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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

Johan de Jonga,b,*, Koen A.P.M. Lemminkb, Abby C. Kingc, Mark Huismand, Martin Stevens
department of Psychology, University of Groningen, The Netherlands

department of Orthopaedics, University of Groningen, The Netherlands

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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 neighbourhoods were assigned to an intervention (IG) (n = 79) or a waiting-list control group (CG) (n = 102). During the 12 months the IG attended two series of 15 moderately intensive GALM sessions once a week and the CG attended one series after a 6-month waiting-list period.

Results: Significant time effects were found for energy expenditure for recreational sports activities (EERECSPORT), other leisure-time physical activity (EELTPA) and total physical activity (EETOTAL). EERECSPORT increased over 12 months for both groups while the significant time x group interaction for EELTPA 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.

Conclusion: Participation in GALM improved EERECSPORT after 12 months, which was reflected in increases in performance-based fitness. The increase in EELTPA 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 EELTPA, more attention should be paid to behavioural skill-building during the GALM program.

Keywords: Physical activity; Health; Fitness; Community-based strategy; Sedentary older adults

1. Introduction

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

To assist the maintenance of physical activity in older adults, especially sedentary and underactive older adults, interventions should be tailored to the individual’s wishes, preferences, and needs [7–9]. The GALM program has been developed to meet these criteria. Two programs that show similarities with GALM in that they were lifestyle oriented and individualised to the preferences and needs of the participants are the Community Healthy Activities Model Program for Seniors (CHAMPS II) and Project Active [10,11]. The CHAMPS II sample was well educated and the intervention was conducted in a high quality health care setting, reducing the generalisability of the results. A main difference between Project Active and GALM was the mean age of the participants, 46 years versus 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 (EETOTAL) were +989 and +813 kcal/week in the IG and CG, respectively. Significant between-group differences favouring the IG were obtained for sleep, diastolic blood pressure, perceived fitness score, and grip strength [12].

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

2. Methods

2.1. Study design and subjects

A group-randomised (cluster) design was used. Five degrees of urbanisation are applied to municipalities in The Netherlands (categories 1–5) based on the number of people living per square kilometre [15]. In order to represent a good cross-section of the Dutch population, we selected municipalities with different degrees of urbanisation: (1) a highly urbanised municipality (category 1); (2) a middle-level urbanised municipality (category 3); (3) a rural municipality (category 5). Ultimately, three municipalities representing these different degrees of urbanisation and were geographically spread over The Netherlands were selected. In the fall of 2000, in each municipality, recruitment took place in four neighbourhoods (designated as ‘neighbourghds’ by local government regulation), of which two were randomly assigned as intervention and two as control neighbourhoods. Ultimately, this resulted in six intervention (IG) and six control (CG) neighbourhoods over the three municipalities. The IG went through the regular GALM strategy and started with the intervention in January 2001. The CG started with the intervention after being placed on a waiting list for 6 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 of 5% and a power of 80%. Based on experiences from former GALM projects, a total of 8504 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 min. 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 = 5102) of the potential participants could be considered either sedentary or underactive according to the 1998 ACSM recommendations [3]. Half of this 60% (n = 2551) 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 (Fig. 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.
2.2. The GALM program

The GALM program can be characterised as a leisure-time physical activity program emphasising moderate-intensity recreational sports activities (e.g., softball, dance, self-defence, swimming, and athletics), and consists of fifteen 60-min sessions at a frequency of once a week, not including holidays [17]. The physical activities conducted were tailored by type, format, intensity, and frequency to meet the preferences and needs of participants. All sessions were conducted in groups of 15–24 participants and were held in a gymnasium located in or near the targeted
neighbourhoods to diminish travelling distance and to make use of the neighbourhood-based social structure. An additional methodological advantage of older adults participating in the GALM program in their own neighbourhood was that it prevented possible contamination between neighbourhoods. During the 12-month study period, the IG immediately started with the GALM program after the recruitment phase and attended two series of 15 sessions (total 30 GALM sessions). The CG was first placed on a waiting list for 6 months and attended one series of 15 sessions thereafter.

2.3. 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 1 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 1-day course on administering the correct test procedures.

2.3.1. Estimated energy expenditure

Two categories of the Voorrips physical activity questionnaire [18] combined with the compendium of physical activities by Ainsworth et al. [19] were used to estimate the energy expenditure for recreational sports activities (EERECSPORT: i.e., swimming, volleyball, cycling, brisk walking, etc.) and other leisure-time physical activities (EELETPA: i.e., gardening, doing odd jobs, walking, and cycling for transportation purposes). Spearman’s correlation coefficients between the Voorrips questionnaire and a 24-h 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].

2.3.2. 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 = 0.57–0.87 versus ICC = 0.78, 95% CI = 0.66–0.86). The 2-week test–retest reliability coefficient of the comparative fitness rating was reported to be 0.94 for older men (95% CI = 0.88–0.97) and 0.84 for older women (95% CI = 0.76–0.90) [20].

2.3.3. 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].

2.3.4. 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 min, 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 16½ 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].

2.4. 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]. Practical issues led some participants to drop out of the GALM program, and consequently out of the study.

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 analysing 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].

### 3. Results

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

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

<table>
<thead>
<tr>
<th>Table 1 Percentage of missing data per measurement</th>
<th>$T_0$ (% missing)</th>
<th>$T_1$ (% missing)</th>
<th>$T_2$ (% missing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated energy expenditure for physical activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE_RECSPORT (kcal/week)</td>
<td>48.1</td>
<td>49.2</td>
<td>49.2</td>
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<tr>
<td>EE_LTPA (kcal/week)</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>EE_TOTAL (kcal/week)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Perceived fitness</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fitness score (1–10)</td>
<td>28.7</td>
<td>29.3</td>
<td></td>
</tr>
<tr>
<td>Comparative fitness rating (10–50)</td>
<td>1.1</td>
<td></td>
<td></td>
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<tr>
<td>Health indicators</td>
<td></td>
<td></td>
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<tr>
<td>RDBP (mmHg)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
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<tr>
<td>RSBP (mmHg)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>45.9</td>
<td>45.9</td>
<td>45.9</td>
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<tr>
<td>Body fat (%)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
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<tr>
<td>Performance-based fitness</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Manual dexterity (s)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
</tr>
<tr>
<td>Reaction time (ms)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
</tr>
<tr>
<td>Functional reach (cm)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
</tr>
<tr>
<td>Grip strength (kgf/kg)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
</tr>
<tr>
<td>Leg strength (s)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
</tr>
<tr>
<td>Sit-and-reach (cm)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
</tr>
<tr>
<td>Shoulder flexibility (°)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
</tr>
<tr>
<td>Walking (×1671 m)</td>
<td>45.3</td>
<td>45.3</td>
<td>45.3</td>
</tr>
</tbody>
</table>

Missing values were imputed $M = 10$ times, using the observed scores and estimated relations in the multivariate data set. This resulted in ten completed, equally plausible versions of the data set. Each of the 10 data sets was then analysed using a standard complete-data procedure, and the results were combined to obtain estimates of effects and standard errors which reflected both sampling variability and the extra uncertainty due to missing data and imputation. The number of $M = 10$ completed data sets was chosen to achieve a 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.

After imputation, the 10 completed datasets consisting of 181 GALM participants were analysed using MLwiN (2004, 2.01) and SPSS version 10 (SPSS Inc., Chicago, IL, 1999). Since we already checked that municipality and neighbourhood were of no significant influence using multilevel analyses [12], the subsequent analyses were conducted at study group level using SPSS. Mean values, 95% confidence intervals (95% CI), and time, group and time × group $P$-values were calculated for each health and fitness characteristic. All analyses were conducted using intention-to-treat, with participants analysed according to their initial randomised assignment. Since we performed multiple testing, a probability value of less than 0.01 was considered statistically significant.
3.1. Energy expenditure for physical activity after 12 months

The significant main effects for time demonstrated that the energy expenditure outcomes EERECSPORT and EETOTAL 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 EELTPA ($F = 9.17; P < 0.01$) revealed that an increase occurred from baseline to 6 months but then stabilised from 6 to 12 months. For EELTPA a significant time × group interaction was found ($F = 9.70; P < 0.01$). Over 12 months, the CG continuously improved in EELTPA while the IG improved from baseline to 6 months but decreased from 6 to 12 months. Besides these significant time and time × group effects, no main effects for group were found ($P > 0.01$). The changes in energy expenditure for IG and CG are illustrated in Fig. 2.

3.2. Health and fitness outcomes after 12 months

Significant main effects for time were found in the fitness score ($F = 23.10; P < 0.01$), BMI ($F = 9.90; P < 0.01$) and the performance-based fitness outcomes of reaction time ($F = 12.21; P < 0.01$), leg strength ($F = 88.67; P < 0.01$), sit-and-reach ($F = 14.00; P < 0.01$), and walking ($F = 16.19; P < 0.01$). All of these time effects were in a favourable direction except for the sit-and-reach, which demonstrated overall improvement from baseline to 6 months but a decrease from 6 to 12 months. A significant time × 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 ($P > 0.01$).

4. Discussion and conclusion

4.1. Discussion

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

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Intervention group (n = 79)</th>
<th>Control group (n = 102)</th>
<th>Main effect</th>
<th>Main effect</th>
<th>Time × group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( T_0 ) mean [95% CI]</td>
<td>( T_1 ) mean [95% CI]</td>
<td>( T_2 ) mean [95% CI]</td>
<td>( T_0 ) mean [95% CI]</td>
<td>( T_1 ) mean [95% CI]</td>
</tr>
<tr>
<td>Energy expenditure for physical activity</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Perceived fitness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparative fitness rating (10–50)</td>
<td>28.6 [28.0, 29.2]</td>
<td>27.3 [26.7, 27.9]</td>
<td>27.9 [27.0, 28.8]  28.3 [27.8, 28.8]</td>
<td>28.1 [27.6, 28.6]</td>
<td>27.6 [27.0, 28.2]</td>
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<tr>
<td>Health indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDBP (mmHg)</td>
<td>84.8 [83.1, 86.4]</td>
<td>82.1 [80.4, 83.7]</td>
<td>86.4 [83.5, 89.3]  84.1 [82.6, 85.5]</td>
<td>83.9 [82.5, 85.4]</td>
<td>85.0 [83.4, 86.7]</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>32.3 [32.0, 32.7]</td>
<td>31.3 [31.0, 31.6]</td>
<td>32.7 [32.1, 33.2]  32.4 [32.1, 32.6]</td>
<td>31.7 [31.5, 32.0]</td>
<td>32.4 [32.0, 32.8]</td>
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<tr>
<td>Performance-based fitness</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Manual dexterity (s)</td>
<td>46.6 [45.8, 47.3]</td>
<td>44.5 [43.7, 45.2]</td>
<td>45.9 [44.3, 47.5]  47.0 [46.4, 47.7]</td>
<td>44.5 [43.8, 45.1]</td>
<td>46.2 [45.2, 47.2]</td>
</tr>
<tr>
<td>Functional reach (cm)</td>
<td>38.6 [37.6, 39.7]</td>
<td>39.8 [38.7, 40.8]</td>
<td>40.2 [38.3, 42.0]  36.8 [35.8, 37.7]</td>
<td>38.8 [37.9, 39.7]</td>
<td>38.4 [37.1, 39.7]</td>
</tr>
<tr>
<td>Grip strength (kgf/kg)</td>
<td>0.497 [0.488, 0.506]</td>
<td>0.500 [0.491, 0.509]</td>
<td>0.484 [0.463, 0.506] 0.492 [0.484, 0.500]</td>
<td>0.480 [0.472, 0.488]</td>
<td>0.505 [0.488, 0.522]</td>
</tr>
<tr>
<td>Shoulder flexibility (°)</td>
<td>48.7 [47.2, 50.1]</td>
<td>46.6 [45.1, 48.1]</td>
<td>49.1 [46.9, 51.3]  48.9 [47.6, 50.1]</td>
<td>48.3 [47.0, 49.6]</td>
<td>51.2 [49.5, 52.9]</td>
</tr>
<tr>
<td>Walking (×16½ m)</td>
<td>50.8 [49.2, 52.5]</td>
<td>55.2 [53.6, 56.9]</td>
<td>55.2 [52.9, 57.5]  51.4 [49.9, 52.8]</td>
<td>53.9 [52.4, 55.3]</td>
<td>54.8 [52.5, 57.1]</td>
</tr>
</tbody>
</table>

\( T_0 \): baseline measurement; \( T_1 \): 6-month measurement; \( T_2 \): 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.
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 EERECSPORT, EELTPA, and EETOTAL. One time × group interaction was found for EELTPA, indicating that the change over time for this outcome measure was different between the IG and CG. Regarding EERECSPORT, results demonstrated that both the IG and CG increased continuously from baseline to 6 months and from 6 to 12 months. For EELTPA, 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 EEELTPA 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; (b) the baseline interview and fitness test sessions, which may have increased participants’ knowledge of healthy behaviour and artificially influenced behaviour [12,38,39]. The further increase in EEELTPA 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 EEELTPA (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 EEELTPA found after 6 and 12 months.

Finally, regarding EEETOTAL, 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 EEELTPA. Although different definitions and measurement methods for physical activity were used, the decline in EEETOTAL (EERECSPORT + EEELTPA) 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 EEELTPA and EEETOTAL. The increase in EERECSPORT from baseline to 6 months (+326 kcal/week) could be explained by participation in the GALM program. However, the further increase in EERECSPORT 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 (EEELTPA) (~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 × group effects for the health and fitness outcomes after 12 months, the increase in energy expenditure for physical activities was reflected in significant main effects for time in fitness score, BMI, and the performance-based fitness outcomes of reaction time, leg strength, sit-and-reach, and walking, which were all in the favourable direction except for the sit-and-reach. However, contrary to the positive health effects after 6 months of GALM, in the current investigation, all health indicators changed in unfavourable directions from 6 to 12 months with the exception of BMI. Our findings are in contrast with results from other studies that did find a lowering of blood pressure effect in elderly subjects after aerobic training and decreased percentage of body fat after lifestyle and structured interventions. The interventions conducted in those studies laid more emphasis on aerobic sessions, though (i.e., walking, running) [11,43,44]. To lower blood pressure, BMI, and body fat, it is recommended to use programs that are at least of moderate intensity and of longer duration, with the health benefits of physical activity strongly linked to the total amount of activity [2,13,14,45]. Plausible explanations for not finding positive health changes after 12 months of GALM may be: first, the different nature of the GALM program relative to these other interventions in the field. Since GALM is not an intensive aerobic exercise-based training program but a moderately intense multidimensional program, the likelihood of demonstrating such health effects may be reduced. Toraman et al., who also investigated the effects of a multicomponent 9-week training program on functional fitness in older adults, found increased upper and lower body strength, aerobic endurance, and agility/dynamic balance, but there was no effect on body composition [46]. In the multidimensional GALM program, motor qualities (i.e., strength, speed, endurance, flexibility and coordination) are trained using motor actions (i.e., running, jumping, batting, throwing, and catching) [17], and in that light it is more realistic to expect changes in performance-based fitness measures that are ‘trained’ according to the specificity principle [47]. Additionally, the moderate intensity of the GALM program may also be a reason for finding effects mainly in performance-based fitness measures [17].
et al., 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-month waiting-list period, this weakened the comparison between IG and CG; (2) since this study was conducted in natural community settings as opposed to in a laboratory, the generalisability was high while the internal validity was less strong, indicating that the study results should be interpreted with caution. However, this study is one of the few studies that provides information of a community-based strategy targeting older sedentary and underactive older adults, a group that especially can profit from physical activity.

4.2. 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.

4.3. 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 behavioural skill-building during the GALM program as well as providing instruction on how to increase other aspects of EE_{LTPA} parallel to participation in the program. Suggestions for this could be include guided individualised goal-setting, regular self-monitoring of targeted activities, and reinforcement for reaching goals, in addition to skills training to increase physical activity in the GALM sessions.

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