_{RSA}$ (kcal/week) | 657 (789) | 715 (1008) | 0.18 | 0.68 |
| $EE_{LTPA}$ (kcal/week) | 1820 (1934)[a] | 1520 (1465) | 1.40 | 0.24 |
| **Perceived health** | | | | |
| Vitality Plus Scale (sum score 10-50) | 39.5 (7.0)[d] | 39.5 (5.8)[b] | 0.00 | 0.95 |
| TAAQOL subscales | | | | |
| - Gross motor functioning (1-100) | 79.5 (21.8) | 83.7 (21.8)[d] | 1.60 | 0.21 |
| - Fine motor functioning (1-100) | 92.9 (19.8) | 92.3 (16.2)[b] | 0.06 | 0.82 |
| - Cognition (1-100) | 82.0 (20.2) | 82.9 (21.6)[a] | 0.09 | 0.76 |
| - Sleep (1-100) | 73.2 (25.4)[a] | 74.8 (25.0)[a] | 0.19 | 0.66 |
| - Social contacts (1-100) | 91.3 (16.4)[c] | 89.5 (17.1)[c] | 0.51 | 0.48 |
| - Daily activities (1-100) | 88.2 (20.6)[c] | 89.0 (18.9)[c] | 0.07 | 0.80 |
| - Vitality (1-100) | 67.5 (22.6)[b] | 68.9 (19.3)[c] | 0.18 | 0.68 |
| - Positive moods (1-100) | 64.3 (21.5)[a] | 65.0 (19.0) | 0.05 | 0.83 |
| - Depressive moods (1-100) | 81.2 (16.0)[b] | 81.7 (18.0)[a] | 0.03 | 0.85 |
| **Perceived fitness** | | | | |
| Fitness score (1-10) | 6.3 (1.1) | 6.4 (1.2) | 0.55 | 0.46 |
| Comparative fitness rating (10-50) | 28.6 (5.6)[a] | 28.3 (4.2)[a] | 0.16 | 0.69 |
| **Health indicators** | | | | |
| RDBP (mmHg) | 84.8 (12.4) | 84.1 (11.7) | 0.14 | 0.71 |
| RSBP (mmHg) | 144.8 (23.0) | 144.2 (21.6) | 0.03 | 0.86 |
| BMI ($kg/m^2$) | 26.9 (3.2) | 26.8 (3.6) | 0.03 | 0.86 |
| Body fat (%) | 32.3 (8.4) | 32.4 (8.2) | 0.00 | 0.99 |
| **Performance-based fitness** | | | | |
| Manual dexterity (s) | 46.6 (5.4) | 47.0 (5.3) | 0.35 | 0.56 |
| Reaction time (ms) | 219 (30) | 227 (42) | 2.04 | 0.16 |
| Functional reach (cm) | 38.6 (5.5) | 36.8 (5.8) | 4.93 | 0.03* |
| Grip strength (kgf/kg) | .497 (.113) | .493 (.133) | 0.03 | 0.86 |
| Leg strength (s) | 20.0 (5.3) | 20.5 (5.7) | 0.32 | 0.57 |
| Sit-and-reach (cm) | 29.3 (9.5) | 26.1 (10.7) | 4.53 | 0.04* |
| Shoulder flexibility (°) | 48.7 (6.3) | 48.9 (7.9) | 0.03 | 0.86 |
| Walking ($x16^2/_3m$) | 50.8 (14.5) | 51.4 (13.6) | 0.07 | 0.78 |

RSA, recreational sports activities; LTPA, leisure-time physical activities; RDBP, resting diastolic blood pressure; RSBP, resting systolic blood pressure; BMI, body mass index.

* Statistically significant $p < 0.05$.

[a] Missing $n = 1$.

[b] Missing $n = 2$.

[c] Missing $n = 3$.

[d] Missing $n = 4$.

**Table 3.** Adjusted mean changes in estimated energy expenditure, perceived health, perceived fitness, health indicators, and performance-based fitness per study group.

| | Control group ($n$ = 102) | Intervention group intention-to-treat ($n$ = 79) | | Intervention group 50% of sessions ($n$= 73) | |
|---|---|---|---|---|---|
| **Characteristics** | **Mean change[a] (95% CI)[b]** | **Mean change[a] (95% CI)[b]** | **$p$[c]** | **Mean change[a] (95% CI)[b]** | **$p$[d]** |
| **Estimated energy expenditure for physical activity** | | | | | |
| $EE_{RSA}$ (kcal/week) | 151 (-9, 312) | 325 (179, 471)** | ns | 323 (169, 476)** | ns |
| $EE_{LTPA}$ (kcal/week) | 662 (510, 813)* | 664 (455, 872)[e, **] | ns | 770 (544, 997)[e, **] | ns |
| **Perceived health** | | | ns | | ns |
| Vitality Plus Scale | -0.17 (-0.61, 0.27)[f] | 0.18 (-0.44, 0.80)[h] | ns | 0.18 (-0.46, 0.81)[h] | ns |
| TAAQOL subscales | | | | | |
| - Gross motor functioning | -0.57 (-2.97, 1.82)[h] | 2.74 (0.47, 5.02)* | ns | 2.54 (0.24, 4.83)* | ns |
| - Fine motor functioning | -0.50 (-1.57, 0.57)[f] | 0.32 (-1.14, 1.78) | ns | 0.32 (-1.35, 1.98) | |
| - Cognition | -2.10 (-3.81, -0.40)[e, *] | -1.42 (-3.17, 0.32) | ns | -0.76 (-2.72, 1.20) | |
| - Sleep | -3.36 (-5.49, -1.24)[e, *] | 2.64 (0.35, 4.94)[e, *] | 0.04 | 2.50 (0.11, 4.90)[e, *] | 0.04 |
| - Social contacts | -0.95 (-2.68, 0.79)[g] | 0.63 (-1.34, 2.60)[g] | ns | -0.11 (-1.95, 1.74)[g] | ns |
| - Daily activities | 0.76 (-1.46, 2.97)[g] | -1.15 (-3.87, 1.57)[g] | ns | -0.95 (-3.68, 1.77)[g] | ns |
| - Vitality | 0.87 (-1.08, 2.82)[g] | -0.61 (-3.02, 1.80)[f] | ns | -0.92 (-3.45, 1.61)[f] | ns |
| - Positive moods | 0.05 (-1.59, 1.70) | -1.18 (-3.28, 0.93)[e] | ns | -1.12 (3.38, 1.14)[e] | ns |
| - Depressive moods | 0.99 (-0.67, 2.65)[e] | -0.04 (-1.53, 1.46)[f] | ns | 0.09 (-1.50, 1.67)[f] | ns |
| **Perceived fitness** | | | | | |
| Fitness score | 0.10 (-0.04, 0.23) | 0.55 (0.41, 0.68)** | $p < 0.01$ | 0.58 (0.43, 0.73)** | $p < 0.01$ |
| Comparative fitness rating | -0.24 (-0.49, 0.006)[e] | -1.34 (-1.71, -0.97)[e, **] | 0.02 | -1.38 (-1.72, -1.03)[e, **] | 0.02 |
| **Health indicators** | | | | | |
| RDBP (mmHg) | -0.15 (-1.41, 1.12) | -2.67 (-4.15, -1.19)** | 0.04 | -2.34 (-3.83; -0.85)** | 0.03 |
| RSBP (mmHg) | 0.25 (-1.98, 2.47) | -2.05 (-4.69, 0.59) | ns | -2.26 (-5.04; 0.53) | ns |
| BMI ($kg/m^2$) | 0.05 (0.02, 0.08)** | -0.12 (-0.15, -0.096)** | ns | -0.11 (-0.14; -0.08)** | ns |
| Body fat (%) | -0.65 (-0.75, -0.55)** | -1.01 (-1.10, -0.91)** | ns | -1.02 (-1.12; -0.92)** | ns |
| **Performance-based fitness** | | | | | |
| Manual dexterity (s) | -2.58 (-2.99, -2.17)** | -2.10 (-2.59, -1.62)** | ns | -2.21 (-2.72; -1.70)** | ns |
| Reaction time (ms) | -11.3 (-15.5, -7.0)** | -8.9 (-12.2, -5.5)** | ns | -9.3 (-12.9; -5.6)** | ns |
| Functional reach (cm) | 2.06 (1.22, 2.89)** | 1.15 (0.22, 2.07)* | ns | 1.16 (0.20; 2.12)* | ns |
| Grip strength (kgf/kg) | -0.013 (-0.017, -0.0086)** | 0.0034 (-0.0005, 0.0072) | $p < 0.01$ | 0.0056 (0.0015, 0.0096)** | $p < 0.01$ |
| Leg strength (s) | -3.05 (-3.61, -2.50)** | -2.94 (-3.53, -2.36)** | ns | -2.44 (-2.84, -2.05)** | ns |
| Sit-and-reach (cm) | 3.17 (2.81, 3.54)** | 1.57 (1.19, 1.95)** | ns | 1.53 (1.12, 1.94)** | ns |
| Shoulder flexibility (°) | -0.52 (-1.70, 0.66) | -2.04 (-3.11, -0.96)** | ns | -2.02 (-3.20, -0.84)** | ns |
| Walking ($x16^2/3m$) | 2.49 (1.35, 3.63)** | 4.40 (3.17, 5.64)** | ns | 3.56 (2.55, 4.58)** | ns |

[a] *Adjusted for baseline measurement, sex and age.*

[b] *95% Confidence Interval (adjusted for baseline measurement, sex and age).*

[c] *p-value for difference between control group and intervention intention-to-treat group, one-sided.*

[d] *p-value for difference between control group and intervention group consisting of participants who followed more than 50% of the GALM sessions, one-sided.*

*RSA, recreational sports activity; LTPA, leisure-time physical activity; RDBP, resting diastolic blood pressure; RSBP, resting systolic blood pressure; BMI, body mass index; ns, not significant.*

* *Statistical within-group difference paired t-test, $p < 0.05$.*

** *Statistical within-group difference paired t-test, $p < 0.01$.*

[e] *Missing n = 1.*

[f] *Missing n = 2.*

[g] *Missing n = 3.*

[h] *Missing n= 4.*

at 6 months ($F = 3.07$; $p < 0.05$). All indicators of health showed favourable results for the IG, with the between-group difference in diastolic blood pressure reaching statistical significance ($F = 3.35$; $p < 0.05$). Perceived fitness characteristics also showed significant 6-month between-group differences. The fitness score increased by 0.55 in the IG and 0.10 in the CG ($F = 7.06$; $p < 0.01$). By contrast, the mean score on the comparative fitness rating decreased 1.34 in the IG compared to 0.24 in the CG ($F = 4.50$; $p < 0.05$). Performance-based fitness scores showed a significant between-group difference in mean change for grip strength ($F = 7.64$; $p < 0.01$).

**Subgroup analysis**

We performed post-hoc analyses to examine the effects of the intervention group including only those subjects who attended at least 50% of the sessions ($n = 73$) (Table 3). After adjustment for baseline measure, sex and age, comparable within and between-group differences were observed as for the intention-to-treat group.

## Discussion and conclusion

**Discussion**

We evaluated the effects of 6-month participation in the GALM program at the level of physical activity, health and fitness outcomes in sedentary older adults aged 55-65. Participant flow showed high attrition rates (IG, 52% vs. 33%, CG), which could be a threat to the internal validity of our study. The main characteristics at baseline however showed that the recruited older adults were still representative of the average GALM participants.[12,19] Comparison between GALM participants' performance-based fitness and normative data of an average group of Dutch adults aged 55-65 revealed that GALM participants scored on average below mean values of the normative dataset. The average score of the GALM participants on the walking test was clearly below the average norm score, which underlines that our study group was less fit.[27] Comparison between participants who dropped out and those who stayed verified no significant differences in age, sex and all of the outcome measures at baseline. A major reason for the high attrition rate was that this research was conducted in a real community setting and depended highly on practical issues like change of instructors and changes in group size, making it necessary for local project managers to combine groups from different days or times into a new group to make the project feasible.

Many of these practical issues were reasons for participants to drop out of the GALM program, and consequently out of the study. From the process evaluation no selective mechanism could be found for the attrition, since 95% of the participants enjoyed the content of the program activities, 89% valued the intensity of the sessions, 87% thought the level difficulty of the sessions was good and 97% appreciated the instructor.[17] The ecologic validity and generalisability of our study results are high, given that we conducted this study in a real community setting (i.e., the individuals' neighbourhoods).

Increased levels of energy expenditure in RSA and LTPA in both study groups during the initial 6-month period were found. The increase in total energy expenditure ($EE_{RECSPORT}$ and $EE_{LTPA}$ together) of approximately 1000 kcal/week (walking briskly approximately 188 minutes per week) in the IG and 800 kcal/week (walking briskly approximately 156 minutes per week) in the CG is an increase of physical activity that equals promoted amounts of 2 kcal/kg/day for enhancement of health.[20,21] The Community Healthy Activities Model Program for Seniors (CHAMPS II) is one of the few programs that shares similarities with GALM, in that it focuses on older adults, uses a population-based recruitment approach, is lifestyle-oriented and individualised for each person's physical activity interest and abilities (i.e., several physical activities options during one session, adapted materials if necessary). Although baseline estimated caloric expenditures for physical activity were higher in our study, the 6-month changes in estimated energy expenditure for physical activity were comparable with the 12-month changes found in that study.[16] Dunn et al. (1998) reported a significant increase in energy expenditure for moderate-to-hard physical activity (approximately 1.4 kcal/kg/day) after six months of participation in a lifestyle or a structured physical activity program for adults (Project Active).[38] Although these studies show similar responses, caution must be used in comparing their energy expenditure changes with our findings, given that they classified physical activity differently.

The estimated energy expenditure data seem to indicate that the participants on the waiting list (CG) were motivated and prepared to participate in GALM. Although the CG participants were instructed to maintain their regular physical activity pattern, we clearly did not succeed in this intention and they became more active than expected. There are several possible reasons for this: first, the intensive door-to-door recruitment strategy and other forms of attention could have primed CG participants to make changes across the 6-month period. The baseline assessments may

have increased participants' knowledge of healthy behaviour and artificially influenced behaviour, thus confounding results.[39,40] Second, while the IG had more than double the increase in energy expenditure for recreational sports activities relative to the CG, the response variability in both groups made such differences difficult to detect. Third, with the 6-month study period starting in the winter and ending in the summer, seasonal variation may have influenced general physical activity patterns and consequently the absolute changes in estimated energy expenditure.[41,42] The results suggest that control groups other than wait-listed groups — involving e.g. attention-control conditions that provide participants with appealing, non-physical activity information — may be preferred when studying older adults, from an intervention as well as a retention perspective.[43] We recommend the use of a control arm in future studies of this type offering individuals something other than physical activity (e.g. nutrition, general health education) that will satisfy them and prevent them from making gains in the behaviour of interest.

The impact of the increase in physical activity level in both groups was reflected in an increase of most of the health and fitness outcomes. The increases in the health and fitness outcomes in our study are in line with other studies. Similar positive effects of 6 to 24 months of exercise on systolic and diastolic blood pressure as well as body fat percentage as indicators of health are reported.[38,44] Positive effects of exercise interventions on aspects of physical fitness among older adults are also reported in other studies, i.e. gait, balance and mobility,[18,45,46] walking parameters,[45-47] strength, flexibility,[46,47] and endurance.[38] The comparison between control group and intervention group resulted in relatively few significant between-group differences favouring the intervention group (i.e., sleep, diastolic blood pressure, perceived fitness score and grip strength). A logical explanation of why our study did not succeed in finding more significant between-group differences is the increase in total energy expenditure for physical activity for the intervention, but also the control group as described before.

A remarkable result was found for the comparative fitness rating. CG participants showed significantly less deterioration than IG participants; the opposite was true for the perceived fitness score measure at follow-up. The fitness score measured a more general perception of health and fitness without an explicit comparison with age-group peers. Participation in the GALM program seemed to influence this general self-perception of health and fitness condition positively. On the other hand, the comparative fitness

rating included a comparison with peers, i.e. older adults of the same sex and age. By participating in the GALM program, the reference group may have changed from neighbours, friends and family members to active and motivated GALM participants. The change in reference group accompanied by a more realistic view may have influenced the comparative fitness rating in the IG negatively. In other words, participating in the GALM physical activity program corrected the participants' "optimistic bias" which has been reported to increase with age in other older-adult populations.[48]

**Conclusion**

The increases in total energy expenditure for physical activity from the GALM intervention, especially for the more intensive recreational sports activities, look promising and are in line with the expected amounts necessary to improve health.[20,21] Six-month results show significant effects on health and fitness indicators in both groups. Between-group differences are limited though, probably as a result of the significant increase in energy expenditure in the control waiting-list group. Knowing that studies with short follow-up have limitations, as older adults may take longer adaptation time to gain optimal benefit from exercise programs, a longer study follow-up is needed.[21] Further research will be conducted to evaluate how changes in physical activity outcomes and other variables develop after 12 months of participation in GALM and to correct for possible seasonal variations. An additional effectiveness study in which the costs of implementing GALM are compared with effects on morbidity and public health resources would be valuable to determine how effective GALM is in producing health gains at a community-based level.

**Practice Implications**

Our study sheds light on the effects of participation in GALM on the level of physical activity, health and fitness in sedentary and underactive older adults. GALM distinguishes itself from other community-based strategies by way of the neighbourhood-oriented recruitment phase and the recreational sports activity program which is based on behavioural change and evolutionary-biological play theories. Since 1997, over 420,000 older adults have been approached using the GALM recruitment strategy, and approximately 41,000 sedentary and underactive older adults participate in the recreational sports programs. The increases in energy expenditure for physical activity from the GALM intervention, especially for the more intensive recreational

sports activities, look promising and are in line with the expected amounts necessary to improve health. Six-month results show significant effects on most health and fitness outcomes. The results underline the fact that GALM can be considered successful in stimulating leisure-time physical activity and improving health and fitness in older adults.

## References


1. Bouchard C, Shephard RJ, Stephens TS, editors. Physical activity, fitness and health: international proceedings and consensus statement. Champaign, IL: Human Kinetics, 1994.
2. US Department of Health and Human Services. Physical activity and health: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996.
3. American College of Sports Medicine Position Stand. Exercise and physical activity for older adults. Med Sci Sports Exerc 1998;30:992-1008.
4. Backx FJG, Swinkels H, Bol E. How physically (in)active are Dutch adults in their leisure-time? [Eng. Trans]. CBS maandschrift 1994;3:4-11.
5. Urlings IJM, Douwes M, Hildebrandt VH, Stiggelbout M, Ooijendijk WTM. Relative validity of a physical activity questionnaire regarding the "activity guidelines"[Eng. Trans.]. Geneeskunde en Sport 2000;33:17-22.
6. Stevens M, Bult P, De Greef MHG, Lemmink KAPM, Rispens P. GALM: stimulating physical activity in sedentary older adults. Prev Med 1999;29:267-76.
7. Van der Bij AK, Laurant MGH, Wensing M. Effectiveness of physical activity interventions for older adults: a review. Am J Prev Med 2002;22:120-33.
8. Ecclestone NA, Myers AM, Paterson DH. Tracking older participants of twelve physical activity classes over a three year period. J Aging Phys Act 1998;6:70-82.
9. King AC. Interventions to promote physical activity by older adults. J Gerontol A Biol Sci Med Sci 2001;56A:36-46.
10. Bandura A. Social foundations of thought and action. Englewood Cliffs (NJ): Prentice Hall, 1986.
11. Bult P, Rispens P. Learning to move: acquiring versatility in movement through upbringing and education. Maastricht, The Netherlands: Shaker Publishing B.V., 1999, 29-42.

12. Stevens M, Lemmink KAPM, De Greef MHG, Rispens P. Groningen Active Living Model (GALM): stimulating physical activity in sedentary older adults; first results. Prev Med 2000;31:547-53.
13. Stevens M, Lemmink KAPM, Van Heuvelen MJG, De Jong J, Rispens P. Groningen Active Living Model (GALM): stimulating physical activity in sedentary older adults; validation of the behavioral change model. Prev Med 2003;37:561-70.
14. Hurley BF, Hagberg JM. Optimizing health in older persons: aerobic or strength training. Exerc Sport Sci Rev 1998;26:61-89.
15. De Jong J, Stevens M, Lemmink KAPM, De Greef MHG, Rispens P, Mulder T. Background and intensity of the GALM program. J Physical Activity and Health 2005;2:51-62.
16. Stewart AL, Verboncoeur CJ, McLellan BY, Gillis DE, Rush S, Mills KM , et al. Physical activity outcomes of CHAMPS II: a physical activity program for older adults. J Gerontol A Biol Sci Med Sci 2001;56A:465-70.
17. De Jong J, Leibbrand K, Stevens M, De Greef MHG, Lemmink KAPM. The effects of the GALM program on physical activity and other lifestyle characteristics, fitness, health and daily functioning of sedentary and underactive older adults [Eng. Trans.]. Groningen, NL:University of Groningen, 2004, 49-67.
18. Buchner DM, Beresford SAA, Larson EB, LaCroix AZ, Wagner EH. Effects of physical activity on health status in older adults II: intervention studies. Annu Rev Publ Health 1992;13:469-88.
19. Popkema DY, De Greef MHG. Performance-based fitness of sedentary older adults in The Netherlands: an analysis of fitness test results of GALM [Eng. Trans]. Groningen, NL:University of Groningen, 2003.
20. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health: A recommendation from the center for disease control and prevention and the American College of Sports Medicine. J Am Med Assoc 1995;273:02-407.
21. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc 1998;30:975-91.

22. De Jong J, Stevens M, De Greef MHG, Dirks CJ, Haitsma J, Lemmink KAPM, et al. GALM questionnaire to select sedentary seniors: reliability and validity. Med Sci Sports Exerc 1999;31:S379.
23. Voorrips LE, Ravelli AC, Dongelmans PC, Deurenberg P, Van Staveren WA. A physical activity questionnaire for the elderly. Med Sci Sports Exerc 1991;23:974-79.
24. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz Am, Strath SJ, et al. Compendium of physical activities: an update of activity coded and MET intensities. Med Sci Sports Exerc 2000;32:S498-504.
25. Myers AM, Malott OW, Gray E, Tudor-Locke C, Ecclestone NA, O'Brien Cousins S, et al. Measuring accumulated health-related benefits of exercise participation for older adults: the Vitality Plus Scale. J Gerontol Med Sci 1999;54A:456-66.
26. Bruil J, Fekkes M, Vogels T, Verrips E. TAAQOL: a health-related quality of life instrument comprising health-status weighted by the impact of health problems. Int J Behav Med 2002;9:P56.
27. Lemmink KAPM. The Groningen Fitness Test for the Elderly [thesis]. Groningen, NL:University of Groningen, 1996.
28. Van Heuvelen MJG, Kempen GIJM, Ormel J, De Greef MHG. Self-reported physical fitness for performance of older persons: a substitute for performance-based measures of physical fitness? J Aging Phys Act 1997;5:298-310.
29. British Columbia Ministry of Health. PAR-Q validation report. Fitness and amateur sport Canada. Canadian standardized test of fitness (CSTF): operations manual, 1986.
30. Yarows SA, Brooks RD. Measurement variation among 12 electronic home blood pressure monitors. Am J Hypertens 2000;13:276-82.
31. Nuñez C, Gallagher D, Visser M, Pi-Sunyer FX, Wang Z, Heymsfield SB. Bioimpedance analysis: evaluation of leg-to-leg system based on pressure contact foot-pad electrodes. Med Sci Sports Exerc 1997;29:524-531.
32. Lemmink KAPM, Kemper H, De Greef MHG, Rispens P, Stevens M. Reliability of the Groningen Fitness Test for the Elderly. J Aging Phys Act 2001;9:194-212.
33. Lemmink KAPM, Kemper HCG, De Greef MHG, Rispens P, Stevens M. The validity of the sit-and-reach test and the modified sit-and-reach test in middle-aged to older men and women. Res Q Exerc Sport 2003;74:331-36.

34. Lemmink KAPM, Kemper HCG, De Greef MHG, Rispens P, Stevens M. The validity of the circumduction test in elderly men and women. J Aging Phys Activity 2003;11:452-63.
35. Csuka M, McCarty DJ. Simple method for measurement of lower extremity muscle strength. Am J Med 1985;78:77-81.
36. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. J Gerontol Med Sci, 1990;45:M192-97.
37. Whitney SL, Poole JL, Cass SP. A review of balance instruments for older adults. Am J Occup Ther 1998;52:666-71.
38. Dunn AL, Garcia ME, Marcus BH, Kampert JB, Kohl III HW, Blair SN. Six-month physical activity and fitness changes in Project Active, a randomized trial. Med Sci Sports Exerc 1998;30:1076-83.
39. ACT writing group. Effects of physical activity counseling in primary care (The activity counseling trial: a randomized controlled trial). J Am Med Assoc 2001;286:677-87.
40. Atienza AA, King AC. Community-based health intervention trials: an overview of methodological issues. Epidemiol Rev 2002;24:72-79.
41. Matthews CE, Freedson PS, Herbert JR, Stanek III EJ, Merriam PA, Rosal MC, et al. Seasonal variation in household, occupational, and leisure-time physical activity: longitudinal analyses from seasonal variation of blood cholesterol study. Am J Epidemiol 2001;153:172-83.
42. Stevens M, Lemmink KAPM, De Jong J, Heineman K. The effect of the GALM introductory program on daily energy expenditure of older adults aged 55-65 years [Eng. Trans.]. Geneeskunde en Sport 2003;36:170-73.
43. King AC, Friedman R, Marcus B, Castro C, Forsyth L, Napolitano M, et al. Harnessing motivational forces in the promotion of physical activity: the Community Health Advice by Telephone (CHAT) Project. Health Educ Res 2002;17:627-36.
44. Ohkubo T, Hozawa A, Nagatomi R, Fujita K, Sauvaget C, Watanabe Y, et al. Effects of exercise training on home blood pressure values in older adults: a randomized controlled trial. J Hypertens 2001;19:1045-52.

45. Shumway-Cook A, Gruber W, Baldwin M, Liao S. The effects of multidimensional exercises on balance, mobility, and fall risk in community-dwelling older adults. Phys Ther 1997;77:46-57.
46. Sharpe PA, Jackson KL, White C, Vaca VL, Hickey T, Gu J, et al. Effects of a one-year physical activity intervention for older adults at congregate nutrition sites. Gerontologist 1997;37:208-15.
47. King AC, Pruitt LA, Phillips W, Oka R, Rodenburg A, Haskell WL. Comparative effects of two physical activity programs on measured and perceived physical functioning and other health-related quality of life outcomes in older adults. J Gerontol Med Sci 2000;55A:M74-M83.
48. Wilcox S, King AC. Self-favoring bias for physical activity in middle-aged and older adults. J Appl Soc Psychol 2000;30:1773-89.

# Twelve-month effects of the Groningen Active Living Model (GALM) on physical activity, health, and fitness outcomes in sedentary and underactive older adults aged 55-65

## Chapter 5

Johan de Jong
Koen APM Lemmink
Abby C King
Mark Huisman
Martin Stevens

*Patient Education and Counselling 2007;66:167-176*

## Abstract

**Objective**
To determine the effects on energy expenditure, health and fitness outcomes after 12 months of GALM.

**Methods**
Subjects from matched neighbourhoods were assigned to an intervention (IG)($n$ = 79) or a waiting-list control group (CG)($n$ =102). During the 12 months the IG attended two series of 15 moderately intensive GALM sessions once a week and the CG attended one series after a six-month waiting-list period.

**Results**
Significant time effects were found for energy expenditure for recreational sports activities ($EE_{RECSPORT}$), other leisure-time physical activity ($EE_{LTPA}$) and total physical activity ($EE_{TOTAL}$). $EE_{RECSPORT}$ increased over 12 months for both groups while the significant time x group interaction for $EE_{LTPA}$ revealed that the CG continuously increased over 12 months and the IG improved in the first 6 months but decreased from 6 to 12 months. Further significant time effects were found for performance-based fitness but no group effects.

**Conclusions**
Participation in GALM improved $EE_{RECSPORT}$ after 12 months, which was reflected in increases in performance-based fitness. The increase in $EE_{LTPA}$ seemed to be a short-term effect (6 months), which may explain the lack of improvement in other health indicators.

**Practice implications**
To further increase $EE_{LTPA}$, more attention should be paid to behavioural skill-building during the GALM program.

## Introduction

Regular physical activity is regarded as an important component of a healthy lifestyle, decreasing the risk of conditions like cardiovascular disease, non-insulin-dependent diabetes mellitus, hypertension, colon cancer and obesity, and increasing functioning and quality of life in older adults.[1-3] Despite all of these benefits, a substantial segment of the Dutch older adult population remains sedentary or insufficiently physically active. Depending on the definition and measurement method used, approximately 35-80% of Dutch adults aged 55 years and older can be considered physically inactive.[4,5] For this reason, the Groningen Active Living Model Groningen (GALM) was developed. The central aim of GALM was stimulating leisure-time physical activity in sedentary and underactive older adults aged 55-65 years. From a public health perspective, this age range was chosen in light of the above inactivity prevalence data and the fact that this age group could benefit from regular increases in physical activity for many years to come. For further details regarding the GALM strategy, the reader is referred elsewhere.[6]

To assist the maintenance of physical activity in older adults, especially sedentary and underactive older adults, interventions should be tailored to the individual's wishes, preferences, and needs.[7-9] The GALM program has been developed to meet these criteria. Two programs that show similarities with GALM in that they were lifestyle oriented and individualised to the preferences and needs of the participants are the Community Healthy Activities Model Program for Seniors (CHAMPS II) and Project Active.[10,11] The CHAMPS II sample was well educated and the intervention was conducted in a high quality health care setting, reducing the generalisability of the results. A main difference between Project Active and GALM was the mean age of the participants, 46 years vs. 59 years, respectively. The possible effects of a nationally implemented community-based program for sedentary and underactive older adults like GALM on health and fitness has, to our knowledge, not been investigated.

Results after 6-month participation in the GALM program demonstrated significant improvements in health and fitness outcomes in the intervention (IG) as well as in the assessment-control group (CG). Changes in total energy expenditure for physical activity ($EE_{TOTAL}$) were +989 kcal/week and +813 kcal/week in the IG and CG, respectively. Significant between-group differences favouring the IG were obtained for sleep,

diastolic blood pressure, perceived fitness score, and grip strength.[12]

However, it is important to note some limitations of this 6-month study: (1) knowing that older adults may take a longer adaptation time to gain optimal benefit from exercise programs, a longer study follow-up is needed.[13,14]; (2) since the intervention took place in the spring, seasonal influence could have played a role in the 6-month increase in energy expenditure for leisure-time physical activities; (3) the increase in energy expenditure among both groups revealed that the CG participants did not behave as controls but were primed to increase their physical activity levels during their 6-month waiting-list period, probably due to the active door-to-door recruitment and the intensive interview and fitness test measurement procedures. Hence, the aim of this study was to analyse the effects of GALM over a 12-month period on energy expenditure, health, and fitness outcomes as a means of addressing some of the limitations of the 6-month study.

## Method

### Study design and subjects

A group-randomised (cluster) design was used. Five degrees of urbanisation are applied to municipalities in The Netherlands (category 1 to 5) based on the number of people living per square kilometre.[15] In order to represent a good cross-section of the Dutch population, we selected municipalities with different degrees of urbanisation: (1) a highly urbanised municipality (category 1); (2) a middle-level urbanised municipality (category 3); and (3) a rural municipality (category 5). Ultimately, three municipalities representing these different degrees of urbanisation and were geographically spread over The Netherlands were selected. In the fall of 2000, in each municipality, recruitment took place in four neighbourhoods (designated as "neigbourhoods" by local government regulation), of which two were randomly assigned as intervention and two as control neighbourhoods. Ultimately, this resulted in six intervention (IG) and six control (CG) neighbourhoods over the three municipalities. The IG went through the regular GALM strategy and started with the intervention in January 2001. The CG started with the intervention after being placed on a waiting list for six months.[6,12]

The trial was designed to include 144 and 192 subjects in the intervention and control groups, respectively, taking into account a corresponding expected dropout percentage of 20% and 40% with an alpha

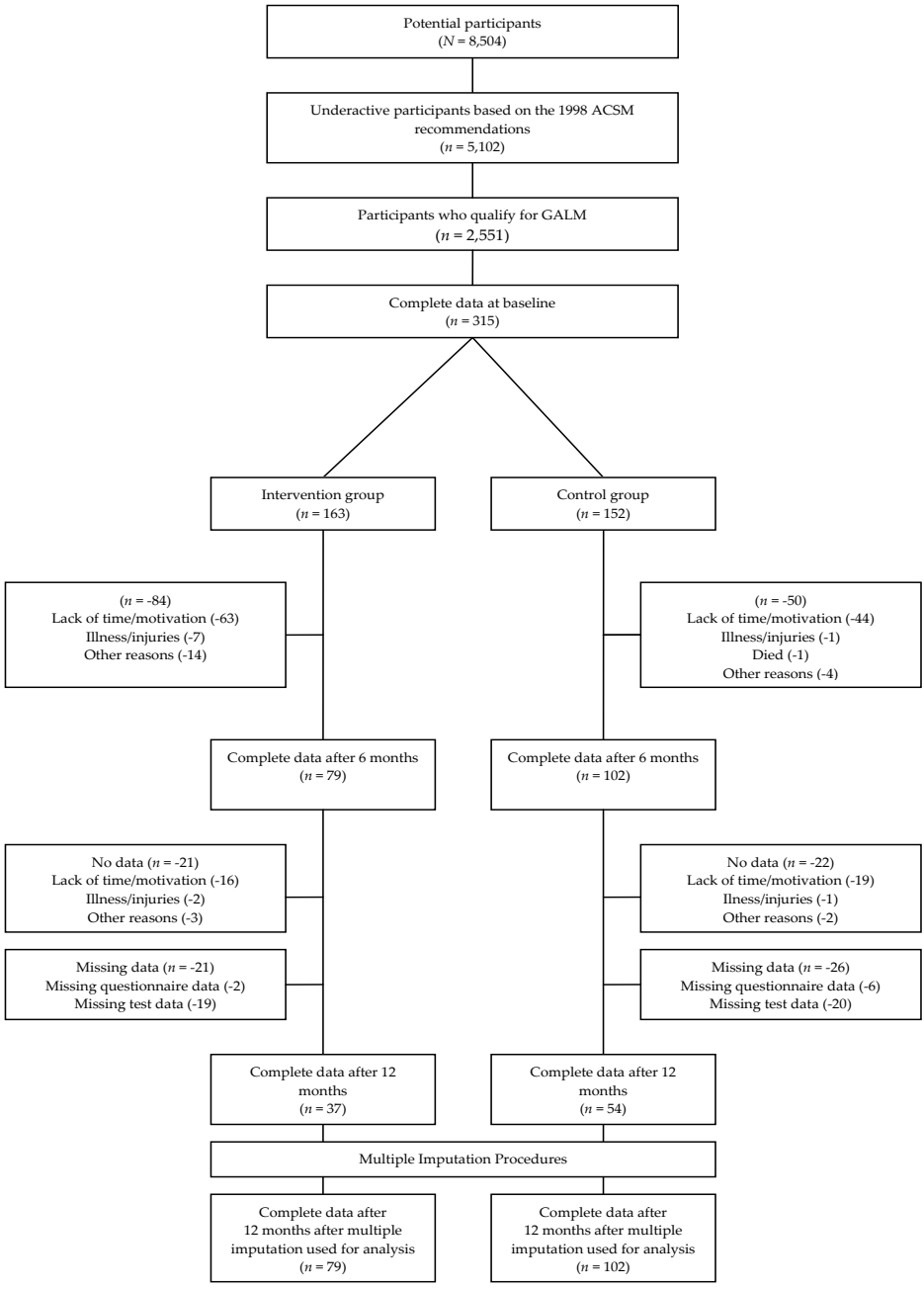



**Figure 1**. Participants flow.

of 5% and a power of 80%. Based on experiences from former GALM projects, a total of 8,504 potential participants were recruited using a targeted strategy to reach the calculated numbers of subjects in the intervention and control groups. During the door-to-door visits, all potential participants were screened using a short questionnaire based on the 1998 ACSM recommendations on exercise and physical activity for older adults.[3,16] According to these recommendations, exercise to increase cardiorespiratory fitness should be performed at least 3 days per week with a duration of at least 20 minutes. Older adults who were physically active at moderate or greater intensity to some extent but did not meet the ACSM 1998 guidelines were considered underactive. Older adults who were completely inactive with respect to physical activity of moderate or greater intensity were considered sedentary.

In this study, no further distinction between both categories was made and both groups were invited to participate in this study. Based on estimates of available population-based data, about 60% ($n$ = 5,102) of the potential participants could be considered either sedentary or underactive according to the 1998 ACSM recommendations.[3] Half of this 60% ($n$ = 2,551) qualified for GALM. The other half was unable to participate for reasons that included illness and personal circumstances, or was not interested in leisure-time physical activity.[6] A total of 315 sedentary and underactive older adults aged 55-65 years, i.e., 12% of the qualified individuals, participated in the baseline measurements; 181 of them (57%) also participated in the 6-month follow-up measurements and were included in this study (Figure 1). The recruitment details of GALM are described in detail elsewhere.[12] Before enrolling in the study, a written informed consent was obtained from each participant. The study protocol was approved by the Medical Ethics Committee of University Medical Center Groningen.

**The GALM program**

The GALM program can be characterised as a leisure-time physical activity program emphasising moderate-intensity recreational sports activities (e.g. softball, dance, self-defence, swimming, and athletics), and consists of fifteen 60-minute sessions at a frequency of once a week, not including holidays.[17] The physical activities conducted were tailored by type, format, intensity, and frequency to meet the preferences and needs of participants. All sessions were conducted in groups of 15-24 participants and were held in a gymnasium located in or near the targeted neighbourhoods to diminish travelling distance and to make use of the neighbourhood-

based social structure. An additional methodological advantage of older adults participating in the GALM program in their own neighbourhood was that it prevented possible contamination between neighbourhoods. During the 12-month study period, the IG immediately started with the GALM program after the recruitment phase and attended two series of 15 sessions (total 30 GALM sessions). The CG was first placed on a waiting-list for 6 months and attended one series of 15 sessions thereafter.

**Measures**

Baseline and follow-up measurements consisted of a questionnaire that was completed at home and a fitness test session. Information about indicators of energy expenditure for physical activity and perceived fitness were collected by way of the questionnaire. The questionnaire data were collected at the end of the GALM program (at 12 months). Within one week after the participants finished their last GALM session, the fitness test sessions were held at a local sports venue. During the test session, indicators of health and performance-based fitness were assessed objectively (see below). All test examiners were students and personnel with a medical or scientific background who completed a one-day course on administering the correct test procedures.

**Estimated energy expenditure**

Two categories of the Voorrips physical activity questionnaire[18] combined with the compendium of physical activities by Ainsworth[19] were used to estimate the energy expenditure for recreational sports activities ($EE_{RECSPORT}$: i.e. swimming, volleyball, cycling, brisk walking, etc.) and other leisure-time physical activities ($EE_{LTPA}$: i.e. gardening, doing odd jobs, walking, and cycling for transportation purposes). Spearman's correlation coefficients between the Voorrips questionnaire and a 24-hour physical activity recall as well as a pedometer (Fitty, Kasper & Richter, Uttenreuth, Germany) as determined in a validation study were 0.78 and 0.72, respectively. The 20-day test-retest reliability coefficient for the questionnaire was 0.89.[18,19]

**Perceived fitness**

Two measures of the perceived fitness questionnaire of the Groningen Fitness Test for the Elderly (GFE) were used: a perceived fitness score and a comparative fitness rating using peers as a frame of reference.[20,21] The original 2-week test-retest reliability of the perceived fitness score was

satisfactory for older men and women (ICC = 0.76, 95% CI = 0.57 to 0.87 vs. ICC = 0.78, 95% CI = 0.66 to 0.86). The 2-week test-retest reliability coefficient of the comparative fitness rating was reported to be 0.94 for older men (95% CI = 0.88 to 0.97) and 0.84 for older women (95% CI = 0.76 to 0.90).[20]

**Health indicators**
Prior to the test session, all participants had their blood pressure measured and completed a modified version of the Physical Activity Readiness Questionnaire (PAR-Q).[22] Participants who had a systolic blood pressure >160 mmHg and/or a diastolic blood pressure >100 mmHg, and/or who answered one or more questions of the PAR-Q affirmatively, had to consult the attending physician. Systolic and diastolic blood pressures were assessed electronically (Omron M4, Omron Corporation, Tokyo, Japan)[23] and Body Mass Index (BMI) was calculated.[1] Body fat was predicted using leg-to-leg bioelectrical impedance analysis (Tanita TBF-300, Tanita Corporation, Tokyo, Japan). This method has been proven to be reliable for measuring body fat percentage, and results have correlated highly with body fat percentages as measured with underwater weighing and dual-energy X-ray absorptiometry in healthy adults.[24]

**Performance-based fitness**
Six test items of the Groningen Fitness Test for the Elderly were used.[20,25] Manual dexterity was measured using the block transfer test. Simple reaction time was assessed by measuring the time the subject needed to react to a visual signal by pushing a button as quickly as possible. The grip strength test was used to measure maximum isometric strength of hand and arm muscles. The sit-and-reach test was conducted to measure flexibility of the hamstrings and lower back. The circumduction test measured shoulder flexibility. The walking test with increasing speed measured aerobic endurance. Subjects walked on a rectangular indoor course. Walking speed was increased by 1 km/h every 3 minutes, starting at a speed of 4 km/h and ending at 7 km/h. Subjects had to keep up the effort as long as possible. The score was the number of completed intervals of $16^2/_3$ m. All test items have proven to be reliable and valid in Dutch older adults.[20,25-27] Additionally, the functional reach and the timed chair-stand tests were administered to measure dynamic balance and leg strength, respectively. Both tests have also proven to be reliable and valid.[28,29]

**Analysis**

The substantial amount of incomplete data over the 12-month study period caused difficulties with respect to analysis of the data. Table 1 shows the percentage of missing data per measurement, which ranged from 28.7% for fitness score to 49.2% for total energy expenditure at 12 months.

A major reason for the high attrition rate was that at each wave, measurement consisted of both a questionnaire and fitness test. In practice, a large number of participants were not tested because they could not participate in the fitness testing. This was due primarily to lack of time or inability to appear at the testing facility unrelated to physical health status. Other reasons for attrition in this study were practical issues that accompany research in a real community setting like change of instructor and change in group size, making it necessary for local project managers to combine groups from different days or times into a new group. Many of these practical issues led some participants to drop out of the GALM program, and consequently out of the study. Comparison of completers and dropouts at baseline showed no significant differences in variables of interest.[12]

A wide range of methods is available to handle missing data (e.g.[30]). In this study, multiple imputation based on the multivariate model[31,32] was used as implemented in the NORM software.[33] This procedure preserves the intention-to-treat principle and provides good results in terms of estimated means and confidence intervals.[30,31,34] Moreover, imputation is more efficient than analyzing complete cases with respect to making full use of the available information and therefore sample size, variance, and standard error calculations. It has the advantage of allowing for the use of straightforward complete-data analysis strategies after imputation and allowing the missing values to be dependent on observed values, using information about existing relations in the multivariate data set to impute missing data.

Imputation procedures are based on the assumption that, given the observed data, missingness is not related to the missing values and does not cause systematic bias. Although this assumption seems plausible in this study, violations have little effect on the analyses of multiply imputed data sets.[35] Moreover, using all observed information in a multivariate normal model, in which the possible dependencies of missingness on observed data are modelled, reduces systematic bias due to non-random missing data.[36,37] Missing values were imputed $M = 10$ times, using the observed scores and estimated relations in the multivariate data set. This resulted in

ten completed, equally plausible versions of the data set. Each of the 10 data sets was then analysed using a standard complete-data procedure, and the results were combined to obtain estimates of effects and standard errors which reflected both sampling variability and the extra uncertainty due to missing data and imputation. The number of $M = 10$ completed data sets was chosen to achieve good efficiency of estimation.[31]

The imputations were based on the multivariate normal model. In an iterative simulation procedure, the missing values were replaced by simulations from the multivariate normal distribution, given the observed values in the data set.[32] The simulated values were obtained by regressing the missing values on the observed scores, where variables at any time point were used as predictors for variables at any other time point. For variables that were not normally distributed, transformations were used to obtain approximate normality. After imputing the incomplete data, the transformed variables were automatically transformed back to their original scales.

**Table 1.** Percentage of missing data per meeasurement.

| | $T_0$ (% missing) | $T_1$ (% missing) | $T_2$ (% missing) |
|---|---|---|---|
| **Estimated energy expenditure for physical activity** | | | |
| - $EE_{RECSPORT}$ (kcal/week) | - | - | 48.1 |
| - $EE_{LTPA}$ (kcal/week) | 0.6 | - | 49.2 |
| - $EE_{TOTAL}$ (kcal/week) | 0.6 | - | 49.2 |
| **Perceived fitness** | | | |
| - Fitness score (1-10) | - | - | 28.7 |
| - Comparative fitness rating (10-50) | 1.1 | - | 29.3 |
| **Health indicators** | | | |
| - RDBP (mmHg) | - | - | 45.3 |
| - RSBP (mmHg) | - | - | 45.3 |
| - BMI (kg/m²) | - | - | 45.9 |
| - Body fat (%) | - | - | 45.3 |
| **Performance-based fitness** | | | |
| - Manual dexterity (s) | - | - | 45.3 |
| - Reaction time (ms) | - | - | 45.3 |
| - Functional reach (cm) | - | - | 45.3 |
| - Grip strength (kgf/kg) | - | - | 45.3 |
| - Leg strength (s) | - | - | 45.3 |
| - Sit-and-reach (cm) | - | - | 45.3 |
| - Shoulder flexibility (°) | - | - | 45.3 |
| - Walking ($x16^{2/3}$ m) | - | - | 45.3 |

T0: baseline measurement.
T1: 6-month measurement.
T2: 12-month measurement.

After imputation, the 10 completed datasets consisting of 181 GALM participants were analysed using MLwiN (2004, 2.01) and SPSS version 10 (SPSS Inc., Chicago IL., 1999). Since we already checked that municipality and neighbourhood were of no significant influence using multilevel

analyses,[12] the subsequent analyses were conducted at study group level using SPSS. Mean values, 95% confidence intervals [95% CI], and time, group and time x group *p*-values were calculated for each health and fitness characteristic. All analyses were conducted using intention-to-treat, with participants analysed according to their initial randomised assignment. Since we performed multiple testing, a probability value of less than 0.01 was considered statistically significant.

## Results

Data from 181 participants were used for analyses. Main characteristics are shown in Table 2 and indicate that the IG and CG were similar at baseline with respect to age, BMI, sex, marital status, level of education, number of chronic diseases, smoking, and alcohol intake. The IG subjects showed an average attendance at the GALM sessions of 80% for the first 6 months and 71% for the next 6 months. The CG had an average attendance rate of 65% for the 6 months of their intervention.

Table 3 presents the mean scores, 95% CI for the IG and CG regarding energy expenditure, health, and fitness outcomes at baseline, after 6 months, and after 12 months, and *p*-values for the main effects for time, group, and the time x group interaction.

**Table 2.** Main characteristics at baseline.

| Characteristics | Intervention group ($n$ = 79) | Control group ($n$ =102) | $F/\chi^2$ | $p$ |
|---|---|---|---|---|
| Age (year) | | | | |
| Mean (*SD*) | 59.6 (2.4) | 58.8 (2.7) | 4.02 | 0.05 |
| Range | 55-65 | 55-65 | | |
| BMI (kg/m²) | | | | |
| Mean (*SD*) | 26.9 (3.2) | 26.8 (3.6) | 0.03 | 0.86 |
| Range | 19.9-35.9 | 20.2-35.8 | | |
| Women (%) | 54.4 | 56.9 | 0.11 | 0.74 |
| Living alone (%)[a] | 17.7 | 19.8 | 0.13 | 0.72 |
| Educational level (%)[b] | | | | |
| Elementary | 43.6 | 33.7 | 5.02 | 0.08 |
| Secondary | 28.2 | 44.5 | | |
| Higher/University | 28.2 | 21.8 | | |
| Number of chronic diseases (%) | | | | |
| 0 | 37.2 | 30.4 | 2.04 | 0.36 |
| 1 or 2 | 34.6 | 45.1 | | |
| >2 | 28.2 | 24.5 | | |
| Smoker (%) | 19.0 | 14.9 | 0.55 | 0.46 |
| Glasses of alcohol per day (%) | | | | |
| 0 | 20.3 | 19.6 | 1.21 | 0.55 |
| 1 or 2 | 72.2 | 76.5 | | |
| >2 | 7.5 | 3.9 | | |

[a] Missing $n$ =1 in control group.
[b] Missing $n$ = 1 in intervention group.

**Energy expenditure for physical activity after 12 months**

The significant main effects for time demonstrated that the energy expenditure outcomes $EE_{RECSPORT}$ and $EE_{TOTAL}$ significantly increased over the 12-month study period ($F = 20.51$; $p < 0.01$ and $F = 24.79$; $p < 0.01$, respectively). The main effect for $EE_{LTPA}$ ($F = 9.17$; $p < 0.01$) revealed that an increase occurred from baseline to 6 months but then stabilised from 6 to 12 months. For $EE_{LTPA}$ a significant time x group interaction was found ($F = 9.70$; $p < 0.01$). Over 12 months, the CG continuously improved in $EE_{LTPA}$ while the IG improved from baseline to 6 months but decreased from 6 to 12 months. Besides these significant time and time x group effects, no main effects for group were found ($p > 0.01$). The changes in energy expenditure for IG and CG are illustrated in Figure 2a-c.

**Health and Fitness Outcomes after 12 months**

Significant main effects for time were found in the fitness score ($F = 23.10$; $p < 0.01$), BMI ($F = 9.90$; $p < 0.01$) and the performance-based fitness outcomes of reaction time ($F = 12.21$; $p < 0.01$), leg strength ($F = 88.67$; $p < 0.01$), sit-and-reach ($F = 14.00$; $p < 0.01$), and walking ($F = 16.19$; $p < 0.01$). All of these time effects were in a favourable direction except for the sit-and-reach, which demonstrated overall improvement from baseline to 6 months but a decrease from 6 to 12 months. A significant time x group interaction was found for the sit-and-reach task ($F = 29.55$; $p < 0.01$) in that the CG continuously improved over time while the IG improved from baseline to 6 months but decreased from 6 to 12 months. No significant main effects for group were found in the health and fitness outcomes ($p > 0.01$).

## Discussion and conclusion

**Discussion**

This study examined the effects of GALM on energy expenditure for physical activity, health, and fitness in sedentary and underactive older adults aged 55-65 years after 12 months of GALM. As in many other longitudinal studies, missing data are of great concern in this study. A wide range of methods is available to handle missing data.[30] In this study, multiple imputation based on the multivariate model was used.[30,32,34] The procedure is based on the assumption that given the observed data, missingness is not related to the missing values and does not cause systematic bias, which is a plausible

**Figure 2a.** $EE_{RECSPORT}$ for the IG and CG over time.

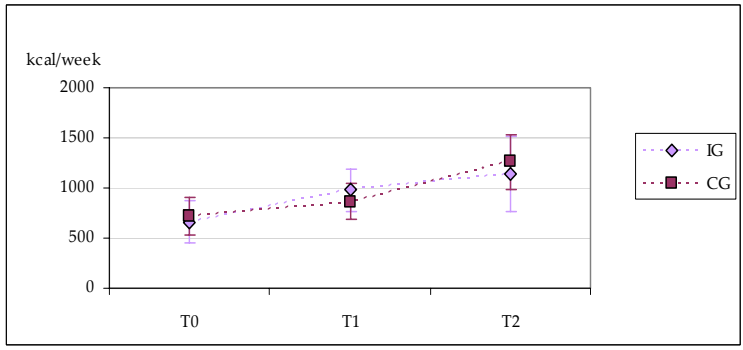



**Figure 2b.** $EE_{LTPA}$ for the IG and CG over time.

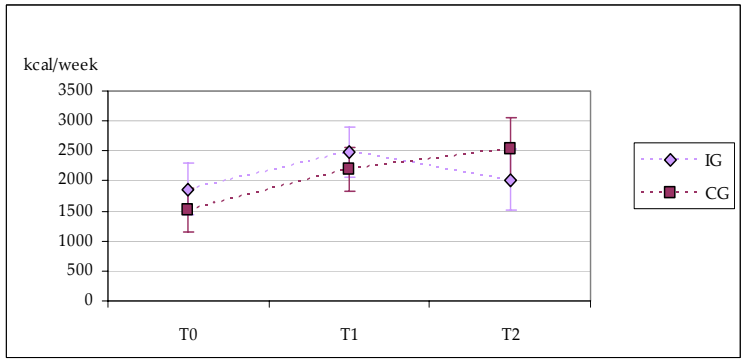
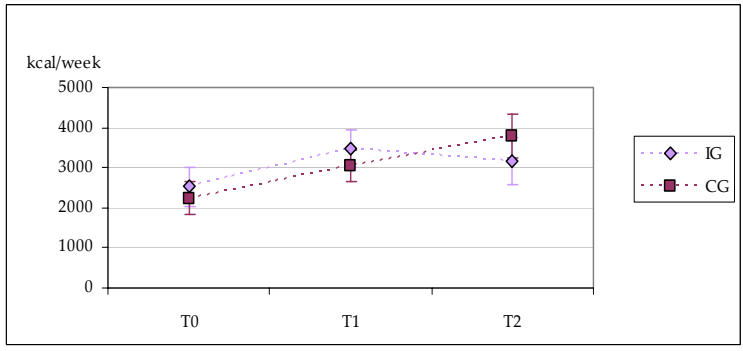



**Figure 2c.** $EE_{TOTAL}$ for the IG and CG over time.



assumption in this study. Moreover, the procedure is fairly robust against violations of this assumption.[35,37] Also, application of the multivariate normal model is appropriate because the variables showed (after transformation) normal distributions.

Apart from the multiply-imputed data sets, the imputation procedure also gives estimated values of the fractions of missing information, which are based on the increase in variance due to missing data and imputation.[31] Fractions of missing information were estimated for each value (means, trends; see Table 3) and ranged from 0.12 to 0.81, the latter indicating a high degree of uncertainty in the estimation. Based on the estimated rates of missing information, the efficiency (in terms of giving the smallest variances) of the imputation procedure could be estimated.[31] Even with fractions of missing information as high as 0.8, the estimated efficiency is at least 96%, increasing to 99% for low fractions. This yields accurate coverage probabilities of confidence intervals.

With respect to energy expenditure for physical activities, significant main effects for time were found for $EE_{RECSPORT}$, $EE_{LTPA}$, and $EE_{TOTAL}$. One time x group interaction was found for $EE_{LTPA}$, indicating that the change over time for this outcome measure was different between the IG and CG. Regarding $EE_{RECSPORT}$, results demonstrated that both the IG and CG increased continuously from baseline to 6 months and from 6 to 12 months. For $EE_{LTPA}$, a different pattern was found in that the IG increased from baseline to 6 months but subsequently decreased from 6 to 12 months. However, the CG continuously increased $EE_{LTPA}$ from baseline to 6 months and from 6 to 12 months. With respect to GALM it can be concluded that the increase in the first 6 months indicated that being assigned to the waiting-list control condition did not stop participants' motivation to prepare to participate in GALM.[12] This priming of CG participants was probably caused by: (a) the intensive door-to-door recruitment strategy; and (b) the baseline interview and fitness test sessions, which may have increased participants' knowledge of healthy behaviour and artificially influenced behaviour.[12,38,39] The further increase in $EE_{LTPA}$ from 6 to 12 months in the CG (+349 kcal/week) could not be explained by seasonal influence since it was the period from autumn to winter. In this period one would expect a decrease instead of an increase in $EE_{LTPA}$ (i.e. gardening, walking, and cycling). Ultimately, the results from this study indicate that no seasonal influence was found with respect to the increases in $EE_{LTPA}$ found after 6 and 12 months.

**Table 3.** Mean for energy expenditure for physical activity, perceived health, perceived fitness, health indicators and performance-based fitness per study group at baseline and after 6 and 12 months.

| | Intervention group ($n$ = 79) | | | Control group ($n$ = 102) | | | Main effect Time | Main effect Group | Time x Group |
|---|---|---|---|---|---|---|---|---|---|
| Characteristics | T0 Mean [95% CI] | T1 Mean [95% CI] | T2 Mean [95% CI] | T0 Mean [95% CI] | T1 Mean [95% CI] | T2 Mean [95% CI] | | | |
| **Energy expenditure for physical activity** | | | | | | | | | |
| - $EE_{RECSPORT}$ (kcal/week) | 657 [446; 869] | 983 [771; 1194] | 1139 [764; 1514] | 715 [ 529; 901] | 867 [680; 1053] | 1261 [991; 1532] | < 0.01 | ns | ns |
| - $EE_{LTPA}$ (kcal/week) | 1863 [1434; 2292] | 2492 [2076; 2907] | 2017 [1508; 2526] | 1520 [1155; 1885] | 2182 [1816; 2547 ] | 2531 [2017; 3044 ] | < 0.01 | ns | < 0.01 |
| - $EE_{TOTAL}$ (kcal/week) | 2520 [2044; 2997] | 3475 [3010; 3939] | 3156 [2574; 3739] | 2235 [1826; 2644] | 3049 [2639; 3457] | 3792 [3231; 4353] | < 0.01 | ns | ns |
| **Perceived fitness** | | | | | | | | | |
| - Fitness Score (1-10) | 6.3 [6.1; 6.4] | 6.8 [6.6; 7.0] | 6.7 [6.5; 6.9] | 6.4 [6.2; 6.5] | 6.5 [6.3; 6.6] | 6.9 [6.7; 7.0] | < 0.01 | ns | ns |
| - Comparative fitness rating (10-50) | 28.6 [28.0; 29.2] | 27.3 [26.7; 27.9] | 27.9 [27.0; 28.8] | 28.3 [27.8; 28.8] | 28.1 [27.6; 28.6] | 27.6 [27.0; 28.2] | ns | ns | ns |
| **Health indicators** | | | | | | | | | |
| - RDBP (mmHg) | 84.8 [83.1; 86.4] | 82.1 [80.4; 83.7] | 86.4 [83.5; 89.3] | 84.1 [82.6; 85.5] | 83.9 [82.5; 85.4] | 85.0 [83.4; 86.7] | ns | ns | ns |
| - RSBP (mmHg) | 144.8 [141.6; 148.0] | 142.8 [139.5; 146.0] | 149.0 [141.3; 156.8] | 144.2 [141.4; 147.1] | 144.5 [141.6; 147.3] | 149.7 [146.1; 153.2] | ns | ns | ns |
| - BMI ($kg/m^2$) | 26.9 [26.8; 27.1] | 26.8 [26.7; 27.0] | 26.9 [26.6; 27.1] | 26.8 [26.7; 27.0] | 26.9 [26.8; 27.0] | 26.5 [26.3; 26.6] | < 0.01 | ns | ns |
| - Body fat (%) | 32.3 [32.0; 32.7] | 31.3 [31.0; 31.6] | 32.7 [32.1; 33.2] | 32.4 [32.1; 32.6] | 31.7 [31.5; 32.0] | 32.4 [32.0; 32.8] | ns | ns | ns |
| **Performance-based fitness** | | | | | | | | | |
| - Manual dexterity (s) | 46.6 [45.8; 47.3] | 44.5 [43.7; 45.2] | 45.9 [44.3; 47.5] | 47.0 [46.4; 47.7] | 44.5 [43.8; 45.1] | 46.2 [45.2; 47.2] | ns | ns | ns |
| - Reaction time (ms) | 219 [214; 224] | 210 [205; 215] | 208 [202; 215] | 227 [223; 231] | 216 [212; 220] | 218 [212; 224] | < 0.01 | ns | ns |
| - Functional reach (cm) | 38.6 [37.6; 39.7] | 39.8 [38.7; 40.8] | 40.2 [38.3; 42.0] | 36.8 [35.8; 37.7] | 38.8 [37.9; 39.7] | 38.4 [37.1; 39.7] | ns | ns | ns |
| - Grip strength (kgf/kg) | 0.497 [0.488; 0.506] | 0.500 [0.491; 0.509] | 0.484 [0.463; 0.506] | 0.492 [0.484; 0.500] | 0.480 [0.472; 0.488] | 0.505 [0.488; 0.522] | ns | ns | ns |
| - Leg strength (s) | 20.0 [19.4; 20.7] | 17.1 [16.4; 17.8] | 17.0 [16.0; 18.0] | 20.5 [19.9; 21.1] | 17.5 [16.9; 18.0] | 16.3 [15.5; 17.1] | < 0.01 | ns | ns |
| - Sit-and-reach (cm) | 29.3 [28.6; 30.0] | 30.9 [30.1; 31.6] | 29.3 [27.8; 30.7] | 26.1 [25.4; 26.7] | 29.2 [28.6; 29.9] | 29.5 [28.7; 30.2] | < 0.01 | ns | < 0.01 |
| - Shoulder flexibility (°) | 48.7 [47.2; 50.1] | 46.6 [45.1; 48.1] | 49.1 [46.9; 51.3] | 48.9 [47.6; 50.1] | 48.3 [47.0; 49.6] | 51.2 [49.5; 52.9] | ns | ns | ns |
| - Walking ($x16^2/3m$) | 50.8 [49.2; 52.5] | 55.2 [53.6; 56.9] | 55.2 [52.9; 57.5] | 51.4 [49.9; 52.8] | 53.9 [52.4; 55.3] | 54.8 [52.5; 57.1] | < 0.01 | ns | ns |

T0: baseline measurement; T1: 6-month measurement; T2: 12-month measurement.

RECSPORT: recreational sports activity; LTPA: leisure-time physical activity; RDBP: resting diastolic blood pressure; RSBP: resting systolic blood pressure; BMI: body mass index.

ns: not significant.

Finally, regarding $EE_{TOTAL}$, the results demonstrate that the IG increased from baseline to 6 months and decreased from 6 12 months, reflecting the same pattern as found for $EE_{LTPA}$. Although different definitions and measurement methods for physical activity were used, the decline in $EE_{TOTAL}$ ($EE_{RECSPORT}$ + $EE_{LTPA}$) was comparable to the decline in physical activity level found in the 24-month effects of Project Active. In that study, increases in physical activity (including moderate, hard, and very hard activities) were found after 6 months, but from 6 to 24 months a decline occurred in both the lifestyle and structured intervention group (0.7 and 0.8 kcal/kg per day, respectively).[11] It also appeared that some sort of shift or compensation in activity pattern occurred in the IG, which is reflected in both $EE_{LTPA}$ and $EE_{TOTAL}$. The increase in $EE_{RECSPORT}$ from baseline to 6 months (+326 kcal/week) could be explained by participation in the GALM program. However, the further increase in $EE_{RECSPORT}$ from 6 to 12 months, although small (+156 kcal/week), suggests that the IG participants also became more active in recreational sports activities outside GALM but compensated for this by decreasing their leisure-time physical activity level ($EE_{LTPA}$)(475 kcal/week). This phenomenon has been observed in some other exercise intervention studies which also found that elderly subjects compensated for exercise training by a decline in spontaneous physical activity.[40-42]

When focusing on the significant time and time x group effects for the health and fitness outcomes after 12 months, the increase in energy expenditure for physical activities was reflected in significant main effects for time in fitness score, BMI, and the performance-based fitness outcomes of reaction time, leg strength, sit-and-reach, and walking, which were all in the favourable direction except for the sit-and-reach. However, contrary to the positive health effects after 6 months of GALM, in the current investigation, all health indicators changed in unfavourable directions from 6 to 12 months with the exception of BMI. Our findings are in contrast with results from other studies that did find a lowering of blood pressure effect in elderly subjects after aerobic training and decreased percentage of body fat after lifestyle and structured interventions. The interventions conducted in those studies laid more emphasis on aerobic sessions, though (i.e., walking, running).[11,43,44] To lower blood pressure, BMI, and body fat, it is recommended to use programs that are at least of moderate intensity and of longer duration, with the health benefits of physical activity strongly linked to the total amount of activity.[2,13,14,45] Plausible explanations for not finding positive health changes after 12 months of GALM may be: first, the different nature of the GALM program

relative to these other interventions in the field. Since GALM is not an intensive aerobic exercise-based training program but a moderately intense multi-dimensional program, the likelihood of demonstrating such health effects may be reduced. Toraman et al. (2004), who also investigated the effects of a multicomponent 9-week training program on functional fitness in older adults, found increased upper and lower body strength, aerobic endurance, and agility/dynamic balance, but there was no effect on body composition.[46] In the multidimensional GALM program, motor qualities (i.e., strength, speed, endurance, flexibility, and coordination) are trained using motor actions (i.e., running, jumping, batting, throwing, and catching),[17] and in that light it is more realistic to expect changes in performance-based fitness measures that are "trained" according to the specificity principle.[47] Additionally, the moderate intensity of the GALM program may also be a reason for finding effects mainly in performance-based fitness measures.[17] Brach et al. (2004), in their study of the association between lifestyle activity throughout the day and moderate-intensity exercise and physical function in older adults, argued that participants in higher-intensity activities had better physical function than individuals who participated in lower-intensity activity.[48] Second, it is possible that the once-a-week frequency of the GALM program did not contribute sufficiently to the total amount of physical activity to positively influence health indicators in the long term. Third, the 6-month increase for $EE_{LTPA}$ found in the IG did not continue and even decreased from 6 to 12 months. This insufficient maintenance effect of GALM in increasing total amounts of moderately intense physical activity in the long term resulted in no positive changes in health indicators after 12 months of GALM, except for BMI.

Finally, it is important to note some limitations of this 12-month study: (1) because the CG did not behave as controls during the 6-months waiting-list period, this weakened the comparison between IG and CG; and (2) since this study was conducted in natural community settings as opposed to in a laboratory, the generalisability was high while the internal validity was less strong, indicating that the study results should be interpreted with caution. However, this study is one of the few studies that provides information of a community-based strategy targeting older sedentary and underactive older adults, a group that especially can profit from physical activity.

**Conclusion**

The results from this investigation indicate that GALM improved $EE_{RECSPORT}$ in the long term (12 months) and $EE_{LTPA}$ in the short term (6 months). Probably as a result of the increase in more intensive recreational sports activity levels, most of the significant increases over time were found in performance-based fitness but no clear improvements in other health outcomes were generally observed.

**Practice Implications**

This study provides information on the effects of a broadly implemented community-based strategy for stimulating leisure-time physical activity in sedentary and underactive older adults. Based on 6- and 12-months effects of GALM, our findings suggest that GALM had a stimulating effect on the more intensive recreational sports activities that were targeted by the intervention, but was less effective in stimulating other leisure-time physical activities. The positive impact of increasing recreational sports activities was mainly reflected in positive trends in performance-based fitness but not in other measured health outcomes.

An important finding from our study was that the intensive door-to-door recruitment strategy may have primed GALM participants to increase their level of other leisure-time physical activities in the short term (6 months) but not in the long term (12 months). These elements may be valuable ingredients that could be integrated in the first phase of future community-based strategies for stimulating physical activity in sedentary and underactive older adults. To further increase the level of recreational sports and other leisure-time physical activity levels of the participants in the long term, we advise increasing the frequency of GALM sessions from once to twice (or more) a week, and lay more emphasis on behavioural skill-building during the GALM program as well as providing instruction on how to increase other aspects of $EE_{LTPA}$ parallel to participation in the program. Suggestions for this could be include guided individualised goal-setting, regular self-monitoring of targeted activities, and reinforcement for reaching goals, in addition to skills training to increase physical activity in the GALM sessions.

## References


1. Bouchard C, Shephard RJ, Stephens TS, editors. Physical activity, fitness and health: international proceedings and consensus statement. Champaign, IL: Human Kinetics, 1994.
2. US Department of Health and Human Services. Physical activity and health: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996.
3. American College of Sports Medicine Position Stand. Exercise and physical activity for older adults. Med Sci Sports Exerc 1998;30:992-1008.
4. Hildebrandt VH, Ooijendijk WTM, Stiggelbout M, Hopman-Rock M. Trendrapport bewegen en gezondheid 2002/2003. Hoofddorp/ Leiden: TNO, 2004.
5. Centraal Bureau voor de Statistiek (CBS). Persbericht PB06-034. Voorburg, NL: CBS, 2006.
6. Stevens M, Bult P, De Greef MHG, Lemmink KAPM, Rispens P. GALM: stimulating physical activity in sedentary older adults. Prev Med 1999;29:267-76.
7. Van der Bij AK, Laurant MGH, Wensing M. Effectiveness of physical activity interventions for older adults: a review. Am J Prev Med 2002;22:120-33.
8. Ecclestone NA, Myers AM, Paterson DH. Tracking older participants of twelve physical activity classes over a three year period. J Aging Phys Act 1998;6:70-82.
9. King AC. Interventions to promote physical activity by older adults. J Gerontol A Biol Sci Med Sci 2001;56A:36-46.
10. Stewart AL, Verboncoeur CJ, McLellan BY, Gillis DE, Rush S, Mills KM, et al. Physical outcomes of CHAMPS II: a physical activity program for older adults. J Gerontol A Biol Sci Med Sci 2001;56A:465-70.
11. Dunn AL, Marcus BH, Kampert JB, Garcia ME, Kohl III, Blair SN. Comparison of lifestyle and structured intervention to increase physical activity and cardiorespiratory fitness. J Am Med Assoc 1999;281:327-34.

12. De Jong J, Lemmink KAPM, Stevens M, De Greef MHG, Rispens P, King AC, et al. Six-month effects of the Groningen Active Living Model (GALM) on physical activity, health and fitness outcomes in sedentary and underactive older adults aged 55-65. Patient Educ Couns 2006;62:132-41.
13. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. J Am Med Assoc 1995;273:402-7.
14. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc 1998;30:975-91.
15. Centraal Bureau voor de Statistiek (CBS), 2006. Available from http://www.cbs.nl/nl-/menu/_unique/_search/default.htm?querytxt=urbanisatiegraad.
16. De Jong J, Stevens M, De Greef MHG, Dirks CJ, Haitsma J, Lemmink KAPM, et al. GALM questionnaire to select sedentary seniors: reliability and validity. Med Sci Sports Exerc 1999;31:S379.
17. De Jong J, Stevens M, Lemmink KAPM, De Greef MHG, Rispens P, Mulder T. Background and intensity of the GALM physical activity program. J Phys Act Health 2005;2:51-62.
18. Voorrips LE, Ravelli AC, Dongelmans PC, Deurenberg P, Van Staveren WA. A physical activity questionnaire for the elderly. Med Sci Sports Exerc 1991;23:974-79.
19. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz Am, Strath SJ, et al. Compendium of physical activities: an update of activity coded and MET intensities. Med Sci Sports Exerc 2000;32:S498-504.
20. Lemmink KAPM. The Groningen Fitness Test for the Elderly [thesis]. Groningen, NL: University of Groningen, 1996.
21. Van Heuvelen MJG, Kempen GIJM, Ormel J, De Greef MHG. Self-reported physical fitness for performance of older persons: a substitute for performance-based measures of physical fitness? J Aging Phys Act 1997;5:298-310.

22. British Columbia Ministry of Health. PAR-Q validation report. Fitness and amateur sport Canada. Canadian standardized test of fitness (CSTF): operations manual, 1986.
23. Yarows SA, Brooks RD. Measurement variation among 12 electronic home blood pressure monitors. Am J Hypertens 2000;13:276-82.
24. Nuñez C, Gallagher D, Visser M, Pi-Sunyer FX, Wang Z, Heymsfield SB. Bioimpedance analysis: evaluation of leg-to-leg system based on pressure contact foot-pad electrodes. Med Sci Sports Exerc 1997;29:524-31.
25. Lemmink KAPM, Kemper H, De Greef MHG, Rispens P, Stevens M. Reliability of the Groningen Fitness Test for the Elderly. J Aging Phys Act 2001;9:194-12.
26. Lemmink KAPM, Kemper HCG, De Greef MHG, Rispens P, Stevens M. The validity of the sit-and-reach test and the modified sit-and-reach test in middle-aged to older men and women. Res Q Exerc Sport 2003;74:331-6.
27. Lemmink KAPM, Kemper HCG, De Greef MHG, Rispens P, Stevens M. The validity of the circumduction test in elderly men and women. J Aging Phys Act 2003;11:452-63.
28. Csuka M, McCarty DJ. Simple method for measurement of lower extremity muscle strength. Am J Med 1985;78:77-81.
29. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. J Gerontol Med Sci, 1990;45:M192-7.
30. Wood AM, White IR, Hillsdon M, Carpenter J. Comparison of imputation and modelling methods in the analysis of a physical activity trial with missing outcomes. Int J Epidemiol, 2005;34:89-99.
31. Rubin DB. Multiple imputation for nonresponse in surveys. New-York: John Wiley & Sons, Inc, 1987.
32. Schafer JL. Analysis of incomplete multivariate data. London: Chapman & Hall, 1997.
33. Schafer, JL. NORM: multiple imputation of incomplete multivariate data under a normal model, version 3, 2000. Available from http://www.stat.psu.edu/~jls/misoftwa.html.
34. Tang L, Song J, Belin TR, Unützer J. A comparison of imputation methods in a longitudinal randomized clinical trial. Stat Med 2005;24:2111-28.

35. Collins, LM, Schafer JL, Kam CM. A comparison of inclusive and restrictive strategies in modern missing procedures. Psychol Methods 2001;6:330-51.
36. Rubin DB, Stern HS, Vehovar V. "Handling don't know" survey responses: the case of the Slovenian plebiscite. J Am Stat Assoc 1995;90:822-8.
37. Schafer JL. Multiple imputation in multivariate problems when the imputation and analysis model differ. Stat Neerl;2003:19-35.
38. ACT writing group. Effects of physical activity counseling in primary care (The activity counseling trial: a randomized controlled trial). J Am Med Assoc 2001;286:677-87.
39. Atienza AA, King AC. Community-based health intervention trials: an overview of methodological issues. Epidemiol Rev 2002;24:72-79.
40. Goran MI, Poehlman ET. Endurance training does not enhance total energy expenditure in healthy elderly persons. Am J Physiol 1992;263:E950-7.
41. Morio B, Montaurier C, Pickering G, Ritz P, Fellmann N, Coudert J, et al. Effects of 14 weeks of progressive endurance training on energy expenditure in elderly people. Br J Nutr 1998;80:511-9.
42. Meijer EP, Westerterp KR, Verstappen FTJ. Effect of exercise training on total daily physical activity in elderly humans. Eur J Appl Physiol 1999;80:16-21.
43. Cox KL, Burke V, Morton AR, Gillam HF, Beiling LJ, Puddey IB. Long-term effects of exercise on blood pressure and lipids in healthy women aged 40-65 years: the sedentary women exercise adherence trial (SWEAT). J Hypertens 2001;19:1733-43.
44. Okhubo T, Hozawa A, Nagatomi R, Fujita K, Sauvaget C, Watanabe Y et al. Effects of exercise training on home blood pressure values in older adults: a randomized controlled trial. J Hypertens 2001;19:1045-52.
45. Oja P. Dose response between total volume of physical activity and health and fitness. Med Sci Sports Exerc 2001;33:S428-37.
46. Toraman NF, Erman A, Agyar E. Effects of multicomponent training of functional fitness in older adults. J Aging Phys Act 2004;12:538-53.

47. McArdle WD, Katch FI, Katch VL. Exercise physiology: energy, nutrition, and human performance. Philadelphia/London, Lea & Febiger, 1991.
48. Brach JS, Simonsick EM, Krichevsky S, Yaffe K, Newman AB. The association between physical function and lifestyle activity and exercise in the health, aging and body composition study. J Am Geriatr Soc 2004;52:502-9.

# Decrease in heart rate after longitudinal participation in the Groningen Active Living Model (GALM) recreational sports program

## Chapter 6

Johan de Jong
Koen APM Lemmink
Erik Scherder
Roy Stewart
Abby C King
Martin Stevens

*Accepted pending revisions Journal of Sports Sciences 2008*

## Abstract

**Objective**
To investigate changes in heart rate at submaximal exercise as an index of cardiovascular function in sedentary and underactive older adults participating in the GALM program.

**Method**
A repeated measurement design was conducted and 151 participants were included, providing 398 heart rate files over a period of 18 months of GALM. Multilevel analyses were conducted and a growth and final model containing a time variable and the covariates of sex, BMI, energy expenditure for recreational sports activity ($EE_{RECSPORT}$), and leisure-time physical activity ($EE_{LTPA}$) were developed.

**Results**
Significant decreases in mean heart rate over time appeared for all walking speeds. The covariates of sex and BMI were significantly related to mean heart rate at each walking speed, except for BMI at 7 km/h. No significant relations between $EE_{RECSPORT}$, $EE_{LTPA}$ and mean heart rate occurred, except for $EE_{LTPA}$ at 7 km/h. From baseline to T4 decreases in predicted mean heart rate were 5.5, 6.0, 10.0 and 9.0 beats/min at walking speeds of 4, 5, 6 and 7 km/h, and relative decreases ranged from 5.1 to 7.4%.

**Conclusions**
A significant decrease in heart rate during submaximal exercise was found, reflecting an increase in cardiovascular function after 18 months of participation in GALM

## Introduction

Regular exercise and physical activity have proven to contribute to a healthier lifestyle among older adults, the fastest-growing segment in the European and Dutch society.[1] In addition to the health benefits of physical activity, important objectives for older adults are maintaining or improving cardiovascular function and the ability to perform activities of daily living independently.[2-4]

Cardiovascular function can be maintained or improved by aerobic exercise programs and can be reflected in a variety of variables, including cardiac output, arteriovenous $O_2$ difference and $VO_2$max. Aerobic exercise also enhances submaximal performance in older adults.[3-5]

A component which reflects cardiovascular function and is highly relevant for older adults is maximal oxygen consumption ($VO_2$max). $VO_2$max decreases 5 to 15% per decade after the age of 25 and is caused by both maximal cardiac output and arteriovenous oxygen difference. This decline is significantly accelerated by a sedentary lifestyle. Various reports show that with prolonged endurance (aerobic) exercise training, older adults elicit the same 10-30% increase in $VO_2$max as younger adults.[3] The magnitude of the increase in $VO_2$max in older adults is also a function of training intensity, with light-intensity training eliciting minimal or no changes vs. high-intensity exercise. Increased levels of $VO_2$max also means that submaximal exercise becomes lighter (i.e. easier to undertake) and declines in heart rate appear at submaximal exercise. Hence it has become widely accepted that heart rates during steady-state submaximal exercise at the same absolute rate of work are substantially reduced due to aerobic exercise training. Reduction in heart rate at fixed submaximal exercise over time is thus an objective and relevant indicator for change in cardiovascular function in older adults.[5]

Until now, most research with respect to the effects of exercise on cardiovascular function has been conducted in endurance (aerobic) exercise programs which primarily or only contained one mode of activity (e.g. running, walking). For that the aim of this study is to investigate whether a versatile exercise program is also capable and effective in improving cardiovascular function in older adults. Therefore the longitudinal changes in heart rate during submaximal exercise as an index of cardiovascular function after 18 months of participation in the Groningen Active Living Model (GALM) recreational sports program will be determined.

GALM is a behavioural change intervention aimed at stimulating leisure-time physical activity in sedentary and underactive older adults aged 55-65.[6,7].

## Methods

### Participants and procedures

A study into the effects of participation in the GALM recreational sports program was conducted in 2000-2003 in The Netherlands. A group-randomized (cluster) design was used. A total of 8,504 older adults aged 55-65 in three Dutch municipalities received written information and were visited door-to-door to screen to identify those who could be considered sedentary or underactive. Based on estimates of population-based data, about 60% ($n$ = 2,551) qualified for GALM. The other 40% were unable to participate due to personal circumstances (e.g. nursing, work, illness) or lack of interest in leisure-time physical activity.[6] A total of 315 sedentary and underactive older adults (12% of qualified individuals) participated in the baseline measurements; 181 of them (57%) also participated in the follow-up measurements and were included in this study.[8]

Over a period of two years, 181 adults were measured after each series of 15 GALM classes: December 2000 (T0), May 2001 (T1), December 2001 (T2), May 2002 (T3) and December 2002 (T4). Data of 28 older adults who used medication for cardiac rhythm problems were excluded. No heart rate files were collected for two participants. Among 151 participants we collected 428 heart rate files, 30 (7%) of which were too damaged for further use. Ultimately 398 heart rate files were used for analyses: the heart rate of 5 older adults was monitored on all five occasions (25 heart rate files), 27 participants were monitored on four occasions (108 heart rate files), 45 participants on three occasions (135 heart rate files), 56 participants monitored on two occasions (112 heart rate files), and 18 participants on one occasion (18 heart rate files). Testing personnel were students with a medical or scientific background who were trained in the test procedure. The study protocol was approved by the Medical Ethics Committee of University Medical Center Groningen.

### The GALM recreational sports program

The GALM recreational sports program can be characterized as a versatile leisure-time physical activity program that emphasizes moderate-intensity recreational sports activities (e.g. softball, dance, self-defence, swimming,

athletics), and consists of fifteen 60-min sessions at a frequency of once a week. For a period of two years, participants attended three 15-session series. The control group was placed on a waiting-list for 6 months before starting. For reasons of program homogeneity, the instructors followed a scheme that prescribed the recreational sports activities and routines per GALM sessions.[7]

**Measurements**

The walking test with increased speed for the Elderly (WISE) was used. WISE is a performance-based field test that measures walking performance as an indicator of aerobic capacity. Participants walked on a rectangular indoor course and walking speed was paced using audio signals from a CD player. Walking speed was increased by 1 km/h every 3 minutes, starting at a speed of 4 km/h and ending at 7 km/h.[9] Participants had to walk one test round to become familiar with the procedure before starting the test. During the WISE, all older adults wore a Polar heart rate monitor (Accurex model, Polar Electro, Tampere, Finland). A 15-s interval was used for heart rate recording, which was synchronized with the starting audio signal from the CD player. At each walking speed the last 4 heart rate samples (last minute) were averaged, thus obtaining steady state mean heart rate values at walking speeds of 4 km/h (HR4), 5 km/h (HR5), 6 km/h (HR6), and 7 km/h (HR7).

Energy expenditure for recreational ($EE_{RECSPORT}$: i.e. swimming, volleyball, cycling, brisk walking) and leisure-time physical ($EE_{LTPA}$: i.e. gardening, doing odd jobs, walking and cycling for transportation purposes) were estimated by using two categories of the Voorrips physical activity questionnaire combined with the Compendium of Physical Activities.[10,11] Body mass index (BMI) was calculated from height and weight, and body fat was predicted using leg-to-leg bioelectrical impedance analysis (Tanita TBF-300, Tanita Corporation, Tokyo).[12]

**Statistical analyses**

Data were analyzed using SPSS version 14.0 (SPSS Inc., Chicago, 2005) and MlwiN (2005, 2.02). Besides the advantage of multilevel analysis taking into account possible clustering effects, another benefit deserves mentioning: the flexibility to deal with unbalanced data structures, e.g. repeated-measures data where data for some individuals is incomplete. Even individuals with only one measurement needn't be deleted even though they contribute only

little information, as this makes it very suitable for analyzing longitudinal data.[13]

Based on a previous analysis, the expectation could be no significant difference between intervention and control group.[14] Before starting the multilevel analysis, we first confirmed this assumption of no significant between-group difference ($p > 0.05$). We therefore considered all participants as one study group for further analysis.

In the present study a two-level hierarchy was defined, with the repeated measurements (defined as level-1 units) nested within adults (level-2 units).[13,15] The first step in the multilevel modelling of heart rate at submaximal intensity exercise was to model a growth model (model 1) consisting of an initial status and the time variable (time). Subsequently, relevant covariates (sex, BMI, $EE_{RESPORT}$, $EE_{LTPA}$) were added to the final model (model 2). *P*-values lower than 0.05 were considered statistically significant.

## Results

Data from 151 participants were used for analyses. Table 1 presents the main characteristics of the participants at baseline. Forty-two percent of the participants were men and the average age of the total group was 59.2 years. Mean program attendance rates were 74%, 72%, and 69% after 6, 12 and 18 months, respectively.

**Table1.** Main characteristics at baseline (mean ± *SD*)

| Characteristics | Men ($n = 64$) | Women ($n = 87$) | Total ($N = 151$) |
|---|---|---|---|
| Age (years) | 59.0 (2.6) | 59.3 (2.6) | 59.2 (2.6) |
| BMI[a] (kg/m$^2$) | 27.0 (3.4) | 26.6 (3.5) | 26.8 (3.4) |
| Body fat (%) | 25.0 (5.4) | 38.1 (5.4) | 32.5 (5.4) |

[a]*Body mass index.*

At baseline the mean heart rates per walking speed were 105 (± 15.0) beats/min at 4 km/h, 118 (± 17.6) beats/min at 5 km/h, 135 (± 19.3) beats/min at 6 km/h1 and 155 (± 15.5) beats/min at 7 km/h, respectively (Table 2). This resulted in relative heart rates of 63.5%, 71.4%, 81.7% and 93.8% of predicted heart rate maximum, respectively (not presented).[16]

**Table 2.** Mean heart rate values (beats/min) per walking speed from T0 to T4.

| | T0[a] Mean ± *SD* (*n*) | T1[a] Mean ± *SD* (*n*) | T2[a] Mean ± *SD* (*n*) | T3[a] Mean ± *SD* (*n*) | T4[a] Mean ± *SD* (*n*) |
|---|---|---|---|---|---|
| $HR_4$[b] | 105 ± 15.0 (122) | 104 ± 15.0 (133) | 99.9 ± 15.3 (72) | 101 ±15.2 (49) | 102 ± 15.3 (22) |
| $HR_5$[b] | 118 ± 17.6 (122) | 115 ± 17.2 (132) | 111 ± 17.9 (72) | 112 ±17.2 (49) | 113 ± 18.6 (22) |
| $HR_6$[b] | 135 ± 19.3 (94) | 131 ± 17.6 (118) | 125 ± 20.2 (63) | 125 ± 19.0 (43) | 128 ± 20.4 (22) |
| $HR_7$[b] | 155 ± 15.5 (46) | 148 ± 15.0 (63) | 144 ± 20.2 (38) | 143 ± 20.2 (29) | 147 ± 21.4 (17) |

*[a]T0-T4: baseline to fourth follow-up measurements; [b]$HR_4$ to $HR_7$: heart rate at walking speed 4 km/h to 7 km/h.*

Table 3 illustrates the multilevel models that were obtained per walking speeds of 4, 5, 6, and 7 km/h, respectively. For each walking speed a growth model (model 1) and a final model (model 2) with the relevant covariates of sex, BMI, $EE_{RECSPORT}$, and $EE_{LTPA}$ was calculated. In all final models (model 2) significant main effects for time ($p < 0.01$), sex ($p < 0.001$), and BMI ($p < 0.05$) appeared at all walking speeds, except for BMI at 7 km/h. No interactions were found for sex x time and BMI x time ($p > 0.05$). Furthermore, no significant main effects were found for $EE_{RECSPORT}$ and $EE_{LTPA}$ ($p > 0.05$), except for $EE_{LTPA}$ at walking speed 7 km/h ($p < 0.01$). Finally, the residual variances derived from model 1 Table 3 showed that the residual variances for between-individuals (level 2) were about twice as big (0.55-0.72) as for within-individuals (level 1) (0.28-0.45) (not presented).

Equations that predicted the development of mean heart rate per walking speed over time of older adults participating in GALM were derived from the final model, shown in Table 3. Only those covariates (sex, BMI) that were significantly associated with heart rate were included in the equations.

Equations:
HR4 = 108.20 (1.47) - 1.05 (0.41) x time - 12.07 (2.00) x sex + 0.84 (0.28) x BMI
HR5 = 122.23 (1.64) - 1.41 (0.46) x time - 16.08 (2.23) x sex + 1.04 (0.31) x BMI
HR6 = 141.08 (1.90) - 2.47 (0.51) x time - 18.18 (2.50) x sex + 0.93 (0.37) x BMI
HR7 = 164.49 (2.82) - 3.20 (0.76) x time - 16.78 (3.18) x sex + 0.62 (0.48) x BMI

With these equations the development of mean heart rate (HR) per walking speed over time could be predicted when the variables time (0-4, baseline to

**Table 3.** The growth (model 1) and the final multilevel model (model 2) per walking speed.

| **Walking speed 4 km/h** | | **Model 1** | | | **Model 2** | |
|---|---|---|---|---|---|---|
| **Fixed effects** | **Coefficient** | ***SE*[a]** | ***p*-value[b]** | **Coefficient** | ***SE*[a]** | ***p*-value[b]** |
| Constant | 104.69 | 1.22 | | 107.45 | 1.56 | |
| Time[c] (0-4) | -1.25 | 0.42 | <0.01 | -1.21 | 0.46 | <0.01 |
| Sex[d] (0-1) | | | | -12.63 | 2.04 | <0.001 |
| BMI[e] (kg/m²) | | | | 0.85 | 0.28 | <0.01 |
| $EE_{RECSPORT}$[f] (kcal/week) | | | | 0.00041 | 0.00056 | n.s |
| $EE_{LTPA}$[g] (kcal/week) | | | | 0.00032 | 0.00026 | n.s. |
| **Random effects** | **Variance** | | | **Variance** | | |
| Between individuals | 156.37 | | | 115.75 | | |
| Within individuals | 73.63 | | | 71.39 | | |
| Deviance | 3116.75 | | | 2922.99 | | |
| **Walking speed 5 km/h** | | **Model 1** | | | **Model 2** | |
| **Fixed effects** | **Coefficient** | ***SE*** | ***p*-value** | **Coefficient** | ***SE*** | ***p*-value** |
| Constant | 117.36 | 1.41 | | 121.61 | 1.74 | |
| Time[c] (0-4) | -1.65 | 0.46 | <0.001 | -1.61 | 0.51 | <0.001 |
| Sex[d] (0-1) | | | | -16.50 | 2.27 | <0.001 |
| BMI[e] (kg/m²) | | | | 1.05 | 0.31 | <0.001 |
| $EE_{RECSPORT}$[f] (kcal/week) | | | | 0.00042 | 0.00062 | n.s. |
| $EE_{LTPA}$[g] (kcal/week) | | | | 0.00024 | 0.00029 | n.s |
| **Random effects** | **Variance** | | | **Variance** | | |
| Between individuals | 214.60 | | | 143.47 | | |
| Within individuals | 91.38 | | | 87.84 | | |
| Deviance | 3207.12 | | | 2994.18 | | |
| **Walking speed 6 km/h** | | **Model 1** | | | **Model 2** | |
| **Fixed effects** | **Coefficient** | ***SE*** | ***p*-value** | **Coefficient** | ***SE*** | ***p*-value** |
| Constant | 134.17 | 1.62 | | 140.10 | 2.04 | |
| Time[c] (0-4) | -2.61 | 0.53 | <0.001 | -2.45 | 0.58 | <0.001 |
| Sex[d] (0-1) | | | | -18.76 | 2.57 | <0.001 |
| BMI[e] (kg/m) | | | | 0.97 | 0.38 | <0.05 |
| $EE_{RECSPORT}$[f] (kcal/week) | | | | 0.00063 | 0.00068 | n.s. |
| $EE_{LTPA}$[g] (kcal/week) | | | | 0.00025 | 0.00034 | n.s. |
| **Random effects** | **Variance** | | | **Variance** | | |
| Between individuals | 251.29 | | | 167.81 | | |
| Within individuals | 99.13 | | | 93.97 | | |
| Deviance | 2781.16 | | | 2569.50 | | |
| **Walking speed 7 km/.h** | | **Model 1** | | | **Model 2** | |
| **Fixed effects** | **Coefficient** | ***SE*** | ***p*-value** | **Coefficient** | ***SE*** | ***p*-value** |
| Constant | 153.54 | 2.02 | | 162.78 | 2.91 | |
| Time[c] (0-4) | -3.08 | 0.77 | <0.001 | -3.40 | 0.85 | <0.001 |
| Sex[d] (0-1) | | | | -17.43 | 3.22 | <0.001 |
| BMI[e] (kg/m) | | | | 0.74 | 0.49 | n.s. |
| $EE_{RECSPORT}$[f] (kcal/week) | | | | -0.00024 | 0.00092 | n.s. |
| $EE_{LTPA}$[g] (kcal/week) | | | | 0.0011 | 0.00045 | <0.01 |
| **Random effects** | **Variance** | | | **Variance** | | |
| Between individuals | 160.74 | | | 97.74 | | |
| Within individuals | 129.09 | | | 121.41 | | |
| Deviance | 1584.90 | | | 1430.08 | | |

*[a]SE: standard error; [b]n.s. = not significant p > 0.05; [c]Time: baseline = 0, T1 after 6 months = 1, T2 after 12 months = 2, T3 after 18 months = 3, T4 after 24 months = 4; [d]sex: women = 0, men = 1; [e]BMI = body mass index centred at a value of 25 kg/m²; [f]$EE_{RECSPORT}$ = energy expenditure for recreational sports activities; [g]$EE_{LTPA}$ = energy expenditure for leisure-time physical activity.*

fourth follow-up measurement), sex (0 = women, 1 = men) and BMI were available. The numbers between brackets were the accessory standard errors and BMI was centred at a value of 25 kg/m$^2$. The development of these predicted mean heart rates over time per walking speed are illustrated in Figures 1a to 1d. From baseline to T4, decreases in predicted mean heart rate were 5.5, 6.0, 10.0 and 9.0 beats/min at walking speeds of 4, 5, 6 and 7 km/h, respectively. The relative decreases were 5.2, 5.1, 7.4 and 5.8% at speeds of 4, 5, 6 and 7 km/h, respectively.

**Discussion**

This study was conducted to investigate whether a versatile physical activity intervention like GALM could effectively improve cardiovascular function. The present results demonstrate a significant decrease in heart rate during submaximal exercise over 18 months of participation in the GALM recreational sports program.

The observed decrease in heart rate during submaximal exercise is not only significant but also meaningful. Lamberts et al.[17] reported about the natural variation in heart rate during submaximal exercise, with a standard error of measurement of submaximal heart rate at 1.1%-1.4%. The relative changes in heart rate from baseline to T4 in our study ranged from 5.1% to 7.5%; this clearly outscores the standard error reported by Lamberts et al. (2004) and could be considered beyond the natural variation in that variable.[17] However, a comparison based on both studies needs to be interpreted with some caution as that study was based on a younger population.

Although GALM was not a high-intensity endurance-based exercise program, a significant decrease in heart rate at submaximal exercise was found. The magnitude of training effects depends on the frequency of training, type of activity, activity duration, but, foremost, intensity of the activities performed. An earlier study evaluating the intensity of the GALM program demonstrated that the overall mean intensity was 73.7% of maximum heart rate,[7] which places the program within the intensity guidelines recommended to enhance aerobic fitness.[3,18] The intensity of the GALM program combined with the fact that persons with the lowest fitness levels had ample room to improve by doing more activity could explain the reported decline in heart rate at a slower speed relative to higher-intensity programs meeting all endurance training guidelines.[19]

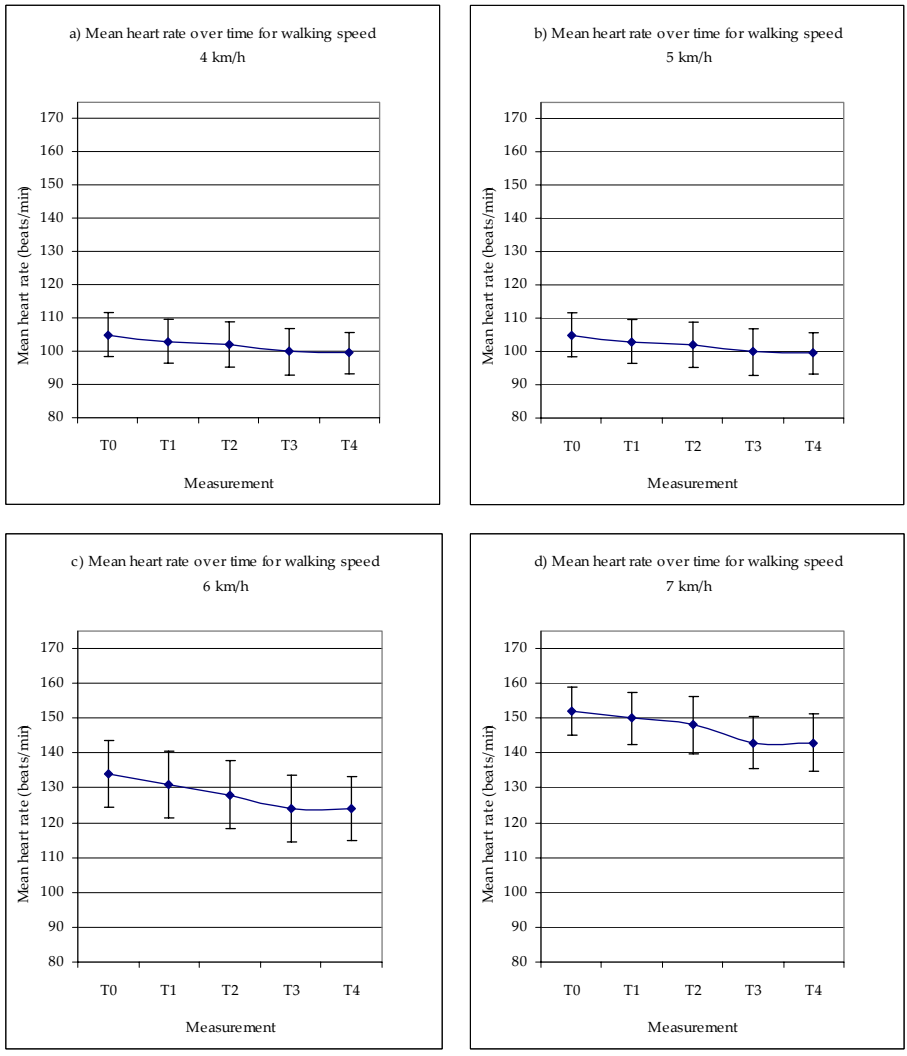



**Figure 1a-1d.** Predicted mean heart rate per walking speed over time.

Furthermore, the results of GALM are in line with those of a study of Carter, Banister, & Blaber (2003).[20] They found a reduction in heart rate at submaximal exercise of 8.1 ± 0.67 beats/min or 6% after endurance training, which indicates that GALM elicited equal increases in cardiovascular function compared with an endurance training program. A point of discussion is the adaptation time,

since the Carter et al. (2003) endurance program sessions took place 4 times per week during a 12-week period while comparable changes in GALM participants took 12 to 18 months with sessions once a week.

The graphics illustrating predicted mean heart rate at different walking speeds over time demonstrate a rapid decrease in predicted mean heart rate in the beginning and a plateauing later on. Such a pattern could mean that the GALM program provided a sufficient training load during the first 12 months but no more after that. A suggestion to further lower heart rate is to realize more overload by increasing the frequency, duration, and intensity of GALM sessions after 12 months of participation.

The covariates of sex and BMI were significantly related to heart rate at all walking speeds except for BMI at 7 km/h. No interactions were found for sex x time or BMI x time, implying that women and participants with a higher BMI value showed lower changes in heart rate at all walking speeds but did not demonstrate different changes over time compared to men and people with a lower BMI. Other studies also found a significant influence of sex and BMI on walking performance.[21]

Contrary to our expectations, no significant links between heart rate changes and $EE_{RECSPORT}$ or $EE_{LTPA}$ over time were found, except for $EE_{LTPA}$ at the highest walking speed (i.e. 7 km/h). A possible explanation is the ample range in self-reported physical activity for recreational sports activities ($EE_{RECSPORT}$: 0-6848 kcal/week), and especially leisure-time physical activities ($EE_{LTPA}$: 0-18560 kcal/week). Consequently, changes in heart rate that normally might be statistically significantly related to energy expenditure for physical activity now vanish because of the broad variation in both energy expenditure measures. Another explanation could be the misclassification of activities that can appear with the Voorrips physical activity questionnaire concerning walking and cycling for transportation vs. recreational sports activity. Alternatively, the chosen physical questionnaire might not have been accurate enough in relation to the number of participants included. For future effect studies of the same size, in line with findings and conclusions from other studies, use of a more objective way of measuring energy expenditure for physical activity (e.g. accelerometers) is recommended.[23]

In summary, our study demonstrates that long-term participation in the GALM program significantly decreased heart rate during submaximal exercise, implying an increase in cardiovascular function of sedentary and underactive older adults aged 55-65 years.

**Conclusion**

Long-term participation in GALM led to a significant decrease in heart rate during submaximal exercise which indicated an increase in cardiovascular function.

## References


1. Rijksinstituut voor Volksgezondheid en Milieu (RIVM) (2007). Avail able from http://www.rivm.nl/vtv/object_document/o4671n16911.html.
2. US Department of Health and Human Services (1996). Physical activity and health: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion.
3. American College of Sports Medicine (ACSM) Position Stand Exercise and physical activity for older adults. Med Sci Sports Exerc 1998;30:992-1008.
4. American College of Sports Medicine and American Heart Association Recommendation. Physical activity and public health in older adults. Med Sci Sports Exerc 2007;39:1435-45.
5. Wilmore JH, Costill DL. Physiology of Sports and Exercise 2004. Champaign, IL: Human Kinetics.
6. Stevens M, Bult P, de Greef MHG, Lemmink KAPM, Rispens P. GALM: stimulating physical activity in sedentary older adults. Prev Med 1999;29:267-76.
7. De Jong J, Stevens M, Lemmink KAPM, de Greef MHG, Rispens P, Mulder T. Background and intensity of the GALM physical activity program. J Physical Activity Health 2005;2:51-62.
8. De Jong J, Lemmink KAPM, Stevens M, de Greef MHG, Rispens P, King AC, et al. Six-month effects of the Groningen Active Living Model (GALM) on physical activity, health and fitness outcomes in sedentary and underactive older adults aged 55-65. Patient Educ Couns 2006;62:132-41.
9. Lemmink KAPM, Kemper H, de Greef MHG, Rispens P, Stevens M. Reliability of the Groningen fitness test for the elderly. Journal of Aging and Physical Activity 2001;9:194-212.
10. Voorrips LE, Ravelli AC, Dongelmans PC, Deurenberg P, van Staveren WA (1991). A physical activity questionnaire for the elderly. Med Sci Sports Exerc 1991;23:974-9.
11. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity coded and MET intensities. Med Sci Sports Exerc 2000;32:S498-504.

12. Nuñez C, Gallagher D, Visser M, Pi-Sunyer FX, Wang Z, Heymsfield SB. Bioimpedance analysis: evaluation of leg-to-leg system based on pressure contact foot-pad electrodes. Med Sci Sports Exerc 1997;29:524-31.
13. Snijders TAB, Bosker RJ. Multilevel analysis: an introduction to basic and advanced multilevel modelling 1999. London: Sage Publications Ltd.
14. De Jong J, Lemmink KAPM, King AC, Huisman M, Stevens M. Twelve-month effects of the Groningen Active Living Model (GALM) on physical activity, health and fitness outcomes in sedentary and underactive older adults aged 55-65. Patient Educ Couns 2007;66:167-76.
15. Singer JD, Willet JB. Applied longitudinal data analysis, Modelling change and event occurrence 2003. New York: Oxford University Press, Inc.
16. Inbar O, Oren A, Scheinowitz M, Rotstein A, Dlin R, Casaburi R. Normal cardiopulmonary response during incremental exercise in 20-70-yr-old men. Med Sci Sports Exerc 1994;26:538-46.
17. Lamberts RP, Lemmink KAPM, Durandt JJ, Lambert MI. Variation in heart rate during submaximal exercise; implications for monitoring training. Journal of Strength and Conditioning Research 2004;18:641-5.
18. American College of Sports Medicine (ACSM) Position Stand The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc 1998;30:975-91.
19. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. J Am Med Assoc 1995;273:402-7.
20. Carter JB, Banister EW, Blaber AP. The effect of age and gender on heart rate variability after endurance training. Med Sci Sports Exerc 2003;35:1333-40.
21. Kline GM, Porcari JP, Hintermeister R, Freedson PS, Ward A, McCarron RF, et al. Estimation of VO2max from a one-mile walking track walk, gender, age, and body weight. Med Sci Sports Exerc 1987;19:253-9.

22. Oja P, Laukkanen R, Pasanen M, Tyry T, Vuori, I. (1991). A 2-km walking test for assessing the cardiorespiratory fitness of healthy adults. Int J Sports Med 1991;12:356-62.
23. Janz, K. F. (2006). Physical activity in epidemiology: moving from questionnaire to objective measurement. Br J Sports Med 2006;40:191-2.

# General discussion

# Chapter 7

## 7.1 Introduction

During the nationwide implementation of GALM, two studies were performed. First of all a study after the development and initial validation of the behavioral change model underlying GALM was conducted which resulted in the thesis of Martin Stevens (2001).[1] Secondly, a study into the effects of participation in GALM on physical activity, health, and fitness outcomes, the present thesis. In this concluding chapter, findings and points of discussion from the preceding chapters concerning theoretical and methodological considerations will be discussed. Finally, implications for public health and future research are described. However, first an overview is given of the main findings of the preceding chapters.

## 7.2 Summary of main findings

Chapter 2 addressed the effectiveness of the GALM recruitment strategy with sedentary and underactive older adults as starting point of the study after the effects of participation in GALM on physical activity, health, and fitness. The results showed that of the 12.3% of the older adults who were included, 79.4% could be indeed considered sedentary or underactive. This implied that the GALM recruitment was successful in selecting and recruiting sedentary and underactive older adults. Chapter 3 described the background and intensity of the GALM physical activity program. The results revealed that the GALM program, which was versatile and multidimensional in nature and contained all sorts of recreational sports activities (e.g. softball, dance, self-defense, swimming, and athletics), was able to meet the intensity guidelines to enhance cardiorespiratory fitness as recommended by the ACSM (1998).[2]

Chapter 4 and 5 report the six-, and twelve-month effects of participation in GALM on physical activity, fitness, and health, respectively. In general the effects after six months showed that there was an increase in $EE_{RECSPORT}$ and $EE_{LTPA}$ in the intervention but also in the control group. These latter results may indicate that the control group participants were primed by the attention going along with the recruitment and the fitness measurements. Furthermore only few significant between-group differences were found favoring the intervention group (sleep, fitness score, diastolic blood pressure, and grip strength). However, both study groups demonstrated many significant improvements in the performance-based fitness outcomes and several health indicators over time.

The results after twelve months illustrated a continuous increase in $EE_{RECSPORT}$ which was reflected by significant time effects in performance-based fitness outcomes. However, a decline for $EE_{LTPA}$ in the intervention group from 6 tot 12 months was found that could not be explained by seasonal influence. This may reflect a compensatory mechanism that has also been found in other studies in that doing more intensive physical activities (i.e. sport) was compensated by a decrease in the level of other physical activities in older adults. No noteworthy effects in health indicators were found.

In summary, GALM demonstrated only to have a short term effect on leisure-time physical activities and health outcomes. Positive long term effects were found for recreational sports activities and performance-based fitness outcomes. Chapter 6 addressed the changes in heart rate during fixed submaximal exercise after 18 months of participation in the GALM recreational sports program as a marker of aerobic endurance. The results showed that there was a significant main effect for time implying that heart rate during fixed submaximal walking performance at 4, 5, 6, and 7 km/h decreased. This significant decrease in heart rate reflected an increase in cardiovascular function after 12 to 18 months of participation in GALM. When the results from chapters 2 to 6 are combined it can be concluded that participation in GALM increased $EE_{LTPA}$ in the short term (6 months) and $EE_{RECSPORT}$ in the long term (12 months). This was reflected in short term effects in the health measures that diminished later on. In line with the increase in $EE_{RECSPORT}$ in the long term positive changes in performance-based fitness occurred over a longer period of time (i.e. cardiovascular function).

## 7.3 Theoretical considerations

This thesis contributes to a clearer understanding of the effects of a multi-modal recreational sports program on physical activity, health and fitness in sedentary and underactive older adults. In the following parts of this paragraph theoretical considerations towards the effects on physical activity, health and fitness will be discussed.

**Effects on recreational sports and leisure-time physical activities**

From chapter 4 and 5 about the 6 and 12 months effects of GALM, respectively, it can be concluded that GALM was able to increase energy expenditure for leisure-time physical activities probably only from baseline

to 6 months and for recreational sports activities from baseline to 12 months. The increase in energy expenditure for recreational sports activities could partly be explained by participation in the GALM recreational sports program so the remaining amount of energy increase was caused by recreational sports activities conducted additional to GALM. This indicated that GALM was able to stimulate recreational sports activities over a 12 month period.

With respect to energy expenditure for leisure-time physical activities chapter 5 showed that some sort of compensatory mechanism took place. The intervention group demonstrated an increase in leisure-time physical activities from baseline tot 6 months. However from 6 to 12 months a compensatory decline was found which could not be explained by seasonal influence. Whether these changes in leisure-time physical activities also occurred in the control group, that after a 6-month waiting-list period was no longer a real control group, remains unclear. In his review Westerterp (2008) entitled "physical activity as determinant of daily energy expenditure" found similar results as in GALM with respect to the fact that an increase in more intense forms of physical activity (e.g. sports, exercise-training etc.) go along with a compensatory decline in other daily physical activities.[3] Although some differences between the studies mentioned by Westerterp (2008) and GALM must be taken into account. The interventions described by Westerterp were conducted over a shorter period of time (12 weeks) and were exercise training programs in nature while the GALM program contained recreational sports activities. Futhermore the energy expenditures values in the GALM study were derived from physical activity questionnaires vs. accelerometers in the studies described in the review by Westerterp.[3] Nevertheless the trend in the studies described by Westerterp and GALM remained the same.

In the review of Westerterp (2008), the study by Goran and Poehlman (1992) demonstrated no change in total energy expenditure in healthy older adults (56-78 years) in response to endurance training.[4] One of their explanations was that the level of exercise, increasing to 85% of $VO_2$max, was too vigorous and thus fatigued them during the rest of the day. Furthermore Meijer et al. (1999 & 2000) also found that a training program (50% of heart rate reserve) in older adults (55-68 years) did not increase the total daily physical activity level. On training days persons showed a significant decrease in non training activity.[5,6] Although this program decreased non-training activity, a significant increase in maximal oxygen

uptake of approximately 8% was observed together with a significantly reduced heart rate during exercise at submaximal intensity. This last finding reveals a paramount parallel with GALM in that a compensatory decline in leisure-time physical activity was found together with a significant decrease in heart rate at submaximal exercise from baseline to 18 months. However some differences between the studies mentioned by Westerterp (2008) and GALM must be taken into account. The interventions described by Westerterp were conducted over a shorter period of time (12 weeks) and were exercise training programs in nature while the GALM program contained recreational sports activities. Futhermore the energy expenditures values in the GALM study were derived from physical activity questionnaires vs. accelerometers in the studies described in the review by Westerterp.[3] In conclusion, the before mentioned assumption as stated in chapter 1 that GALM may cause a transfer towards physical activity beside the GALM program is true regarding recreational sports activities but must probably be rejected for leisure-time physical activities.

**Effects on health-related and performance-based fitness outcomes**

As described in chapter 3 the GALM recreational sports program can be characterized as follows: a) frequency of once per week; b) duration of 60 minutes per week; c) versatile and containing recreational sports activities; d) moderate to high intensity. From the results from chapter 4, 5, and 6 it can be concluded that participation in the GALM program led to several favorable changes in performance-based but no clear effect in health-related fitness outcomes.

The increases in performance-based fitness outcomes go along with the continuing increase in energy expenditure for recreational sports activities that were observed from baseline to 12 months. The significant decrease in heart rate at submaximal intensity as an indicator for cardiovascular function reported in chapter 6 is also very promising and relevant. Despite the fact the study participants grew older they demonstrated on average a clear and significant decline in heart rate during submaximal exercise indicating the activity became lighter for them. The studies of Meijer et al. (1999 & 2000) demonstrated comparable results with respect to aerobic endurance in that apart from the aforementioned compensatory decline in leisure-time physical activity energy expenditure, the observed older adults reported a favorable decline in heart during submaximal exercise.[5,6]

Toraman (2004) described the effects of a multicomponent training program on functional fitness in older adults 60-86 years and found increases in upper and lower body strength, aerobic endurance, and agility/dynamic balance but no effects on body composition.[7] Although a different definition of fitness was used in the Toraman study, his findings confirm the results found in the GALM study in that significant results were found in what was described in the GALM study as performance-based outcomes. A plausible explanation for only finding significant increases in performance-based fitness outcomes and no significant favorable changes in health-related fitness outcomes could be as follows. The ACSM 1998 position stand stated that potential health benefits can occur as consequence of regular exercise performed more frequently and for a longer duration but at a lower intensity level than recommended to increase fitness.[2,8] From the results from other studies and this thesis it seems that participation in multicomponent physical activity programs like GALM may not sufficiently increase the total amount or volume of physical activity necessary to cause favorable health-related changes. However, the intensity and specifity of physical activities conducted in multi-component programs which have been reported as important training variables for increasing performance-based fitness outcomes (e.g. strength, aerobic endurance, flexibility etc.) were sufficient.[8,9]

GALM was based on the 1995 ACSM/CDC and 1998 ACSM recommendations. However in 2007 the ACSM and the American Heart Association (AHA) published an updated recommendation on physical activity and public health for adults in general,[10] and a companion recommendation for older adults.[11] The 2007 ACSM/AHA recommendation for adults provided an update of the 1995 ACSM/CDC recommendation. Although fundamentally unchanged from the 1995 recommendation, key issues (e.g. frequency, incorporation of vigorous-intensity physical activity etc.) were more clarified and therefore improving the recommendation. Furthermore this 2007 ACSM/AHA recommendation for older adults was extended in that: a) combinations of moderate- and vigorous-intensity activity can be performed to meet the total amount of physical activity recommended to improve and maintain health; b) additional muscle strengthening activities should be performed; c) additional flexibility activities should be performed; d) activities that improve balance should be performed. Despite the fact that GALM was developed earlier than the publication of the 2007 ACSM/AHA recommendations for older adults, it can be concluded that the GALM

recreational sports activity program with respect to the multimodal nature meets these updated recommendation that promotes such an approach. The GALM recreational sport program combines moderate- and more vigorous intensity physical activities and because of it multimodal nature pays attention to strength, balance and flexibility. In that perspective the GALM recreational sports program and other multimodal physical activity programs can be considered as an interesting, effective and attractive alternative for future intervention aiming at stimulating physical activity in sedentary and underactive older adults. To also improve health-related fitness outcomes additional actions should be promoted that lays more emphasis on increasing overall daily physical activity (e.g. individualized goal-setting regarding other physical activities, regular self-monitoring of targeted activities, reinforcement for reaching goals, behavioral skill building etc.).

## 7.4 Methodological considerations

**Internal validity**

In longitudinal observational and intervention studies it is almost inevitable that some outcomes will be unobserved or subjects to drop out of the study.[12] In the GALM effect study a relatively high attrition rate occurred (chapter 4 and 5) despite the fact all sorts of preventive and reparative actions were undertaken to counter this (e.g. newsletter, phone calls etc.). A major reason for the high attrition was that at each wave, measurements consisted of a questionnaire and test session. In practice, in many cases participants missed one or more questionnaire and/or fitness test sessions due to primarily lack of time, inability to appear at test session etc. Another aspect was the drop out of persons. If the drop out of subjects were to be selective, the results found would not be representative for all eligible participants of GALM. However, comparison between drop outs and the GALM participants who stayed verified that no significant differences regarding main characteristics and outcomes measures appeared at baseline. Reasons responsible for the drop out were many practical issues like illness and change of accommodation, time schedule for the sessions, and trainer.

Inappropriate handling of the missing data like deleting cases with missing data or ad imputation methods may result in misleading conclusions. Therefore multiple imputation procedures and multi-level analyses were conducted.[12-16] Both methods are well accepted and used in

cases where missing data in longitudinal datasets occur under the restriction of certain statistical assumptions. Since this was true for the GALM effect study the internal validity of this study can be considered sufficient.

**External validity**

A strong point of the GALM study is that the results and conclusions are highly representative and generizable to the Dutch population of sedentary and underactive older adults since it was conducted in a real community-based setting. The study participants were recruited in three municipals representing three of five degrees of urbanization that are applied in The Netherlands: (1) highly urbanized municipality category 1; (2) middle-level urbanized municipality category 3; (3) rural municipality category 5.[17] Furthermore, the recruitment strategy and recreational sport program in this study was an exact copy of how they are conducted in regular GALM projects.

The feasibility of the recruitment strategy and the GALM recreational sports activity program together with the scale on which GALM has been implemented, make this study unique. To our knowledge, no comparable study after the effects of such a broadly implemented strategy with the aforementioned characteristics has been described in the literature so far.

**Waiting-list control group**

For ethical reasons, the control group participants were placed on a waiting-list for only a short period of 6 months. However, results after 6 months of GALM (chapter 4) revealed that control group participants also increased their energy expenditure level for recreational sport and other leisure-time physical activities. These results seem to indicate that the waiting-list control group participants were motivated and prepared to participate in GALM. This priming was probably caused by the intensive door-to-door recruitment and other forms of attention like the interview and fitness test which also have been reported in others studies.[18,19]

One plausible theory for the increase in physical activity, health and fitness outcomes favoring the intervention group not reach the level of significance may be this priming effect. This priming and the fact that the control group participants also started being physically active in GALM after their waiting-list period caused that no real control group was available after 6 months study period which is a limitation in this study.

**Measurement of energy expenditure for physical activity**

The self-reported estimated energy expenditure data that was collected by means of the Voorrips physical activity questionnaire for the elderly,[20] showed that very large standard deviations appeared indicating there was a broad range in energy scores on group level. The small differences in energy expenditure scores for physical activity in combination with the large standard deviations may be a reason for not finding significant between-group differences and relations with health and fitness outcomes. This is especially relevant concerning the measurement of other leisure-time physical activity. In that perspective, the pattern from our study results in that GALM did not have a clear effect on health, may be a consequence of this. However, the data can not provide us more information on this relation. On the other hand, validation studies showed that physical activity questionnaires compiling information on high intensity activities like sports activities are more reliable than other physical activities since older adults can recall these activities much better.[21] Therefore, the significant increase in $EE_{RECSPORT}$ and the consequent increase in fitness outcomes could be considered an important and reliable finding. For future studies comparable with GALM, more objective and sensitive measures for assessing (small) changes in physical activity levels that could be already relevant in this target group are promoted (e.g., accelerometers).[22]

**Measurement of health and performance-based outcomes**

In this study a compromise was made between measures necessary to detect in a valid and reliable way (small) changes caused by participation in GALM vs. feasibility for large scale use and authenticity of GALM. This resulted in measurements of health and fitness related outcomes that were originally part of the fitness test (Groningen Fitnesstest for the Elderly) as conducted in GALM extended with bio-impedance, timed chair-stand and functional reach.

The study was designed to include 144-192 participants in the intervention as well as the control group, respectively, taking into account expected dropout percentage of 20% and 40% with an alpha of 5% and a power of 80%. From the actual dropout rates, it becomes clear we did not manage to realize the expected numbers of inclusion and dropouts.

The lower numbers of participants (chapter 4 and 5) in combination with the restricted sensitivity of especially the health measurements may have caused that (small) changes remained undetected or did not reach the level of significance. For instance, in the GALM study body fat was

predicted by means of bio-electrical impedance (BIA) measurement. BIA is widely used to estimate body composition because it is simple, quick and cheap and has potential epidemiological value.[23] Regarding the restricted numbers of participants included in our study it is questionable whether BIA was still a reliable measure to predict percentage of body fat and detect possible (small) changes in body fat. The same parallel can be drawn for the measurement of electronically measured blood pressures. Since the chosen health related measures suffered from the sensitivity and study size issue, this may also be a reason for not finding significant changes in health outcomes.

## 7.5 Implications for public health and future research

This present thesis revealed that participating in the GALM recreational sport program leads to longitudinal increases in energy expenditure for recreational sports activities and performance-based fitness in sedentary and underactive older adults. No clear increases in leisure-time physical activity and health-related outcomes were found over a longer period of time.

To our knowledge, this study is the first study that investigated the effects of a strategy containing a recruitment strategy that was feasible for community based purposes on a large scale and a multimodal recreational sports activity program on physical activity, health, and fitness outcomes in sedentary and underactive older adults. Knowing that this group forms a growing cohort in Western societies, that can profit highly from becoming physically active and feel attracted to a program like GALM makes it a very relevant objective for future studies.

From our experience the following recommendations for future initiatives and research can be made. An important finding from this study was the effectiveness and feasibility of the door-to-door GALM recruitment strategy. This type of recruitment is a very useful and effective tool for future community-based strategies and other target groups.

Another recommendation would be to develop a more differentiated program after the GALM recruitment since not all older adults have the same needs, wishes or functional capacities. Already successful examples are individual programs for older adults who do not want to participate in group-based programs entitled COACH. There is also an opportunity for older adults with chronic diseases or limitations to join a group-based program entitled SCALA.[24,25] Furthermore the multimodal GALM recreational sports program could also be integrated in national initiatives like

"Beweegkuur".[26] This project promotes primary and secondary prevention regarding diabetes mellitus type 2 that is a growing problem amongst older adults over 60 years of age in The Netherlands. Older adults are screened by physicians and subsequently advised to start an (more) active lifestyle. For the segment of older adults that feels attracted to a versatile group-based recreational sports program, GALM could be an attractive alternative.

From this thesis and other aforementioned studies multimodal physical activity programs appear to be appealing, feasible and effective in increasing performance-based fitness outcomes which are relevant for older adults in performing activities in daily living and remain functioning independently. Future studies should further investigate the impact of this type of programs. Such studies should use more reliable and objective measures to detect changes in amount and nature of physical activity. This could be done by using accelerometers or sensor technology able to not only measure (small) changes in physical activity but also type and intensity of activities.[27]

The fact that a compensatory decline in leisure-time physical activity appears during GALM does not mean that promoting recreational sports activities in older adults should be restricted since they have a favorable influence in performance-based fitness outcomes. However a major challenge remains to also increase other leisure-time physical activities and integrating individualized goal-setting regarding other physical activities, regular self-monitoring of targeted activities, reinforcement for reaching goals, behavioral skill building etc. is recommended to reach this goal.

**References**


1. Stevens M. Groningen Active Living Model: development and initial validation. 1999.
2. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc 1998;30:975-91.
3. Westerterp KR. Physical activity as determinant of daily energy expenditure. Physiol Behav 2008;93:1039-43.
4. Goran MI, Poehlman ET. Endurance training does not enhance total energy expenditure in healthy elderly persons. Am J Physiol 1992;263:E950-57.
5. Meijer EP, Westerterp KR, Verstappen FTJ. Effects of exercise training on total daily physical activity in elderly humans. Eur J Appl Physiol 1999;80:16-21.
6. Meijer EP, Westerterp KR, Verstappen FTJ. The effect of exercise training on daily physical activity and substrate utilization in the elderly. Int J Sports Med 2000;21:499-504.
7. Toraman NF, Erman A, Agyar E. Effects of multicomponent training of functional fitness in older adults. J Aging Phys Act 2004;12:538-53.
8. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. J Am Med Assoc 1995;273: 402-7.
9. McArdle WD, Katch FI, Katch VL. Exercise physiology: energy, nutrition, and human performance. Philadelphia/London, Lea & Febiger, 1991.
10. Haskell WL, Lee MI, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39(8):1423-34.

11. American College of Sports Medicine and American Heart Association. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39:1435-45.
12. Wood AM, White IR, Hillsdon M, Carpenter J. Comparison of imputation and modelling methods in the analysis of a physical activity trial with missing outcomes. Int J Epidemiol, 2005;34:89-99.
13. Rubin DB. Multiple imputation for nonresponse in surveys. New-York: John Wiley & Sons, Inc, 1987.
14. Schafer JL. Analysis of incomplete multivariate data. London: Chapman & Hall, 1997.
15. Snijders TAB, Bosker RJ. Multilevel analysis. An introduction to basic and advanced multilevel modelling. London: Sage Publications Ltd, 1999:166-99.
16. Tang L, Song J, Belin TR, Unützer J. A comparison of imputation methods in a longitudinal randomized clinical trial. Stat Med 2005;24:2111-28.
17. Centraal Bureau voor de Statistiek (CBS), 2006. Available from http://www.cbs.nl/nl-/menu/_unique/_search/default.htm?querytxt=urbanisatiegraad.
18. ACT writing group. Effects of physical activity counseling in primary care (The activity counseling trial: a randomized controlled trial). J Am Med Assoc 2001;286:677-87.
19. Atienza AA, King AC. Community-based health intervention trials: an overview of methodological issues. Epidemiol Rev 2002;24:72-9.
20. Voorrips LE, Ravelli AC, Dongelmans PC, Deurenberg P, Van Staveren WA. A physical activity questionnaire for the elderly. Med Sci Sports Exerc 1991;23:974-9.
21. Bonnefoy M, Normand S, Pachiaudi C, Lacour R, Laville M, Kostka T. Simultaneous validation of ten physical activity questionnaires in older men: a doubly labeled water study. J Am Geriatrics Society 2001;49(1):28-35.
22. Janz KF. Physical activity in epidemiology: moving from questionnaire to objective measurement. Br J Sports Med 2006;40: 191-2.

23. Wells JCK, Williams JE, Fewtrell M, Singhal A, Lucas A , Cole TJ. A simplified approach to analysing bio-electrical impedance data in epidemiological surveys. Int J Obesity 2007;31:507–14.
24. Dijkstra Y, Jansma F, Bult P, Jong de J, Greef de MHG, Lemmink KAPM, et al. SCALA: een sportstimuleringsstrategie. Lichamelijke Opvoeding 1999;4:187-90.
25. Sprenger SR, de Greef MHG, Popkema DY. Effects of the COACH lifestyle activity program in sedentary seniors. Movement Studies & Research Groningen/Center for Human Movement Sciences University Groningen, Groningen 2005.
26. Nederlands Instituut voor Sport en Bewegen (NISB). Beweegkuur: het beste recept voor uw gezondheid (conceptversie 0.3). NISB, Bennekom, 2008.
27. Zijlstra W, Aminian K. Mobility assessment in older people: new possibilities and challenges. Eur J Ageing 2007;4:3-12.

# Summary

**Summary**

Regular physical activity is considered as an important component of a healthy lifestyle that decreases the risk of coronary heart disease, diabetes mellitus type 2, hypertension, colon and breast cancer, obesity and other debilitating conditions. Furthermore, physical activity can improve functional capacity and therefore also the quality of life in older adults. Despite all these favourable effects, a substantial part of the Dutch older adults is still underactive or even sedentary. To change this for the better the Groningen Active Living Model (GALM) was developed.

Aim of GALM is to stimulate recreational sport activities in sedentary and underactive older adults in the age band 55-65. After a door-to-door visit as part of an intensive recruitment phase, a fitness test was conducted followed by the GALM recreational sports program. This program was based on principles from evolutionary-biological play theory and insights from social cognitive theory. For two main reasons the program was versatile in nature (e.g. softball, dance, self-defence, swimming, athletics etc.): a) to improve compliance to the program different sports were offered which was reported to be more appealing for older adults; b) to aim at more components of motor fitness (e.g. strength, flexibility, speed, endurance, and coordination). From 1997-2005 more than 552.094 persons have been visited door-to-door, over 55.740 are tested, and 41.310 participated in the GALM recreational sports program. The aim of the present thesis is to determine the effects of participation in the GALM recreational sports program on physical activity, health, and fitness outcomes.

In *chapter 2* the effectiveness of the GALM recruitment in selecting and recruiting sedentary and underactive older adults is described. Three municipalities in The Netherlands were selected and in every municipality four neighbourhoods were included. Two of each of the four neighbourhoods were randomly assigned as intervention and the others as control neighbourhoods. In total 8,504 person were mailed and received a home visit. During this home visit the GALM recruitment questionnaire was collected on which the selection between sedentary/underactive and physically active older adults was based. Ultimately we succeeded in including 12.3% (315 of the 2,551 qualifying) of the older adults, 79.4% of whom could be indeed considered sedentary or underactive. The cost of successfully recruiting an older adult was estimated at $84.

To assess the effects of a physical activity intervention on health and fitness and explain the results, it is necessary to know program characteristics regarding frequency, intensity, time and content of the activities. With respect to the GALM recreational sports activity program, the only unknown characteristic was intensity. In *chapter 3* the intensity of this program is systematically described. By means of heart rate monitors, data of 97 persons (mean age 60.1 yr) were collected in three municipalities. The mean intensity of all 15 GALM sessions was 73.7% of the predicted maximal heart rate. Six percent of the monitored heart rate time could be classified as light, 33% as moderate and 61% as hard. In summary the GALM recreational sports program meets the 1998 ACSM recommendations for intensity necessary to improve cardiorespiratory fitness.

In *chapter 4 and 5*, the effects of 6 and 12 months of participation in the GALM recreational sports program were described and 181 persons were followed over time. Results after 6 months revealed only few significant between-group differences favouring the intervention group (i.e. sleep, diastolic blood pressure, perceived fitness score and grip strength). Changes in energy expenditure for leisure-time physical activities ($EE_{LTPA}$) showed an increase in both study groups. From 6 to 12 months a decrease in $EE_{LTPA}$ occurred in the intervention group and an increase in the control group. The significant positive time effects for the health outcomes (diastolic blood pressure, BMI, percentage body fat) that were found after 6 months were diminished from 6 to 12 months. However, the energy expenditure for recreational sports activities ($EE_{RECSPORT}$) demonstrated a continuous increase over 12 months. Parallel to this, significant main effects for time were found in performance-based fitness outcomes (i.e. simple reaction time, leg strength, flexibility of hamstrings and lower back, and aerobic endurance). After 12 months, only a significant between-group difference for flexibility of the hamstrings and lower back was found favouring the control group. In conclusion, a short term increase in $EE_{LTPA}$ was found with along going improvements in health outcomes that more or less disappeared from 6 to 12 months. In the long term, results showed a continuous increase in $EE_{RECSPORT}$ and performance-based fitness. This latter increase is probably a reflection of the significant improvement over time in $EE_{RECSPORT}$ and the fact that recreational sports activities are of higher intensity.

Aerobic endurance is regarded as the most important component of motor fitness that is relevant for older adults to function independently.

In *chapter 6*, the development in aerobic endurance after 18 months of participation in the GALM recreational sports program was assessed by means of changes in heart rate at fixed submaximal exercise. Since both groups were comparable regarding changes in energy expenditure for physical after 6 month and testing confirmed this, both groups were combined and considered as one group. A multi-level analyses with a model for change was developed. At all walking speeds (4, 5, 6, and 7 km/h) a significant decrease in heart rate over time was found. The average decrease in heart rate was 5.0, 6.0, 10.0, and 9.0 beats/min for the walking speeds 4, 5, 6, and 7 km/h, respectively. The relative decrease varied from 5.1 to 7.1% relative to average heart rates at baseline. These results illustrate that participation in the GALM recreational sports program has a positive significant effect on aerobic endurance and that the participants are able to perform at submaximal intensity more easily.

Based on the overall results it can be concluded that this study contributes to the field in how to effectively recruit sedentary and underactive older adults and stimulate them to become and stay active in recreational sports activities. As far as we know, this recruitment in combination with the recreational sport program is not only unique but also effective in increasing performance-based fitness in the long term. Short term effects were found in other leisure-time activities and health outcomes. To further stimulate other leisure-time and probably health outcomes beside the favorable effects that were already seen, additional interventions that pay more attention to behavioural change regarding how to integrate more other activities beside sports activities is recommended.

# Samenvatting

## Samenvatting

Regelmatig lichamelijk actief zijn wordt beschouwd als een belangrijke component van een gezonde leefstijl die het risico op het krijgen van onder andere hart en vaatziekte, diabetes mellitus type 2, hoge bloeddruk, dikke darm en borstkanker, overgewicht en andere ziekten verkleind. Daarnaast heeft lichamelijke activiteit voor ouderen ook nog als belangrijk voordeel dat het de zelfredzaamheid positief beïnvloedt en daarmee ook de kwaliteit van leven. Ondanks al deze voordelen, is een groot deel van de Nederlandse populatie ouderen nog steeds onvoldoende of geheel lichamelijk inactief. Dit was de aanleiding om het Groninger Sport Model (GALM) te ontwikkelen.

Het doel van GALM is om sedentaire en onvoldoende lichamelijk actieve ouderen in de leeftijdscategorie van 55-65 jaar te stimuleren tot deelname aan sportieve activiteiten. Na een persoonlijk deur-aan-deur benadering vindt een fitheidstest plaats met daaropvolgend het GALM sportprogramma. Dit sportprogramma is gebaseerd op een biologisch-evolutionaire spel theorie en principes uit de sociaal-cognitieve theorie. Verder is het sportprogramma zeer veelzijdig (bijvoorbeeld softbal, dans, zelfverdediging, zwemmen, atletiek etc.) met als tweeledig doel: a) zoveel mogelijk tegemoetkomen aan de beweeg wensen en behoeften van de doelgroep; b) aanspraak te maken op alle componenten van motorische fitheid (kracht, lenigheid, snelheid, uithoudingsvermogen en coördinatie) die gedurende alle sporten aan bod komen. In de periode 1997-2005 zijn er meer dan 552094 personen benaderd, meer dan 55740 personen getest en meer dan 41310 personen zijn gaan deelnemen aan het GALM sportprogramma. Het doel van het huidige onderzoek is de effecten van deelname aan het GALM sportprogramma op lichamelijke activiteit, gezondheid en fitheid te bepalen.

In *hoofdstuk 2* is de effectiviteit van de GALM benadering in het rekruteren van daadwerkelijk sedentaire en onvoldoende lichamelijk actieve ouderen onderzocht. Verspreid over drie gemeenten in Nederland zijn per gemeente vier wijken geïncludeerd. Van deze vier wijken werden er at random twee wijken als interventie en twee als controle wijken bestempeld. In totaal werden er 8503 brieven verstuurd en personen deur-aan-deur bezocht om de GALM vragenlijst af te nemen die onderscheid maakt tussen voldoende en onvoldoende lichamelijk actief waarbij de laatste categorie de doelgroep van GALM was. Uiteindelijk slaagden we erin om 12,3% (315 van

de 2551 personen die voor GALM in aanmerking zouden kunnen komen) van de potentiële doelgroep lichamelijk inactieve ouderen te rekruteren. Van de gerekruteerde bleek 79.4% daadwerkelijk sedentair of onvoldoende lichamelijk actief te zijn. De kosten die gepaard gingen met het rekruteren van één GALM deelnemer waren ongeveer € 50.

Voor het bepalen van het effect van een interventie op fitheid en gezondheid is het belangrijk te weten wat de frequentie, intensiteit, tijdsduur en type/aard van de belasting is. De belangrijkste en tevens onbekende factor wat betreft het GALM program is de intensiteit. In *hoofdstuk 3* is de intensiteit van het GALM sportprogramma systematisch in kaart gebracht. Met behulp van hartslagmeters is gedurende 15 lessen bij 97 personen (gemiddelde leeftijd 60.1 jaar) over de drie onderzoeksgemeenten data verzameld en geanalyseerd. De resultaten wezen uit dat de gemiddelde intensiteit van het GALM programma bestaande uit 15 lessen lag op 73,7% van de voorspelde maximale hartslag van de onderzoeksgroep. Hierbij kon 6% van de lestijd als licht, 33% als gemiddeld en 61% als zwaar beschouwd worden. Samenvattend betekent dit dat het GALM sportprogramma voldoet aan de ACSM richtlijnen (1998) die gelden voor de intensiteit die nodig is voor het verbeteren van het cardiorespiratoire uithoudingsvermogen bij ouderen.

Om de effecten van deelname aan het GALM sportprogramma op het lichamelijke activiteiten patroon, fitheid en gezondheid te bepalen zijn 181 personen in de tijd gevolgd. Uit de resultaten van *hoofdstuk 4 en 5* kan geconcludeerd worden dat het energie verbruik voor overige activiteiten toeneemt gedurende de eerste 6 maanden in beide onderzoeksgroepen. Van 6 tot 12 maanden neemt deze vervolgens af in de interventie groep maar stijgt door in de controle groep. De significante positieve veranderingen in de gezondheidsvariabelen (diastolische bloeddruk, BMI, vetpercentage) die gedurende de eerste 6 maanden van GALM gemeten zijn, verdwijnen tussen 6 tot 12 maanden. Het energie verbruik voor sportieve activiteiten stijgt echter over de gehele interventie periode van 12 maanden. Deze tendens is ook waarneembaar in de metingen van motorische fitheid die resulteert in significante hoofdeffecten voor tijd wat betreft enkelvoudige reactietijd, beenkracht, lenigheid lage rug/benen en aëroob uithoudingsvermogen. Er is een significant verschil tussen beide onderzoeksgroepen voor lenigheid van de lage rug/hamstring waarbij de controle groep meer verbetert. Samenvattend kan geconcludeerd worden dat er een korte termijn effect is van een toename in het lichamelijke activiteiten patroon en de hiermee samenhangende kortstondige verbetering in gezondheidsindicatoren.

GALM heeft een langduriger effect op het sportieve activiteiten niveau dat toeneemt van 0 tot 6 maanden alswel van 6 tot 12 maanden. De toename in meer en intensiever bewegen zien we weerspiegeld in een significante toename in diverse componenten van motorische fitheid.

Het aëroob uithoudingsvermogen wordt in het kader van het zelfstandig functioneren van ouderen vaak beschouwd als de belangrijkste component van fitheid. In *hoofdstuk 6* wordt aan de hand van de verandering van hartslag bij een gestandaardiseerde submaximale inspanning bepaald in hoeverre het aëroob uithoudingsvermogen van de ouderen verandert gedurende 18 maanden deelname aan GALM. Aangezien er na 6 maanden GALM geen onderscheid meer was tussen interventie en controle groep wat betreft energie verbruik voor lichamelijke activiteit zijn beide groepen samengevoegd. Multilevel analyse is toegepast waarbij een groei en volledig model zijn ontwikkeld. Op alle wandelsnelheden (4, 5, 6 en 7 km/h) werd een significante afname in hartslag over de tijd waargenomen. De afname in hartslag was 5.0, 6.0, 10.0 en 9.0 slagen/min voor de wandelsnelheden 4, 5, 6 en 7 km/h en de relatieve afname varieerde van 5.1 tot 7.5% in verhouding tot de hartslag op baseline. Deze resultaten geven weer dat deelname een GALM een positief significant effect heeft op aëroob uithoudingsvermogen en dat dit tevens een zeer relevante verbetering oplevert tijdens submaximale inspanning bij ouderen.

Op basis van de onderzoeksresultaten wordt geconcludeerd dat dit onderzoek een bijdrage levert aan de kennis rondom het succesvol stimuleren van een moeilijk te bereiken doelgroep en het verbeteren van fitheid en gezondheid hierbij. De directe benadering en rekrutering van ouderen die sedentair of onvoldoende lichamelijk actief zijn samen met het veelzijdige sport en spelprogramma maakt dat GALM uniek is. GALM slaagt er in gedurende een langere periode sportieve activiteiten en motorische fitheid positief te beïnvloeden. Om het lichamelijke activiteiten patroon voor overige activiteiten en gezondheidsindicatoren over de lange termijn te verbeteren moeten aanvullende interventies gepleegd worden. Hierbij kan worden gedacht aan individuele goal-setting ten aanzien van lichamelijke activiteiten, regelmatig zelf meten van beoogde beweegdoelen, training van vaardigheden ten aanzien van gedragsverandering.

# List of publications
# &
# Curriculum vitae

## List of publications

**Peer-reviewed articles**

Stevens M, de Greef MHG, Bult P, *de Jong J*, Lemmink KAPM, Kroes GH,

Rispens P. Groningen Active Living Model (GALM): a new concept for sports stimulation for sedentary elderly people – first results. J Aging Physical Activity 1997:5;387-88.

Stevens M, Lemmink KAPM, van Heuvelen MJG, *de Jong J*, Rispens P. Groningen Active Living Model (GALM): stimulating physical activity in sedentary older adults; validation of the behavioral change model. Prev Med 2003:37;561-70.

*De Jong J*, Stevens M, Lemmink KAPM, de Greef MHG, Rispens MHG, Mulder T. Background and intensity of the GALM physical activity program. J Physical Activity Health 2005:2;51-62.

*De Jong J*, Lemmink, KAPM, Stevens M, de Greef, MHG, Rispens R, King AC, Mulder T. Six-month Effects of the Groningen Active Living Model (GALM) on physical activity, health and fitness outcomes in sedentary and underactive older adults aged 55-65. Patient Education and Counseling 2006:62;132-41.

*De Jong J*, Lemmink, KAPM, King AC, Huisman M, Stevens M. Twelve-month effects of the Groningen Active Living Model (GALM) on physical activity, health and fitness outcomes in sedentary and underactive older adults aged 55-65. Patient Education and Counseling, 2007:66;167-76.

Stevens M, *De Jong J*, Lemmink KAPM. Effectiveness of the GALM recruitment strategy with sedentary and underactive older adults. Preventive Medicine, 2008:47;398-401.

*De Jong J*, Lemmink KAPM, Stewart R, Scherder E, Stevens M. Longitudinal changes in heart rate after participating in the Groningen Active Living model (GALM) recreational sports program. Pending revisions J Sports Sci 2008.

**Chapters in books**

Lemmink KAPM, Stevens M, de Greef MHG, *de Jong J*, Mulder Th. GALM over Nederland: sportstimulering werkt! In: Jansen J, Schuit AJ, van der Lucht F (red). Tijd voor gezond gedrag: Bevorderen van gezond gedrag bij specifieke groepen, 2002. Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 157- 162.

**Proceedings**

Lemmink KAPM, de Greef MHG, *de Jong J*, Rispens P, Stevens M. Development of a walking test with incremental speed: reliability and validity. In: Proceedings International Conference on Aging and Physical Activity 1997. Austin, TX, USA, 377.

Lemmink KAPM, de Greef MHG, *de Jong J*, Rispens P, Stevens. Development of a walking test with incremental speed.: Reliability and validity. Journal of Aging and Physical Activity 1997:5;377.

*De Jong J*, Lemmink KAPM, de Greef MHG, Dijkstra Y, Stevens M (1998). The effects of the GALM sports program on performance based motor fitness and perceived motor fitness. In: Proceedings of the third annual congress of the European College of Sport Science, Manchester, United Kingdom, 256.

Dijkstra Y, Lemmink KAPM, de Greef M, *de Jong J*, Stevens M. Effects of a Sports program for sedentary (55-65) on motor and physiological fitness. (1998). In: Proceedings of the fourth Scandinavian Congress on Medicine and Science in Sports. In: Scandinavian Journal of Medicine and Science in Sports, 320.

Lemmink KAPM, *de Jong J*, de Greef MHG, Rispens P, Stevens M. Validity of a walking test with increasing speed for adults over age 55. In: Proceedings Medicine and Science in Sports and Exercise 2000:32(5); S318.

Stevens M, Lemmink KAPM, de Greef MHG, *de Jong J*, Rispens P. GALM: stimulating leisure-time physical activity in sedentary older adults. In: Proceeding Medicine and Science in Sports and Exercise 2000:32(5); S38.

Van Mechelen W, Borghouts J, de Greef M, *de Jong J*, Kemper H, Stiggelbout M. The promotion of physical activity in the elderly: The Dutch experience. In: Proceedings Medicine and Science in Sports and Exercise 2002:34(5) Supplement 1;S237.

*De Jong J*, Stevens M, Lemmink KAPM, de Greef MHG, Mulder T, Rispens P. Six-month results from the GALM exercise program on indicators of health and fitness in sedentary older adults. In: Proceedings Medicine and Science in Sports and Exercise 2003:35(5);S136.

*De Jong J*, Lemmink KAPM, Stevens M, de Greef MHG, MulderT, Rispens P. GALM effect study: 6 and 12-month changes in energy expenditure, health, and fitness outcomes. In: Proceedings GALM conference 2003. Institute of Human Movement Sciences, University of Groningen, The Netherlands. Bangkok

**Review activities**
Reviewer for Preventive Medicine since 2007.

**Nederlandse vakbladen en rapporten**
Lemmink KAPM, *de Jong J*. De wandeltest met oplopende snelheid. Relatie met aëroob uithoudingsvermogen. Geneeskunde en Sport 1996;29(4):120-125.

Stevens M, Lemmink KAPM, *de Jong J*, Heineman K. Het effect van het GALM-introductieprogramma op het dagelijkse energieverbruik van senioren van 55-65 jaar. Geneeskunde en Sport 2003;36(6):170-174.

*De Jong J*, Leibbrand K, Stevens M, de Greef MHG, Lemmink KAPM. (2004). Effecten van het GALM bewegingsprogramma op de mate van lichamelijke activiteit en ander leefstijlkenmerken, fitheid, ervaren gezondheid en dagelijks functioneren van sedentaire senioren. ZorgOnderzoek Nederland (Preventie), project nummer 9607.081.2, ISBN 90-367-2109-1.

**Abstracts in congresverslagen/tijdschriften (presentaties)**

*De Jong J*, Lemmink KAPM, Stevens M, de Greef MHG, Mulder T, Rispens P. Effecten van deelname aan het Groninger Actief Leven Model GALM). GALM symposium, Groningen, 2004.

*De Jong J*, Lemmink KAPM, Stevens M, De Greef MHG, Mulder T, Rispens P. Effecten van deelname aan het Groninger Actief Leven Model (GALM) op lichamelijke activiteit en andere leefstijlkenmerken, fitheid, ervaren gezondheid en dagelijks functioneren van sedentaire senioren. In verslag 7e Nationaal Gerontologiecongres perspectief op een vergrijzende maatschappij 2004, Ede, 43-44.

*De Jong J*, Stevens M, Lemmink KAPM, King AC. Effecten Groninger Actief Leven Model (GALM) op energieverbuik, gezondheid en fitheid van sedentaire senioren. Vereniging voor Sport Geneeskunde (VSG). Noordwijk, 2006.

*De Jong J*, Stevens M, Lemmink KAPM, King AC. Six-month effects of the Groningen Active Living Model (GALM) on physical activity, health and fitness in sedentary and underactive older adults. In: Proceeding 9th International Congress Behavioral Medicine 2006, Bangkok, Thailand.

**Curriculum Vitae**

Johan de Jong werd op 3 mei 1970 geboren in Bergum. Na zijn middelbare schoolperiode aan het Atheneum te Drachten (1982-1988) studeerde hij van 1988-1992 aan de Academie voor Lichamelijke Opvoeding te Groningen (ALO). Na de ALO met goed gevolg afgerond te hebben studeerde hij van 1992-1995 Bewegingswetenschappen aan de Rijksuniversiteit Groningen. Zijn afstudeerscriptie had als titel: de validering van een wandeltest met oplopende snelheid. Tijdens de laatste fase van zijn studie was hij werkzaam als assistent bij de diverse fittesten gehouden in het kader van de ontwikkeling van het Groninger Actief Leven Model (GALM).

Van 1997-2000 is hij als projectmedewerker GALM werkzaam geweest voor de landelijke stichting Meer Bewegen voor Ouderen (MbvO) die later opgegaan is in het Nederlands Instituut voor Sport en Bewegen (NISB). Zijn werkzaamheden bestond uit het begeleiden, coördineren en verder ontwikkelen van GALM.

Vanaf 2000 is hij als promovendus werkzaam voor Bewegingswetenschappen aan de Rijksuniversiteit Groningen. Tijdens deze periode heeft hij naast zijn onderzoeksaanstelling een jaar als docent bij Bewegingswetenschappen gefunctioneerd. Sinds 2001 is hij naast zijn onderzoekswerkzaamheden verbonden als docent medisch biologische vakken aan de opleiding Sport en Bewegen van de Hanzehogeschool Groningen.

In de periode 2004-2006 heeft als teamleider van de nieuw ontwikkelde opleidingsstroom “Sportgezondheid” gefunctioneerd binnen het Instituut voor Sportstudies aan de Hanzehogeschool Groningen (samenbundeling van de Academie voor Lichamelijke Opvoeding en Sportgezondheid & Management).

Vanaf 2006 tot heden is hij naast zijn docentschap werkzaam als onderzoeker/associate lector binnen het lectoraat “Sportwetenschap” dat sinds 2007 onderdeel uitmaakt van het Instituut voor Sportstudies.

# Dankwoord

## Dankwoord

Een promotie uitvoeren en afronden is een zeer omvangrijke klus met de nodige ups and downs. Tijdens deze intensieve periode zijn er diverse personen die op verschillende manieren zeer behulpzaam geweest en hen wil ik door middel van dit dankwoord hartelijk bedanken.

Copromotores Koen Lemmink en Martin Stevens, beste Koen en Martin bedankt voor jullie kritische maar altijd opbouwende commentaren en in het bijzonder jullie geduld. Het totale traject heeft "iets" langer geduurd dan oorspronkelijk gepland maar jullie hebben altijd het vertrouwen gehad in een goede afloop waarvoor mijn dank. Prof. dr. E. Scherder, beste Erik. Pas tegen het eind van mijn promotietraject kregen we met elkaar te maken. Jouw opmerkingen hebben mij vooral in de eindfase gemotiveerd om ook de laatste publicaties eruit te slepen. Bedankt voor de prettige samenwerking. Ook wil ik emeritus hoogleraar P. Rispens als een van de initiatiefnemers van de ontwikkeling van GALM en Prof. dr. T. Mulder bedanken voor hun begeleiding in de beginfase van mijn promotietraject.

Prof. dr. R.L. Diercks, Prof. dr. J.W. Groothoff en Prof. dr. W. van Mechelen wil ik bedanken voor hun snelle en deskundige beoordeling van mijn manuscript.

Paul Huisman, Roy Stewart, Abby King, Patricia Schouwink en Ruth Rose bedank ik voor hun inhoudelijke, statistische en tekstuele ondersteuning tijdens de productie van deze dissertatie.

De uitvoering van dit onderzoek was nooit mogelijk geweest zonder de samenwerking met de lokale GALM projectgroepen in Losser, Heerenveen en Gouda. In het bijzonder wil ik Sportraad Zuid-Holland (inmiddels Sportservice Zuid-Holland), Sportraad Overijssel en SPORT fryslân noemen, bedankt Veronique van der Hoorn, Anita Bakker en Krijn van Houten. Daarnaast ben ik natuurlijk alle deelnemende ouderen in deze gemeenten zeer erkentelijk voor hun medewerking en deelname aan de vele interviews en testen.

In de loop van mijn promotietraject is het Instituut voor Sportstudies (HIS) van de Hanzehogeschool Groningen mijn werkgever geworden. Tijdens en naast de werkzaamheden voor het Instituut heb ik de ruimte en mogelijkheden gekregen mijn promotie af te ronden. Ik wil iedereen die me hierbij ondersteund heeft en in het bijzonder de leden van het team Sportgezondheid en de dean van het Instituut Bert van der Tuuk hartelijk bedanken voor deze geboden ruimte. Ik hoop de opgedane know how via

het onderwijs en het net opgerichte lectoraat Sportwetenschap in te kunnen brengen en een rol te kunnen spelen in de verdere intensivering van de samenwerking tussen de Rijksuniversiteit Groningen en de Hanzehogeschool Groningen.

De (ex)leden van het landelijke implementatieteam GALM (Casper Dirks, Ger Kroes, Mathieu de Greef, Oscar Dorrestijn, Feyuna Jansma en Yldau Dijkstra) en mede initiator van GALM Petrus Bult wil ik bedanken voor de inspirerende pioniersfase van GALM die we met z'n allen hebben doorlopen. We waren, op de oudgedienden na, een stel jonge honden en hadden met z'n allen heel veel dadendrang en enthousiasme. Uiteindelijk hebben we een heel goed project ontwikkeld en uitgevoerd waaraan zeer veel ouderen in binnen- en zelfs buitenland wekelijks meedoen. Jullie gezelschap, humor en samenwerking voorafgaand en tijdens het GALM effectonderzoek heb ik altijd als zeer prettig ervaren.

Kitty Leibbrand, beste Kitty, bedankt voor de administratie, telefoontjes, trainingen, testen, interviews etc. die je mij uit handen hebt genomen tijdens de uitvoering van het onderzoek en minstens zo belangrijk de gezelligheid tijdens de vele meetmomenten. Ik heb aan deze tijd een goede vriendin overgehouden en ben ook erg blij dat je als paranimf wilt optreden.

Oscar Dorrestijn, tijdens onze inspirerende fietstochten hebben we veel promotiezaken doorgenomen van positief tot negatief. Inmiddels zit jij nu in hetzelfde schuitje. Een advies van mij, neem mijn tijdspad niet als voorbeeld. Tot slot wil ik ook jou bedanken dat je als paranimf wilt optreden.

Heit en mem, Migchiel, Sandra, Gerard, Judy, Bastiaan-Willem, Marlon, Jeroen en Bineke, jullie wil ik bedanken voor het aanhoren van mijn gemopper tijdens de mindere momenten, het begrip hebben voor het weer verschuiven van deadlines en de vele ongeplande werkmomenten. Ik heb jullie positieve steun altijd erg gewaardeerd.

Voordat ik dit dankwoord afsluit wil ik iedereen, die ik onbewust vergeten ben te noemen in dit dankwoord maar wel een rol gespeeld heeft in de totstandkoming van dit proefschrift, hartelijk bedanken.

Last, but certainly not least wil ik met het noemen van twee hele dierbare en belangrijke personen in mijn leven dit dankwoord besluiten. Lieve Esther en Tim, door jullie onvoorwaardelijke steun, geduld en geloof in de goede afloop heb ik dit proefschrift uiteindelijk na al die jaren kunnen en mogen afronden. Het was zeker niet gemakkelijk als ik weer eens kwam vertellen dat ik een weekend of een vakantie moest doorwerken en privézaken moest wijken.

Naast de promotietraject werkzaamheden hebben we gezamenlijk nog het nodige meegemaakt wat het allemaal nog eens extra intensief gemaakt heeft. Als ik hierop terugkijk kan ik alleen maar zeggen dat ik heel erg trots ben op hoe we deze periode in eerste instantie met z'n tweeën en later met z'n drieën volbracht hebben. Nu we de finish hebben gehaald van deze duurprestatie genaamd promotie, gaan we een hoop andere leuke dingen doen. In een woord **BEDANKT Esther en Tim**!