The GALM effect study

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The GALM effect study

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

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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 van 55 tot 65 jaar. Deze dissertatie beschrijft de resultaten van de longitudinale studie naar de effecten van deelname aan GALM.

Johan de Jong

Contents

General introduction

Chapter 1

1. Introduction

In Western society, older adults form a population segment that is growing in numbers as well as in age. In 2004, the mean percentage of people over age 65 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 by 50% by the year 2025.[1] The mean age of the older adults is also still growing. From 1980 to 2004, life expectancy after the age of 65 has developed from 15.53 to 18.36 and 16.51 to 18.37 years in Europe and the Netherlands, respectively.[2]

With this in mind, reducing and postponing disability, diseases and the functional loss that accompany 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 aspects of cardiovascular function (e.g. VO_2max, cardiac output) as well as enhancing submaximal performance. Strength training can help offset the loss in muscle mass and strength associated with normal aging.

Health status can also be improved through a reduction in risk factors associated with disease states (e.g. cardiovascular disease, non-insulin dependent diabetes mellitus, hypertension, colon cancer, obesity, etc.), thereby increasing life expectancy. Additional benefits of regular exercise include improvement of bone health and thus a reduced 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 and alleviation of depression symptoms and behavior. In conclusion, the benefits associated with regular exercise and physical activity contribute to a more healthy 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 1990s, actual data with respect to physical inactivity among older adults was scarce. Depending on the measurement methods used, physical inactivity percentages varied between 35 and 80% of Dutch older adults.[7,8]

1.1 Physical activity, fitness and health

A conceptual model that illustrates the interrelatedness between physical activity, fitness and health is 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, and household and other cores (e.g. nursing relatives).

With respect to 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 sports performance. Regarding older adults, performance-based fitness refers to components necessary to optimally perform activities of daily living.[3] Performance-based fitness depends heavily on motor skills, cardiorespiratory power and capacity, muscular strength, power or endurance, body size, body composition, motivation and nutritional status.[3]

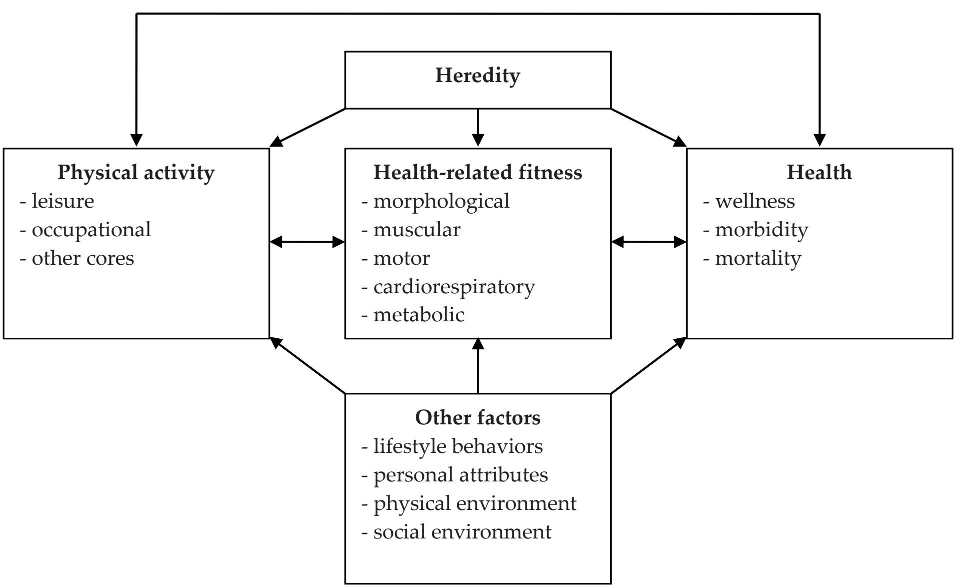

Figure 1. The Bouchard model.[3]

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 include morphological (e.g. body composition, flexibility), muscular (e.g. power, strength, endurance), motor (e.g. balance, coordination), cardiorespiratory (e.g. maximum aerobic capacity, lung 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 health-related fitness, a major point of criticism of the Bouchard model appears. Within the Bouchard model there is a lack of clarity 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, makes both components relevant to be assessed in this study. In the progress of this thesis the terms performance-based fitness and health indicators will be used referring to 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), as well as morbidity and mortality (negative health). The Bouchard model summarizes the interrelationships that appear between physical activity, fitness and health. 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 also influence the three key concepts and their interrelationships.

From the perspective of public health, the Bouchard model shows that physical activity, by influencing fitness, can influence health and vice versa. An independent mutual link is also possible between physical activity and health, regardless of 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 section the focus will lie on these two relationships by 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 of 8-10 different exercises at least twice a week) is suggested. Besides these guidelines, which focus primarily on cardiorespiratory and muscular fitness, they also recognized the potential health benefits of more frequent regular exercise at lower intensity for longer duration, independently of cardiorespiratory fitness. The 1990 recommendations stated that levels of physical activity lower 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 a primary focus on the link 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, preferably all days of the week. These 30 minutes could be covered 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 longer duration.

In 1998, besides the recommendations for adults,[12] the ACSM 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 focus not only on improving or maintaining health but also on improving cardiorespiratory fitness, strength, coordination and flexibility. To reach these objectives, in order to enhance not only health but also the cardiorespiratory fitness and the ability to perform daily activities independently, the 1998 recommendations promote physical activities of longer duration and higher intensity than recommended by the 1995 ACSM/CDC guidelines. Based on the 1995 and 1998 recommendations, a Dutch recommendation entitled *de Nederlandse Norm voor Gezond Bewegen* (NNGB), was developed in 1998.[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 number of studies reporting on the effects of uni- or bi-dimensional exercise-based physical activity (training) programs, evidence on multi-modal physical activity programs remains scarce. These multi-modal programs can be characterized by simultaneously prescribed doses and intensities of strength, aerobic and balance training, and are feasible and capable of eliciting changes in physical functioning and quality of life.

Baker et al. (2007) conducted a systematic review on the effects of multi-modal exercise programs for older adults, and in the end 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 criterion (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 3-12 months. The general 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 untill now 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 multi-dimensional 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 in the GALM recreational sports program.[15,16,18]

The content of the recreational sports 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, GALM differs on several points: 1) the content of the GALM program is primarily based on behavioral change theories; 2) for reasons of compliance with the program, GALM is versatile and sessions are held once a 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. It differs from other multi-modal exercise programs in that it consists of recreational sports activities. To our knowledge, no study so far has reported on the effects of physical activity, health and fitness after participating in a recreational sports program for 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, thanks to the versatile nature of the GALM recreational sports program participants can develop preferences toward one or more physical activity modes which they may conduct in addition to GALM. If this transfer occurs, the increase in physical activity can lead to improvements 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 the thesis

In *Chapter 2* the recruitment phase of GALM and its efficiency in selecting and including sedentary and underactive older adults in the 55-65 age category is described.

Chapter 3 depicts the background and intensity of the GALM physical activity program. The theories on which the GALM physical activity program is based and the translation to practice are elaborated on. The intensity of the program is measured objectively, based on heart rate monitoring.

Chapter 4 presents the six-month effects of participation in the GALM program on physical activity, health and fitness outcomes.

Chapter 5 provides the longitudinal results after twelve months of participation in the GALM program for physical activity, health and fitness outcomes.

Chapter 6 describes the longitudinal changes in heart rate during submaximal exercise as an indicator of cardiovascular function after 18 months of participation in the GALM program.

In *Chapter 7* the major findings of the study and the overall effects of participation in the GALM program for physical activity, health and fitness outcomes are discussed.

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The Groningen Active Living Model, an example of successful recruitment of sedentary and underactive older adults

Chapter 2

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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.

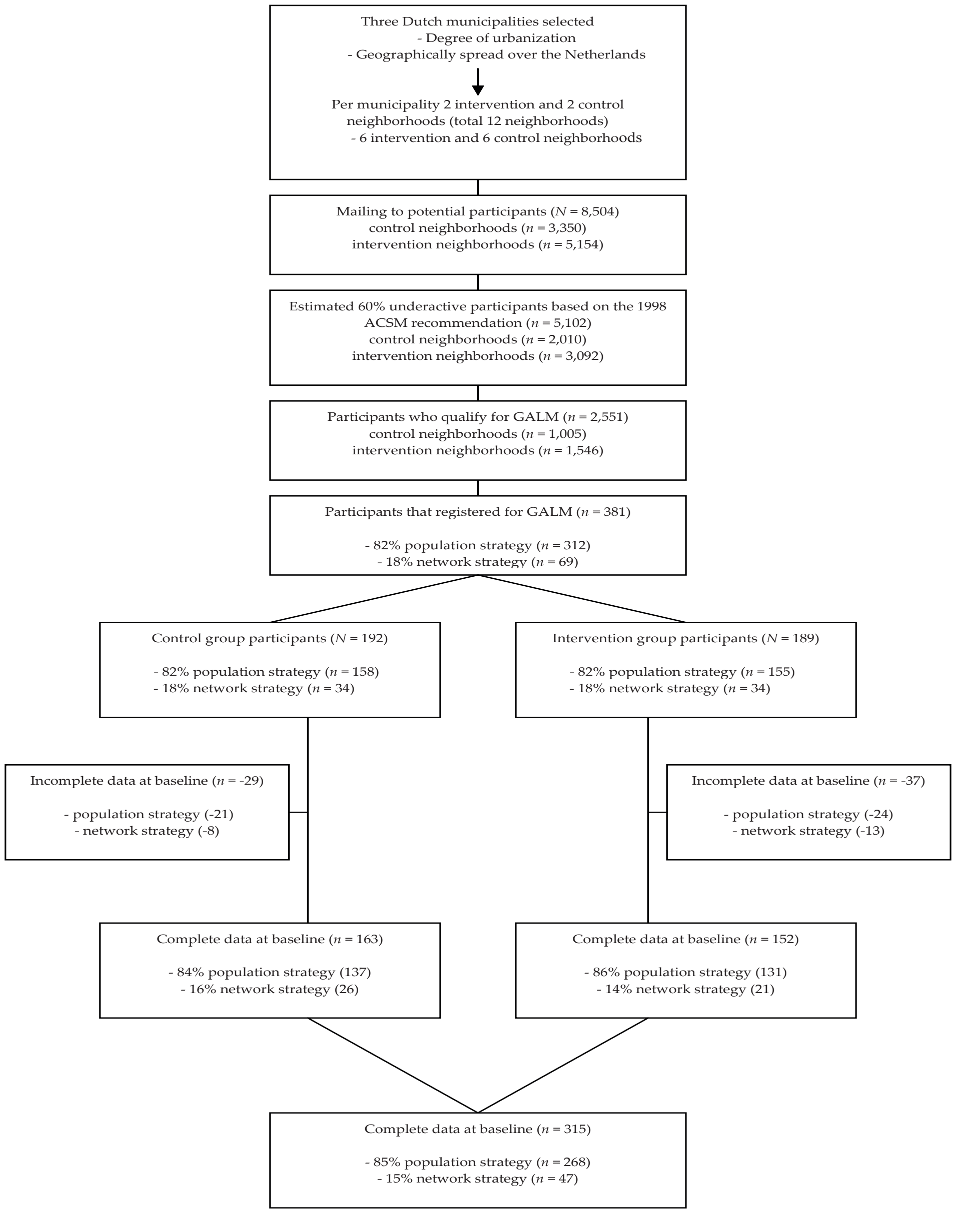

Figure 1. Results of the GALM recruitment strategy (Fall 2000, the Netherlands).

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		χ^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		χ^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 I am thinking about starting within 6 months" or "I am not regularly active in recreational sports activities" (less than 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 sports 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

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Background and intensity of the GALM physical activity program

Chapter 3

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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 that is, on average, of moderate intensity, participants will 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 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 program 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 to 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 coefficients 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 min 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 to 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 to 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 to 25 min of playing in which the learned and practiced skills were used in the context of a game or other activities; d) 5 to 10 min of cooling-down consisting of flexibility and relaxation activities. After each session, a 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 y (*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 to 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 (y)	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/m^2)	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.

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 an evolutionary-biological 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 and leisure-time sport activity scheme (Table 1) had to be adhered to strictly and all instructors completed a 3-d GALM training course.

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.

Recreational sports activity	Heart rate monitoring					
	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)	65.0 (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 to 69% of HRmax.[12]

Hard, ≥70 of HRmax.[12]

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 session, the introductory/ball game and the dance session.

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_2max it can be concluded that the overall mean intensity of the GALM program was about 60% of VO_2max or heart rate reserve with a variation between 50% and about 72% of VO_2max.[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 appear 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 program 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]

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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

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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 neighborhoods 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 emphasizing 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, favoring 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 characterized 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 hypothesized that increased physical activity could lead to significant improvements in health and fitness outcomes.[20,21]

Method

Study design and subjects

A group-randomized trial was used. Based on urbanization 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 neighborhoods that were assigned as intervention or control neighborhoods. These twelve neighborhoods were matched on number of older adults aged 55-65 living in that neighborhood and socioeconomic status, and randomly assigned to study condition within matched pairs. Older adults from the six intervention neighborhoods automatically became intervention group participants (IG). Correspondingly, older adults from the six control neighborhoods 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]

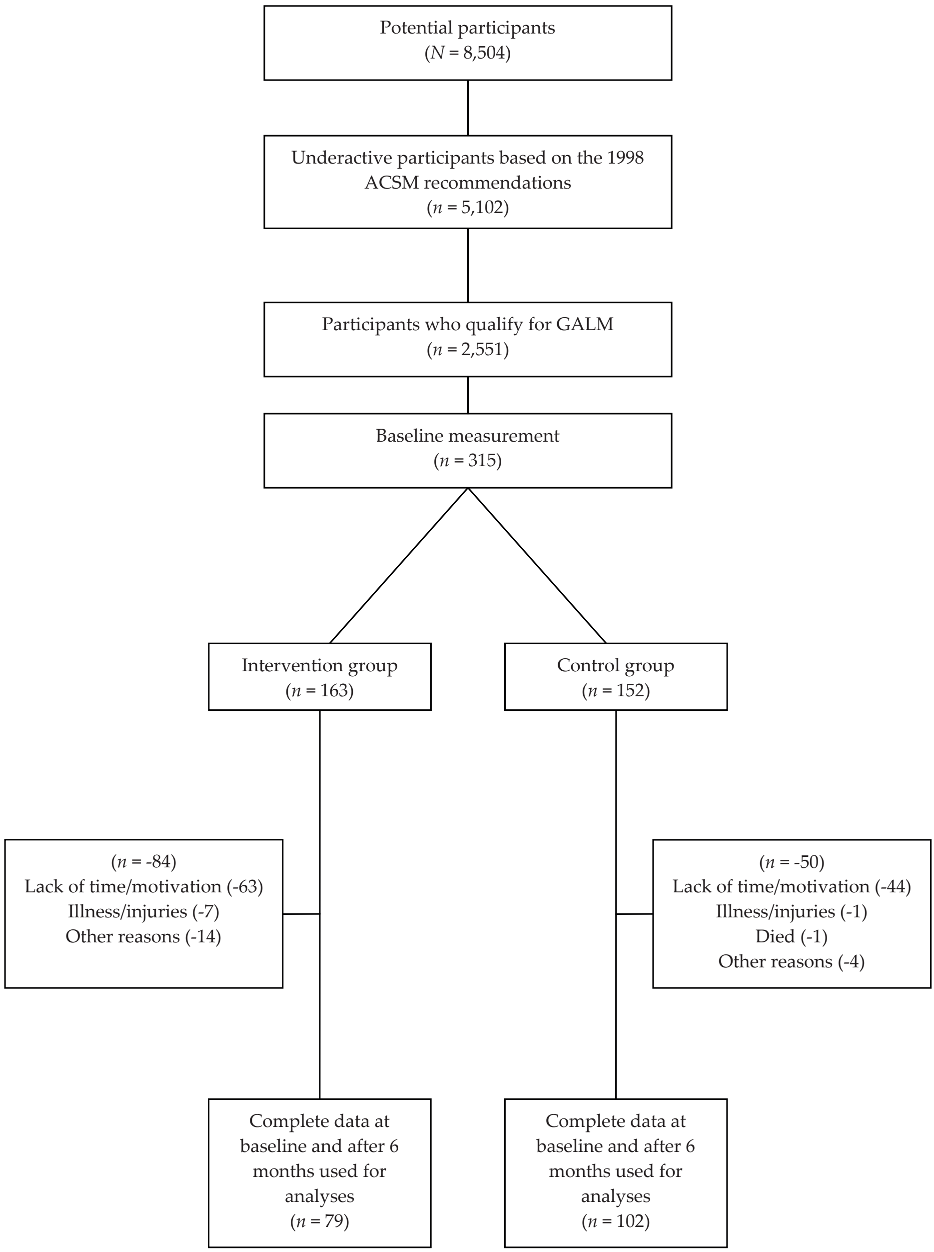

Figure 1. Participants flow.

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 characterized as a leisure-time physical activity program emphasizing 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 favorite recreational sports activities were incorporated into the GALM program (e.g. softball, dance, self-defense, 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 neighborhoods 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 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 analyzed 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 neighborhood 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 analyzed according to the initial randomized assignment.

Secondary analyzes 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%, *SD* = 19).

Table 1. Main characteristics at baseline.

Characteristics	Intervention group (n = 79)	Control group (n = 102)	F/χ^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/m^2)				
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 favor 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, $p < 0.05$).

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

Characteristics	Intervention group (n = 79) Mean (SD)	Control group (n = 102) 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$^2/_3$ m)	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 (x$16^2/_3$m)	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.*

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 at 6 months ($F = 3.07$; $p < 0.05$). All indicators of health showed favorable 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. Participants 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 generalizability of our study results are high, given that we conducted this study in a real community setting (i.e. the individuals' neighborhoods).

Increased levels of energy expenditure in RECSPORT 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 individualized 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 behavior and artificially influenced behavior, 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 behavior 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 favoring 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 neighbors, 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 neighborhood-oriented recruitment phase and the recreational sports activity program which is based on behavioral 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.

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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

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Abstract

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

Methods
Subjects from matched neighborhoods 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 behavioral 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. 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 individualized 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 generalizability 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 favoring 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-randomized (cluster) design was used. Five degrees of urbanization are applied to municipalities in the Netherlands (category 1 to 5) based on the number of people living per square kilometer.[15] In order to represent a good cross-section of the Dutch population, we selected municipalities with different degrees of urbanization: (1) a highly urbanized municipality (category 1); (2) a middle-level urbanized municipality (category 3); and (3) a rural municipality (category 5). Ultimately, three municipalities representing these different degrees of urbanization and were geographically spread over the Netherlands were selected. In the fall of 2000, in each municipality, recruitment took place in four neighborhoods (designated as 'neighborhoods' by local government regulation), of which two were randomly assigned as intervention and two as control neighborhoods. Ultimately, this resulted in six intervention (IG) and six control (CG) neighborhoods 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

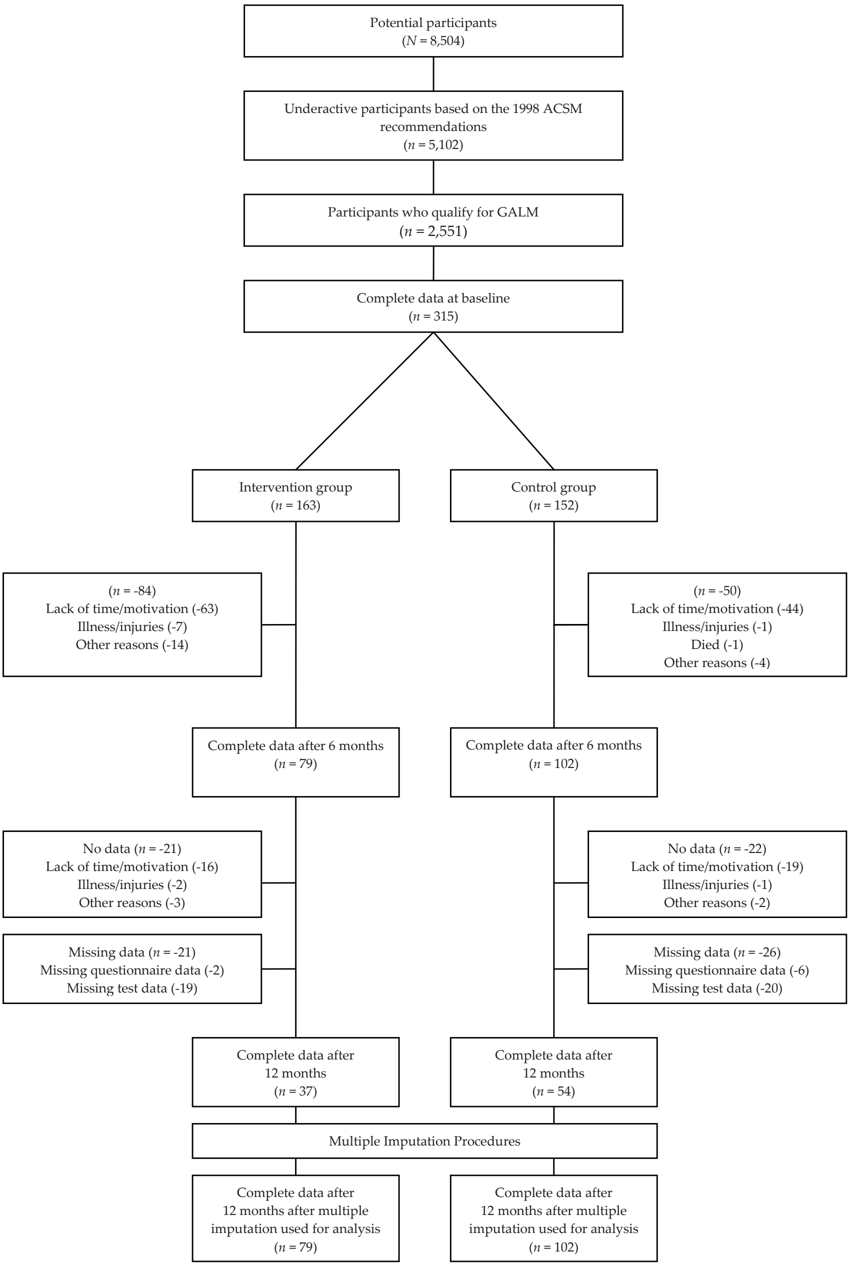

Figure 1. Participants flow.

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 characterized as a leisure-time physical activity program emphasizing moderate-intensity recreational sports activities (e.g. softball, dance, self-defense, 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 neighborhoods to diminish travelling distance and to make use of the neighborhood-based social structure.

An additional methodological advantage of older adults participating in the GALM program in their own neighborhood was that it prevented possible contamination between neighborhoods. 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 analyzed 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 measurement.

	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/m^2)	-	-	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 analyzed using MLwiN (2004, 2.01) and SPSS version 10 (SPSS Inc., Chicago IL., 1999). Since we already checked that municipality and neighborhood 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 randomized 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.

Table 2. Main characteristics at baseline.

Characteristics	Intervention group (n = 79)	Control group (n = 102)	F/χ^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/m^2)				
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.*

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.

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 favorable 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

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	Main effect	Time x
	T0	T1	T2	T0	T1	T2	Time	Group	Group
Characteristics	Mean [95% CI]	Mean [95% CI]	Mean [95% CI]	Mean [95% CI]	Mean [95% CI]	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/m²)	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 (x16²/3m)	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.

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 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 behavior and artificially influenced behavior.[12,38,39]

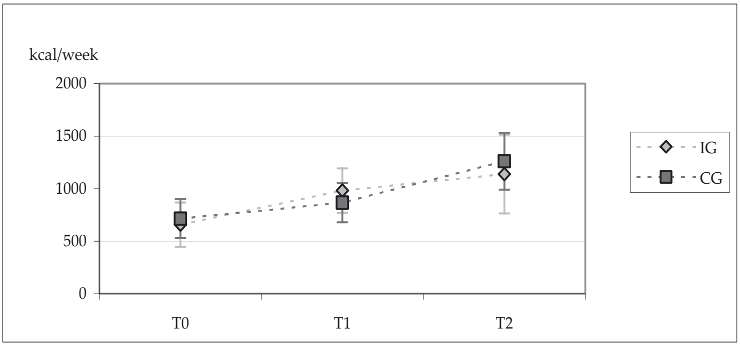

Figure 2a. $EE_{RECSPORT}$ for the IG and CG over time.

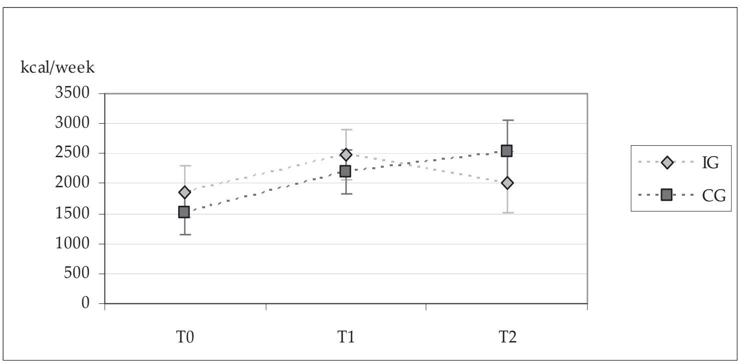

Figure 2b. EE_{LTPA} for the IG and CG over time.

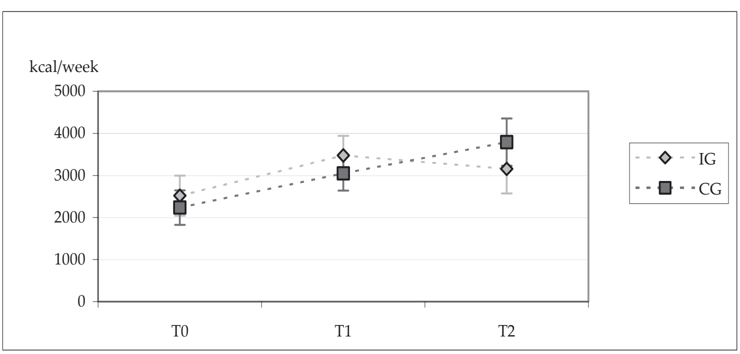

Figure 2c. EE_{TOTAL} for the IG and CG over time.

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.

Finally, regarding EE_{TOTAL}, the results demonstrate that the IG increased from baseline to 6 months and decreased from 6 to 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 favorable 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 unfavorable 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 multi-component 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 multi-dimensional 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 generalizability 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-month 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 behavioral 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 individualized 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.

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

Chapter 6

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Abstract

Objective

To investigate changes in heart rate during submaximal exercise as an index of cardiovascular function in older adults participating in the GALM recreational sports program who were sedentary or underactive at baseline.

Methods

A repeated measurement design was conducted; 151 participants were included, providing 398 heart rate files over a period of 18 months of GALM. Multilevel analyses were conducted; growth and final models containing a time variable and the covariates of sex, BMI, energy expenditure for recreational sports activities ($EE_{RECSPORT}$) and leisure-time physical activities (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 4-, 5-, 6- and 7 km/h walking speeds; relative decreases ranged from 5.1 to 7.4%.

Conclusions

Significant decreases found in heart rate during submaximal exercise reflected a potential 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 European and Dutch societies.[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_2max. Another marker of increase in cardiovascular function is a lowering of the heart rate or bradycardia at rest and during submaximal exercise.[5,6] Aerobic exercise also enhances submaximal performance in older adults.[3,4,7]

A component which reflects cardiovascular function and is highly relevant for older adults is maximal oxygen consumption (VO_2max). VO_2max 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_2max as younger adults.[3] The magnitude of the increase in VO_2max in older adults is also a function of training intensity, with light-intensity training eliciting minimal or no changes vs. high-intensity exercise.

Indirect methods estimate VO_2max from maximal exercise duration, peak workload and/or heart rate responses achieved during submaximal or maximal exercise. Increased levels of VO_2max, mean that submaximal exercise becomes lighter (i.e. easier to undertake), reflected by a decline in heart rate response to a fixed submaximal power output on a cycle ergometer, a fixed walking or running speed.[5-7] Regular participation in moderate-intensity or more vigorous exercise can result in a range of positive cardiovascular effects. For example, over time submaximal exercise is marked by a decreased physiological demand (i.e. lower heart rate) for a given task, so that tasks that previously seemed difficult and fatiguing become easier, and enjoyable everyday pursuits can be continued for a longer time.[8] Such adaptations can delay or overcome functional limitations that may otherwise be imposed by the physiological changes of ageing and disease.[8]

It has thus become widely accepted that heart rates during steady-state submaximal exercise at the same absolute rate of work can be substantially reduced over time with aerobic exercise training. Hence reduction in heart rate at fixed submaximal exercise over time is an objective and relevant indicator for change in cardiovascular function among older adults.[5-7]

Until now, most research on 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). The aim of this study is to investigate whether the versatile GALM physical activity program consisting of a diversity of recreational sports activities (e.g. softball, dance, self-defense, swimming, athletics, etc.) can also improve cardiovascular function in older adults effectively. The GALM recreational sports program, which is primarily based on an evolutionary-biological play theory and insights of social cognitive theory, aims at stimulating these activities in sedentary and underactive older adults aged 55-65.[9,10] Previous results of the GALM recreational sports program (see description below) illustrate that the overall mean intensity of the program was 73.7% of the predicted heart rate maximum.[10,11] From baseline to 12 months, participants in the intervention and control groups increase $EE_{RECSPORT}$ to 482 and 546 kcal/week, respectively. Increases in EE_{LTPA} were 207 and 1011 kcal/week for the intervention and control groups, respectively.[12] These changes indicate that participants increased their physical activity levels not only during the GALM sessions but also outside of the GALM program, given that the mean targeted kcal/week increase associated with the GALM recreational sports program was approximately 385 kcal/week.

To determine possible adaptations in cardiovascular function, the focus of the current investigation was to evaluate the longitudinal changes in heart rate during submaximal exercise as an index of cardiovascular function after 18 months of participation in the GALM recreational sports program.

Methods

Participants and procedures

This study was part of a broader/larger study into the effects of participation in the GALM recreational sports program on physical activity, health and fitness which was conducted in 2000-2003 in the Netherlands. In this broad study, 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 those who could be considered sedentary or underactive. Based on estimates of population-based data, about 60% (*n* = 5,102) could be considered sedentary or underactive according to the 1998 ACSM recommendations.[3] Based on a study of this type of recruitment strategy, it was projected that approximately half of the 60% (*n* = 2,551) qualified for GALM.[13] The other half was not interested or unable to participate (personal circumstances such as illness, work, family caregiving).[9]

Ultimately, a total of 315 sedentary and underactive older adults (12% of qualified individuals) participated in all of the baseline measurements; 181 of them (57%) also participated in the follow-up measurements and were included in this study. The 134 study participants who dropped out were not significantly different with respect to sex, age, stage of motivational readiness for behavioral change, $EE_{RECSPORT}$, EE_{LTP} and health and fitness measures.[14]

Over a period of two years, 181 adults were measured after each series of 15 GALM sessions: 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 the remaining 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 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-defense, swimming, athletics) and consists of fifteen 60-min sessions at a frequency of once a week. Participants attended three 15-session series for a period of two years. The control group was placed on a waiting list for 6 months before starting.

The structure of each GALM session was a follows: (1) 5-10 minutes warm-up period; (2) 20-25 minutes of skills practicing in which the exercises offered were differentiated according to participants' level and need, 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 that participants lived in. 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. For reasons of program homogeneity, the instructors followed a scheme that prescribed the recreational sports activities and routines for GALM sessions. The frequency of the GALM sessions was once a week and sessions lasted 60 minutes. Previous results illustrate that the overall mean intensity for the GALM recreational sports program was 73.7% of the predicted heart rate maximum, with percentages ranging from 64.6% for the fitness session to 83.1% for the korfball session, respectively;[10] 33% of the session time could be classified as moderate and 61% as hard.[15]

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 three minutes, starting at a speed of 4 km/h and ending at 7 km/h.[16] 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 four 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). For reasons of standardization, participants were instructed not to eat or drink two hours prior to the measurements.

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) activities were estimated by using two categories of the Voorrips physical activity questionnaire combined with the compendium of Physical Activities.[17,18]

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).[19]

Statistical analyses

Data were analyzed using SPSS version 14.0 (SPSS Inc., Chicago, 2005) and MlwiN (2005, 2.02). Longitudinal changes in heart rate at submaximal exercise were investigated using multilevel modelling. Besides the advantage of multilevel analysis taking into account possible clustering effects, another benefit deserves mention: 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.[20]

Based on a previous analysis, the expectation was of no significant differences between the intervention and control groups.[12] Before starting the multilevel analysis, we first confirmed this assumption of no significant between-group differences ($p > 0.05$). As this was indeed the case, we combined the intervention and control groups and 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).[20,21] The first step in the multilevel modelling of heart rate at submaximal intensity exercise was to employ a growth model (model 1) consisting of an initial status (e.g. mean heart rate at a fixed walking speed) and the time variable (time). Next, 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 (attended sessions per time frame of 6 months/maximal number of 15 sessions offered x 100%) 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.*

Read vertically, Table 2 presents the mean heart rate values per walking speed at each measurement (T0 to T4). 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/h 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).[11]

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. 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 for each walking speed. 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 ($p > 0.05$). No significant main effects were found for $EE_{RECSPORT}$ and EE_{LTPA} ($p > 0.05$) either, except for EE_{LTPA} at walking speed 7 km/h ($p < 0.01$). Finally, the residual variances derived from model 1 in Table 3 show that the residual variances for between-individuals (level 2) were about twice as large (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 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 is 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.

Finally, subgroup analyses were conducted to examine if there were differences between participants who were more fit and made it to the highest walking speed (7 km/h) vs. participants who had to stop at lower walking speeds at baseline. In this way two groups were formed: 1) a group consisting of 54 participants who completed the highest walking speed at baseline; and 2) a group of 97 participants who did not finish the highest walking speed of 7 km/h at baseline. After adding this variable to the final multilevel model, no significant differences were found between the two groups at walking speeds of 4, 5 and 6 km/h (p-values > 0.05).

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/m^2)				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/m^2)				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/m^2; [f]$EE_{RECSPORT}$ = energy expenditure for recreational sports activities; [g]EE_{LTPA} = energy expenditure for leisure-time physical activities.

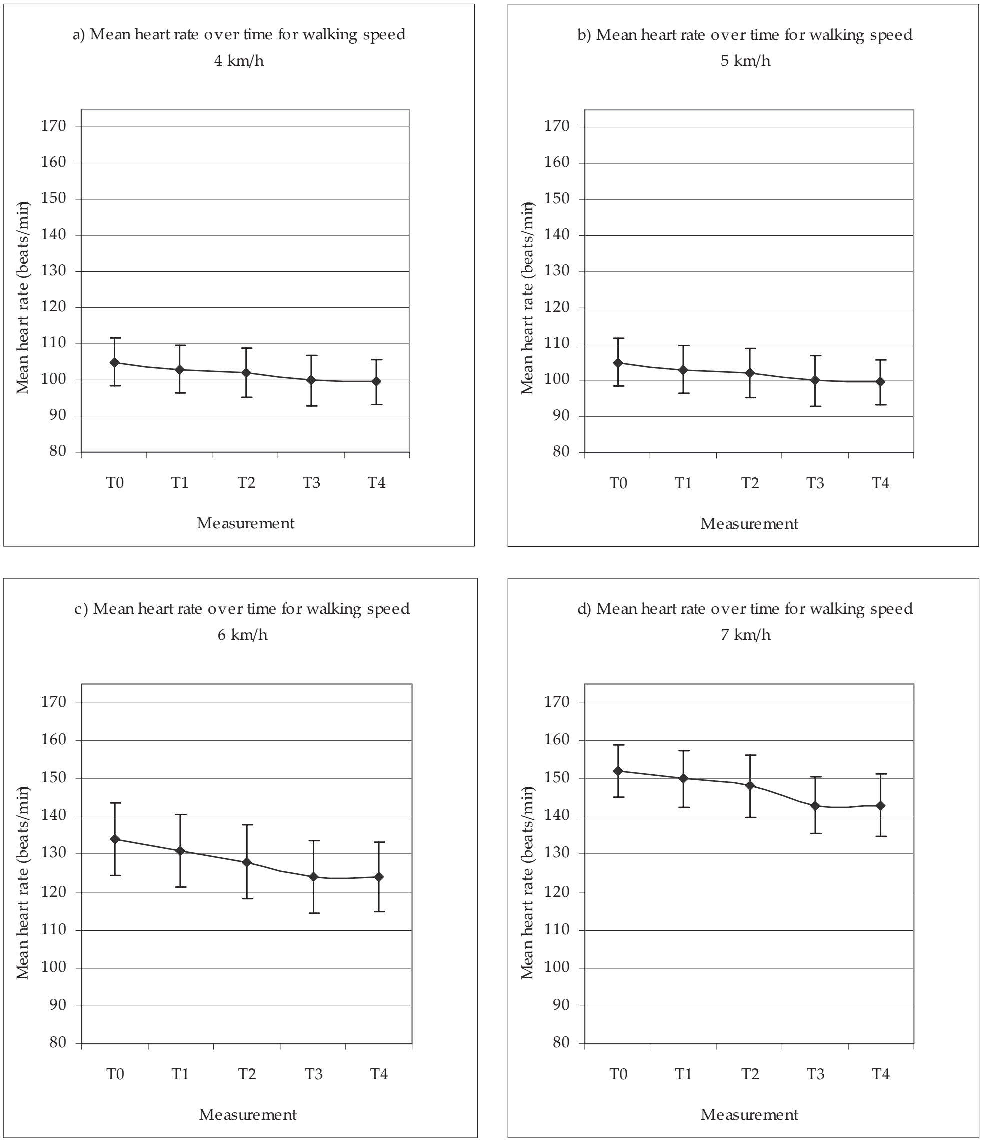

Figure 1a-1d. *Predicted mean heart rate per walking speed over time.*

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, Lemmink, Durandt and Lambert (2004) 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%.[22] The relative changes in heart rate from baseline to T4 in our study ranged from 5.1% to 7.4%; this clearly outscores the standard error reported by Lamberts et al. (2004) and could be considered beyond the natural variation for that variable. However, a comparison between the two studies needs to be interpreted with some caution as that study was based on a younger population.[22]

In addition, it is important to note some limitations of this study. First of all the study did not contain a control group, so results must be interpreted with caution. Secondly, we did not succeed in measuring the resting heart rate. Many studies report on adaptations in resting heart rate. So, results on changes in resting heart rate during participation in the GALM recreational sports program would have been valuable. Before starting the walking test, participants were asked to sit still for five minutes and not touch the heart rate transmitter that was attached via a chest strap. Many participants of this community-based program did not follow the instructions though, with a lack of standardization of resting heart rate as result. Consequently, these data were not considered reliable and were excluded from further analysis. Finally, not all participants had data of all measurements over time, which would have strengthened the results of this study. To that end, multilevel modelling was used. In longitudinal community-based studies with missing data at different moments in time, multilevel modelling is a good alternative in treating such unbalanced data structures and making full use of all available data with participants with few measurements accounting only little in the final results.[20]

Although the GALM recreational sports program is not a high-intensity endurance-based exercise program, a significant decrease in heart rate during submaximal exercise was found. The magnitude of training effects depends on frequency of training, type of activity, activity duration and, foremost, intensity of the activities performed. An earlier study evaluating the intensity of the GALM recreational sports program demonstrated that the overall mean intensity was 73.7% of predicted maximum heart rate,[10,11] which places the program within the intensity guidelines recommended to enhance aerobic fitness.[3,15] The intensity of the GALM recreational sports 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.[23]

Furthermore, the results of GALM are in line with studies by Carter, Banister & Blaber (2003) and Belman & Geasser (1991).[24,25] Carter et al. found a reduction in heart rate during submaximal exercise of 8.1 ± 0.67 beats/min or 6% after endurance training.[24] Belman & Geasser found a comparable training-induced reduction in heart rate of 8 beats/min at a submaximal power output after 8 weeks of lower-intensity exercise training (30 min walking at 50% of VO_2max four times a week).[25] From boths studies it can be concluded that GALM elicits equal increases in cardiovascular function compared with endurance training program. A point of discussion is the adaptation time, since the Carter et al. and Belman & Geasser endurance program sessions took a 12 and 8-week period, respectively, while comparable changes in GALM took 12 to 18 monts.

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 recreational sports program provided a sufficient training load during the first 12 months but no more after that. A potential suggestion concerns promoting more overload, and thus heart rate-related benefits, 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; however, this does 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.[26,27]

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 of self-reported physical activity for recreational sports activities ($EE_{RECSPORT}$: 0-6848 kcal/week), especially leisure-time physical activities (EE_{LTPA}: 0-18560 kcal/week). Consequently, changes in heart rate that might normally be statistically significantly related to energy expenditure for physical activity potentially vanished because of the broad variation in both energy expenditure measures. Another explanation could be the misclassification of activities on the Voorrips physical activity questionnaire concerning walking and cycling for transportation vs. recreational sports activities. Alternatively, the chosen physical activity questionnaire might not have been accurate enough in relation to the number of participants included.

For future investigations 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.[28]

Conclusion

In summary, our study demonstrates that long-term participation in the GALM recreational sports program significantly decreases heart rate during submaximal exercise, implying an increase in cardiovascular function of sedentary and underactive older adults aged 55-65. This increase in cardiovascular function is comparable with other training programs. The results show that the GALM recreational sports program, which is primarily based on an evolutionary-biological play theory and insights from social cognitive theory, is as effective towards improving cardiovascular function as programs that are primarily based on training principles (intensity, frequency and duration).

Since this study was conducted in a real community setting, the results are relevant from public health perspective. From research into the effectiveness of the recruitment strategy of GALM we know that five percent (5.4%) of the GALM participants fit within the pre-contemplation phase and 74% of the participants in the contemplation/preparation phase as measured with the Dutch version of the Stages of Change questionnaire at the start of the program.[13] In addition, a comparison between GALM particpants' 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, which underlines that they are less fit.[14] From the literature it is known that people with low levels of fitness and health can gain most from a small increase in physical activity.[23,29] Hence from a public-health perspective it can be concluded that participation in GALM can have a potentially significant impact on fitness and health of sedentary and underactive older adults.

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General discussion

Chapter 7

7.1 Introduction

Two studies were conducted during the nationwide implementation of GALM. First a study on the development and initial validation of the behavioral change model underlying GALM was conducted, which resulted in the thesis of Martin Stevens (2001).[1] The second study, into the effects of participation in GALM on physical activity, health and fitness outcomes, is 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 provided 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 on the effects of participation in GALM on physical activity, health and fitness. The results showed that of the 12.3% of older adults who were included, 79.4% could be indeed considered sedentary or underactive. This implies 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 multi-dimensional 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]

Chapters 4 and *5* report on 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 as well as in the control group. These latter results may indicate that the control group participants were primed by the attention that accompanies 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. A decline for EE_{LTPA} in the intervention group from 6 to 12 months was found that could not be explained by seasonal influences. This may reflect a compensatory mechanism also found in other studies — that doing more intensive physical activities (i.e. sports) is compensated by a decrease in the level of other physical activities among older adults. No noteworthy effects in health indicators were found. In summary, GALM demonstrated to have only 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 combining the results from *Chapters 2* to *6*, 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 of 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 multimodal recreational sports program on physical activity, health and fitness in sedentary and underactive older adults. Theoretical considerations regarding the effects on physical activity, health and fitness will be discussed in the remainder of this section.

Effects on recreational sports and leisure-time physical activities

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

for recreational sports activities from baseline to 12 months.

The increase in energy expenditure for recreational sports activities could be partly explained by participation in the GALM recreational sports program, so the remaining amount of energy increase was caused by recreational sports activities conducted in addition to GALM. This indicates 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* shows that some sort of compensatory mechanism took place. The intervention group demonstrated an increase in leisure-time physical activities from baseline to 6 months, however from 6 to 12 months a compensatory decline was found which could not be explained by seasonal influences. Whether these changes in leisure-time physical activities also occurred in the control group, which after a 6-month waiting list period was no longer a real control group, remains unclear.

In his review entitled "Physical activity as determinant of daily energy expenditure", Westerterp (2008) found similar results to GALM regarding the fact that an increase in more intense forms of physical activity (e.g. sports, exercise-training) go along with a compensatory decline in other daily physical activities.[3] In the review of Westerterp (2008), the study by Goran and Poehlman (1992) demonstrated no change in total energy expenditure among healthy older adults (ages 56-78) in response to endurance training.[4] One of their explanations was that the level of exercise, increasing to 85% of VO_2max, was too vigorous and thus fatigued them for the rest of the day. Meijer et al. (1999 & 2000) also found that a training program (50% of heart rate reserve) in older adults (ages 55-68) 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. Some differences between the studies mentioned by Westerterp (2008) and GALM must be taken into account though. 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. Furthermore, the energy expenditures values in the GALM study were derived from physical activity questionnaires vs. accelerometers in the studies described in the Westerterp review.[3]

In conclusion, the aforementioned assumption as stated in *Chapter 1* that GALM may cause a transfer towards physical activity besides 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 a week; b) duration of 60 minutes per week; c) is versatile and contains recreational sports activities; d) moderate to high intensity. From the results of *Chapters 4*, *5* and *6* it can be concluded that participation in the GALM program led to several favorable changes in performance-based fitness outcomes 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 that the study participants grew older, they demonstrated on average a clear and significant decline in heart rate during submaximal exercise, indicating that the activity became lighter for them. The studies of Meijer et al. (1999 & 2000) demonstrate 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 rate during submaximal exercise.[5,6]

Toraman (2004) described the effects of a multi-component training program on functional fitness in older adults aged 60-86 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, as significant results were found in what is 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 states that potential health benefits can occur as a 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 of other studies and this thesis it seems that participation in multi-component 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 specificity 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) were sufficient.[8,9]

GALM was based on the 1995 ACSM/CDC and 1998 ACSM recommendations. 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 (such as frequency and incorporation of vigorous-intensity physical activity) were more clarified and therefore improved the recommendation. This 2007 ACSM/AHA recommendation for older adults was also extended by the following: 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 a multi-modal nature, meets these updated recommendations that promote such an approach. The GALM recreational sport program combines moderate- and more vigorous-intensity physical activities, and because of its multi-modal nature pays attention to strength, balance and flexibility. From that perspective, GALM and other multi-modal physical activity programs can be considered as interesting, effective and attractive alternatives for future interventions aimed at stimulating physical activity in sedentary and underactive older adults. To also improve health-related fitness outcomes, additional actions should be promoted that lay more emphasis on increasing overall daily physical activity (individualized goal-setting for 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 will drop out of the study.[12] In the GALM effect study, a relatively high attrition rate occurred (*Chapters 4* and *5*) even though all sorts of preventive and reparative actions were undertaken to counter this (e.g. newsletter, phone calls). A major reason for the high attrition rate was that at each wave, measurements consisted of a questionnaire and test session. In practice, participants often missed one or more questionnaire and/or fitness test sessions due primarily to factors such as lack of time or inability to appear at the test session. Another aspect was the dropouts. If the dropout of subjects were to be selective, the results found would not be representative of all participants eligible for GALM. Still, comparison between dropouts and the GALM participants who stayed verified that no significant differences regarding main characteristics and outcome measures appeared at baseline. Reasons for the dropping 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 hoc imputation techniques (e.g. last observation carried forward) may result in misleading conclusions. Therefore multiple imputation procedures and multilevel 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 generalizable 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 municipalities 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 sports 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 on 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, control group participants were placed on a waiting list for only a short period of 6 months. 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 reaching level of significance may be this priming effect. The priming and the fact that the control group participants also started being physically active in GALM after their waiting list period resulted in no real control group being available after the 6-month study period, which is a limitation of 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 a broad range in energy scores at the group level. The small differences in energy expenditure scores for physical activity combined 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 with respect to the measurement of other leisure-time physical activities. From that perspective, the pattern from our study results — GALM not having a clear effect on health — may be a consequence of this.

However, the data cannot provide us with more information on this relation. On the other hand, validation studies show that physical activity questionnaires compiling information on high-intensity activities like sports are more reliable than questionnaires on other types of 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 and 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 (GFE, Groningen Fitness Test 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 and the control group, respectively, taking into account an 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 (*Chapters 4* and *5*) combined with the restricted sensitivity of especially the health measurements may have resulted in (small) changes remaining undetected or not reaching level of significance. For instance, in the GALM study body fat was predicted by means of bioelectrical 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 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

The present thesis revealed that participating in the GALM recreational sports 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 or health-related outcomes were found over a longer period of time.

To our knowledge, this study is the first to investigate the effects of a strategy containing a recruitment strategy that was feasible for community-based purposes on a large scale and a multi-modal recreational sports activity program for 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 like COACH for older adults who do not want to participate in group-based programs. There is also an opportunity for older adults with chronic diseases or limitations to join a group-based program entitled SCALA.[24,25] The multi-modal GALM recreational sports program could also be integrated into national initiatives like 'Beweegkuur'.[26] This project promotes primary and secondary prevention of diabetes mellitus type 2, a growing problem among older adults over 60 years of age in the Netherlands. Older adults are screened by physicians and subsequently advised to engage in a 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, multi-modal physical activity programs appear to be appealing, feasible and effective toward increasing performance-based fitness outcomes which are relevant for older adults to perform activities of 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 that can 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 among 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, hence efforts such as integrating individualized goal-setting for other physical activities, regular self-monitoring of targeted activities, reinforcement for reaching goals and behavioral skill-building are recommended to this end.

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Summary

Summary

Regular physical activity is considered to be 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. Physical activity can also improve functional capacity and therefore also the quality of life in older adults. Despite all these favorable effects, a substantial part of the Dutch older adult population 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 sports activities in sedentary and underactive older adults in the 55-65 age band. 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. The program was versatile in nature (e.g. softball, dance, self-defense, swimming, athletics, etc.) in two main ways: a) to improve compliance with the program different sports were offered, which was reported to be more appealing for older adults; b) by aiming at more components of motor fitness (e.g. strength, flexibility, speed, endurance and coordination). Between 1997 and 2005 more than 552,000 persons were visited door-to-door, over 55,700 were 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.

Chapter 2 describes 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 neighborhoods were included. Two of each of the four neighborhoods were randomly assigned as intervention and the others as control neighborhoods. 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. *Chapter 3* describes the intensity of this program systematically. Using 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.

Chapters 4 and 5 describe the effects of 6 and 12 months of participation in the GALM recreational sports program, and 181 persons were followed over time. Results after 6 months revealed only few significant between-group differences favoring 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 of 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, favoring the control group. In conclusion, a short-term increase in EE_{LTPA} was found with accompanying improvements in health outcomes that more or less disappeared in 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 a 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 during fixed submaximal exercise. Since both groups were comparable regarding changes in energy expenditure for physical activity after 6 months and testing confirmed this, both groups were combined and considered as one group. A multilevel analyses with a model for change was developed. A significant decrease in heart rate over time was found at all walking speeds (4, 5, 6 and 7 km/h). The average decrease in heart rate was 5.5, 6.0, 10.0 and 9.0 beats/min for the 4, 5, 6 and 7 km/h walking speeds, respectively. The relative decrease varied from 5.1 to 7.4% 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 toward 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 besides the favorable effects that were already seen, additional interventions that pay more attention to behavioral change in terms of how to integrate other activities besides sports activities are 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 verkleint. 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 Actief Leven 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 persoonlijke deur-aan-deur benadering vindt een fitheidstest plaats met daaropvolgend het GALM sportprogramma. Dit sportprogramma is gebaseerd op een biologisch-evolutionaire speltheorie 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 beweegwensen 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 552.000 personen benaderd, meer dan 55.700 personen getest en meer dan 41.310 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 controlewijken bestempeld. In totaal werden er 8.504 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 2.551 personen die voor GALM in aanmerking zouden kunnen komen) van de potentiële doelgroep lichamelijk inactieve ouderen te rekruteren. Van de gerekruteerde ouderen 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 sportprogramma 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 sportprogramma 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 activiteitenpatroon, fitheid en gezondheid te bepalen zijn 181 personen in de tijd gevolgd. Uit de resultaten van *hoofdstukken 4 en 5* kan geconcludeerd worden dat het energieverbruik voor overige activiteiten toeneemt gedurende de eerste 6 maanden in beide onderzoeksgroepen. Van 6 tot 12 maanden neemt deze vervolgens af in de interventiegroep, maar stijgt door in de controlegroep. 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 energieverbruik voor sportieve activiteiten stijgt echter over de gehele interventieperiode van 12 maanden. Deze tendens is ook waarneembaar in de metingen van motorische fitheid die resulteren 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 controlegroep meer verbetert. Samenvattend kan geconcludeerd worden dat er een korte termijn effect is van een toename in het lichamelijke activiteitenpatroon en de hiermee samenhangende kortstondige verbetering in gezondheidsindicatoren. GALM heeft een langduriger effect op het sportieve activiteitenniveau 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 controlegroep wat betreft energieverbruik 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/uur) werd een significante afname in hartslag over de tijd waargenomen. De afname in hartslag was 5,5, 6,0, 10,0 en 9,0 slagen/minuut voor de wandelsnelheden 4-, 5-, 6- en 7 km/uur en de relatieve afname varieerde van 5,1 tot 7,4% 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 sportprogramma maakt dat GALM uniek is. GALM slaagt er in gedurende een langere periode sportieve activiteiten en motorische fitheid positief te beïnvloeden. Om het lichamelijke activiteitenpatroon 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 en training van vaardigheden ten aanzien van gedragsverandering.

List of publications
&
curriculum vitae

List of publications

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Curriculum vitae

Johan de Jong is op 3 mei 1970 geboren in Bergum. Na zijn middelbare schoolperiode aan het Atheneum in Drachten (1982-1988) studeerde hij van 1988-1992 aan de Academie voor Lichamelijke Opvoeding (ALO) in Groningen. 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 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 bestonden 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 werkzaam 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 binnen het lectoraat 'Sportwetenschap' dat sinds 2007 onderdeel uitmaakt van het Instituut voor Sportstudies.

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Dankwoord

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