A Community-Based Fitness and Mobility Exercise Program for Older Adults with Chronic Stroke: A Randomized, Controlled Trial

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OBJECTIVES: To examine the effects of a community-based group exercise program for older individuals with chronic stroke.

DESIGN: Prospective, single-blind, randomized, controlled intervention trial.

SETTING: Intervention was community-based. Data collection was performed in a research laboratory located in a rehabilitation hospital.

PARTICIPANTS: Sixty-three older individuals (aged $\geq$50) with chronic stroke (poststroke duration $\geq$1 year) who were living in the community.

INTERVENTION: Participants were randomized into intervention group (n = 32) or control group (n = 31). The intervention group underwent a fitness and mobility exercise (FAME) program designed to improve cardiorespiratory fitness, mobility, leg muscle strength, balance, and hip bone mineral density (BMD) (1-hour sessions, three sessions/week, for 19 weeks). The control group underwent a seated upper extremity program.

MEASUREMENTS: Cardiorespiratory fitness (maximal oxygen consumption), mobility (6-minute walk test), leg muscle strength (isometric knee extension), balance (Berg Balance Scale), activity and participation (Physical Activity Scale for Individuals with Physical Disabilities), and femoral neck BMD (using dual-energy x-ray absorptiometry).

RESULTS: The intervention group had significantly more gains in cardiorespiratory fitness, mobility, and paretic leg muscle strength than controls. Femoral neck BMD of the paretic leg was maintained in the intervention group, whereas a significant decline of the same occurred in controls. There was no significant time-by-group interaction for balance, activity and participation, nonparetic leg muscle strength, or nonparetic femoral neck BMD.

CONCLUSION: The FAME program is feasible and beneficial for improving some of the secondary complications resulting from physical inactivity in older adults living with stroke. It may serve as a good model of a community-based fitness program for preventing secondary diseases in older adults living with chronic conditions. **J Am Geriatr Soc 53:1667–1674, 2005.**

Key words: cerebrovascular accident; health promotion; osteoporosis; rehabilitation

The consequences of physical inactivity are particularly detrimental in older individuals with chronic disease. Impairments resulting from chronic disease (e.g., reduced mobility, pain), in addition to the lack of accessible and appropriate community-based exercise programs, could lead to further sedentary lifestyle and additional declines in functional status.[1] Physical inactivity could also contribute to secondary debilitating or life-threatening diseases. A recent study found that approximately one-third of cardiac disease and osteoporosis cases were attributable to lack of physical activity and pose a tremendous burden on the healthcare system.[2]

Stroke is one of the most common chronic conditions seen in older adults, with incidence approximately doubling each decade after the age of 55.[3] Most stroke survivors continue to live with residual physical impairments, which may promote a sedentary lifestyle and resultant secondary complications.[4] One of the secondary complications commonly observed after stroke is poor cardiorespiratory fitness.[5,6] Low cardiorespiratory fitness is related to poor

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functional performance[7] and increased risk of stroke and cardiovascular disease (CVD).[8,9] Indeed, cardiac events and recurrent stroke are major occurrences in stroke survivors.[10,11]

Other common stroke impairments are poor balance and muscle weakness,[12–14] which may contribute to the higher incidence of falls in older adults with stroke than the age-matched population.[15] In addition, poor mobility and decreased loading of the hemiparetic leg may also result in decline of hip bone mineral density (BMD).[16,17] The increased falls and reduced bone health may in part explain the two- to four-times-greater hip fracture risk in stroke survivors.[18]

The fact that the number of older individuals with chronic stroke in the community is on the rise compounds these secondary conditions seen in stroke survivors. Studies have shown that the incidence of stroke is increasing, particularly in older people,[3] but the mortality rate of stroke has been declining,[3] and more stroke survivors are returning home instead of going into inpatient rehabilitation programs.[19] These factors may translate into an increasing number of older adults living with a chronic stroke in the community who have not attained optimal functional recovery and are at risk of developing secondary complications due to physical inactivity.

There has been an increasing recognition of the importance of health promotion for people with disabilities.[20] One of the key components of health promotion for people with disabilities is "the prevention of health complications (medical secondary conditions) and further disabling conditions."[20] According to a proposed conceptual model of health promotion,[20] community-based fitness programs play one important role in achieving this objective. Considering that physical inactivity in older adults with chronic stroke could lead to devastating secondary health complications, an accessible and multidimensional fitness program is urgently needed,[21] but most exercise programs proposed for chronic stroke, are not community based and have addressed only one or two of the impaired domains.[5,6,22–24] Moreover, although it is known that stroke is a major risk factor for hip fracture,[18] no study has examined the effects of exercise on hip BMD in stroke. This study aimed to assess the efficacy of a multidimensional community-based fitness and mobility exercise (FAME) program for individuals with chronic stroke. This is the first study to examine the effects of exercise on hip BMD in this population. It was hypothesized that the individuals who underwent the FAME program would have significantly more improvement in cardiorespiratory fitness, mobility, leg muscle strength, balance, activity and participation, and hip BMD than those in the control group.

METHODS

Participants

Participants were recruited from a local rehabilitation hospital database, community stroke clubs, and local newspaper advertisements. All potential participants were first screened using a telephone interview based on the following inclusion criteria: a single stroke more than 1 year before, aged 50 and older, ability to walk more than 10 m independently (with or without walking aids), and living at home. Exclusion criteria were history of serious cardiac disease (e.g., myocardial infarction), uncontrolled blood pressure (systolic blood pressure > 140, diastolic blood pressure > 90), pain while walking, neurological conditions in addition to stroke, and other serious diseases that precluded the individual from participating in the study.

Those who fulfilled the above criteria were required to provide informed and written consent. In addition, the primary care physician was required to provide written information regarding medical history of the individual (diagnosis, comorbid conditions) and his/her recommendation about the participant's participation. The local university and hospital ethics committees approved the study. The experiments were conducted in accordance with the Helsinki Declaration.[25]

Once the required consent and information were obtained, participants were brought into the laboratory for further screening. First, the functional classification level of the American Heart Association Stroke Outcome Classification was used to measure residual disability in activities of daily living (ADLs, e.g., dressing, bathing, grooming) and instrumental activities of daily living (IADLs, e.g., shopping, preparing meals) (level I = as independent as before the stroke; level V = completely dependent in ADLs and IADLs).[26] Second, ability to pedal a cycle ergometer (Excalibur, Lode B.V. Medical Technology, Groningen, Netherlands) was tested. The participant had to be able to pedal at 60 revolutions per minute and raise the heart rate to at least 60% of maximal heart rate. Third, because significant cognitive deficits may adversely affect an individual's ability to follow instructions during the exercise sessions, the Mini-Mental State Examination was administered, and a score greater than 22 was required for inclusion.[27]

Study Design

A prospective, single-blind, randomized, controlled intervention trial was undertaken. The participants were stratified according to sex because men tended to have higher maximal oxygen consumption (VO_2max),[28] muscle strength,[28] and BMD[29] than women. The participants were then randomly assigned to the intervention or control group by drawing ballots marked "I" (intervention) or "C" (control). An individual who was not involved in enrollment or any of the screening and outcome assessments performed the randomization. The research personnel who performed the outcome assessments were blinded to the group assignment. Participants were not blinded to group assignment. They were informed that they were in a lower extremity or upper extremity program. Participants were instructed not to tell the assessors about the group assignment or the treatment they received and not to discuss the protocol with the stroke community.

Interventions

The intervention and control groups underwent an exercise program for 19 weeks (1-hour sessions, three sessions per week) in the same multipurpose room of a community hall. The participants occupied the community space only during the exercise sessions. The two groups exercised at different times of the day. In each session, a physical therapist, an occupational therapist, and an exercise instructor supervised nine to 12 participants. Hip protectors (SAFE-HIP, Tutex, Denmark) were provided to those in the intervention group, and they were instructed to wear them in each session.

The FAME program was provided to the intervention group (Appendix 1). To determine cardiorespiratory training intensity, maximum heart rate achieved at the end of the cycle ergometer test was used to calculate the heart rate reserve (HRR).[28] As the trial progressed, exercise intensity and duration were increased as tolerated (Appendix 1), as adapted from the guidelines recommended by the American College of Sports Medicine.[28] During aerobic exercise training, participants wore a heart rate monitor (Polar A3, Polar Electro Inc., Woodbury, NY) and were instructed to exercise within the set target heart rate zone. The average heart rate attained, the duration over which the target heart rate was sustained, and the specific exercises completed in each session were recorded. The control group underwent a seated upper extremity program (Appendix 2). No aerobic exercises, leg strengthening, or balance training were given. Adverse events (e.g., falls) were monitored and recorded. A fall was defined as unintentionally coming to rest on the floor or another lower level.

Outcomes

The same trained assessors measured all outcomes immediately before the commencement of the interventions and again immediately after the termination of the interventions.

VO_2max was considered to be the criterion measure of cardiorespiratory fitness.[28] Each participant underwent a maximal exercise test on the Excalibur cycle ergometer. A physician used a 12-lead electrocardiography system (Quark C12, COSMED Srl, Rome, Italy) to monitor cardiac activity. Participants wore a face mask, and oxygen consumption (VO_2) was continuously measured using a portable metabolic unit, which performed breath-by-breath gas analysis (Cosmed K4 b^2 system, COSMED Srl). The level of perceived exertion was monitored using the 16-point Borg Rating of Perceived Exertion Scale.[30] Blood pressure was measured at rest and at the end of the test. The testing protocol was adjusted to the capabilities of the individuals.[28] The workload started at 20 W and increased by 20 W/min for 29 participants. For the other 34 participants, who were more severely impaired, the workload started at 10 W, with increments of 10 W/min. For each participant, the same seat height and testing protocol were used at baseline and 19 weeks. Participants were required to pedal at 60 revolutions per minute. The test continued until the participant became fatigued. The respiratory exchange ratio at the end of the test was noted. The VO_2 data were averaged every 15 seconds. The maximal value obtained was considered to be the VO_2max (mL/kg per minute).

The 6-minute walk test (6MWT) was used to assess mobility.[31] The distance walked in 6 minutes was recorded. The 6MWT has been shown to be a reliable method of assessing walking performance in individuals with stroke.[32] A handheld dynamometer (Nicholas MMT, Lafayette Instruments, Lafayette, IN) was used to evaluate isometric knee extension strength. The participant was seated upright in a chair with back support, the knee was placed in 90° flexion, and the assessor stabilized the thigh to eliminate synergistic movements. Each participant was asked to perform a maximal isometric contraction of knee extension. Three trials were performed on each side, and force data were averaged. Handheld dynamometry is a reliable method to assess muscle strength in stroke.[33] Functional balance was assessed using the Berg Balance Scale (maximal score = 56), which has shown to be a reliable and valid tool to assess balance in older adults.[34] Activity participation was measured using the Physical Activity Scale for Individuals with Physical Disabilities (PASIPD),[35] a 13-item questionnaire that assesses the amount of participation in physical activities of different intensities for the previous 7 days. Each activity was assigned a specific metabolic equivalent (MET) value; the maximal score was 199.5 MET h/d. The validity of PASIPD has been established.[35]

Bilateral hip scans were performed using dual-energy x-ray absorptiometry (DEXA; Hologic QDR 4500, Hologic Inc., Waltham, MA). The same technician performed all scans using standard procedures. Femoral neck BMD (g/cm^2) was reported as the primary outcome because the femoral neck is the most common site of fracture in stroke.[18] Each participant was classified as having osteoporosis or osteopenia according to the definitions of the World Health Organization,[36] using the reference data provided.[29] Regarding the precision of the DEXA scanner, the coefficient of variation for femoral neck BMD was 0.93%.

Statistical Methods

The sample size was based on predictions of change for cardiorespiratory fitness. A power of 0.80 and $P < .05$ were desired for the calculation. Based on an average VO_2max $\pm$ standard deviation of 17.3 ± 3.0 mL/kg per min[5] and a desired 15% change,[6] 21 participants per group were required. To account for a 20% attrition rate, at least 26 participants per group needed to be recruited.

Baseline variables between the two groups were compared using independent *t* tests (for continuous variables) and chi-square (for categorical variables). Intention-to-treat analysis was performed. For dropouts, it was conservatively assumed that no changes occurred in any of the outcome measures at 19 weeks. Therefore, the missing values at 19 weeks were input using baseline values for these individuals.[37] To reduce the probability of type I error from multiple comparisons, a single multivariate analysis of variance incorporating all primary outcomes was performed to determine whether there was an overall significant time-by-group interaction. Two-way analysis of variance (within factor, time; between factor, group) were then performed to analyze the data post hoc. The difference between the pretest and posttest scores and 95% confidence intervals for each outcome variable were also reported. All statistical analyses were performed using SPSS 11.5 software (SPSS Inc., Chicago, IL) using a significance level of .05 (two-tailed).

RESULTS

Sixty-three individuals fulfilled all criteria and were enrolled in the study (Figure 1). There were three dropouts. Two dropped out of the intervention group: one after six sessions because of the inability to commit the time, one after nine sessions because he found the exercise too

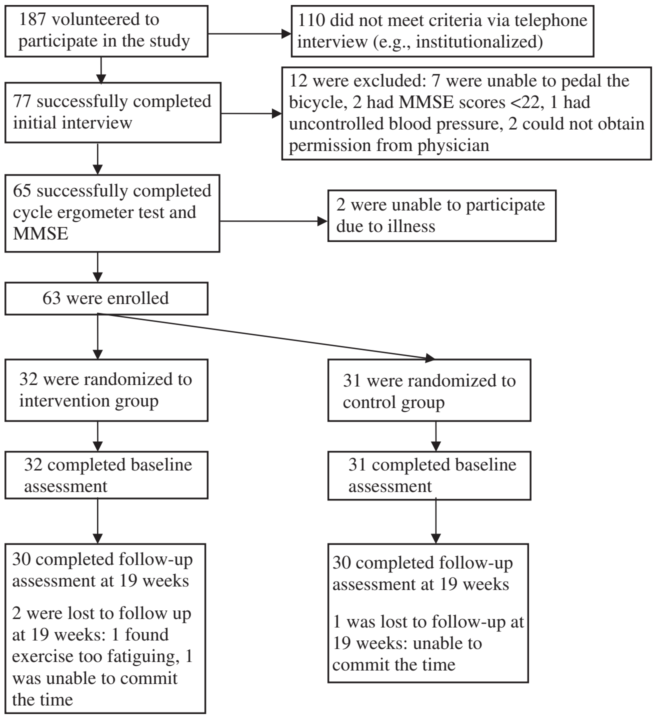

Figure 1. Study flow chart. Sixty-three individuals were enrolled in the study and were randomly assigned to the intervention (n = 32) or control (n = 31) group. Thirty individuals in each group completed the program. MMSE = Mini-Mental State Examination.

fatiguing. One dropped out of the control group after eight sessions because of inability to commit the time. The dropouts tended to have better balance (mean Berg = 54.0) and mobility (mean 6MWT distance = 498.3 m). There were no significant differences in any of the variables between the intervention and control groups at baseline ($P > .20$ for all variables) (Tables 1 and 2).

On average, the two groups attended a similar number of sessions (intervention group, 81.4%; control group, 80.4%). For cardiorespiratory training in the intervention group, six participants could not progress beyond the initial target heart rate zone (40–50% HRR). These six participants tended to have poorer balance (mean Berg = 41.2) and mobility (mean 6MWT distance = 193.9 m) at baseline. None of these six participants were on beta-blockers. Seven participants were trained at 70% to 80% HRR at the end of the trial. An additional 12 and five participants reached 60% to 70% and 50% to 60% HRR, respectively. On average, the target heart rate was sustained for 15 minutes.

Multivariate analysis showed a significant time-by-group interaction (Wilk's Lambda = 0.670, $P = .004$), indicating that, overall, the FAME program produced more gains than the control treatment. Elimination of the three dropouts from the analysis produced similar results (Wilk's Lambda = 0.644, $P = .003$). Post hoc analysis (Table 2) revealed that the intervention group had significantly more improvements in VO_2max, 6MWT distance, and paretic leg muscle strength than controls. A significant time-by-group interaction was also found for the paretic femoral neck BMD, for which there was a 2.5% decline in controls but maintenance of BMD in the intervention group. Both groups improved in balance and PASIPD score, but there was no significant time-by-group interaction.

Given the positive improvements from the FAME program, additional post hoc analyses were performed to examine the relationship between initial level of impairment and amount of improvement (i.e., change score) in the intervention group using Pearson correlations for each primary outcome. In the intervention group, there was a significant negative correlation between baseline score and change score for two of the primary outcomes, namely, Berg ($r = -0.827$, $P < .001$) and PASIPD ($r = -0.36$, $P = .04$), although correlations were not significant between baseline and change scores for the other outcome measures (VO_2max, 6MWT distance, leg muscle strength, and femoral neck BMD).

There were five falls (4 participants) in the intervention group. Three falls occurred with the participant still holding onto a support (e.g., knee gave way while in a squat position) but were still considered falls because the participant came to rest on a lower level. One fall occurred when the participant was kicking a ball. Another fall occurred when the participant was stepping down from a 2-inch-thick foam pad. In both cases, the participants were being spotted and were able to recover independently immediately after the fall. Most falls were thus low impact. One fall occurred in the control group while the participant was walking. No injuries were reported.

DISCUSSION

The study showed that the proposed FAME program is feasible and beneficial for improving cardiorespiratory fitness, mobility, and paretic leg muscle strength and maintaining hip BMD in individuals with chronic stroke. The program may provide a good model for community-based fitness programs for older people with chronic disabilities.

The results support the hypothesis that the intervention group would have significantly more gains in cardiorespiratory fitness. The FAME program resulted in significantly greater improvement in VO_2max (10.7%) than controls (2.2%). The amount of gain in VO_2max is comparable with that of other stroke programs (duration: 10–12 weeks) that used a cycle ergometer or treadmill for cardiorespiratory training.[6,24,37] The difference in results between the intervention and control groups could not be due to difference in effort during the maximal exercise test because the respiratory exchange ratio achieved at the end of the ergometer test showed no group-by-time interaction. The average baseline VO_2max obtained by the participants in this study was approximately at the 10th percentile of the age- and sex-matched population, indicating poor cardiorespiratory fitness.[28] Individuals with low VO_2max values need to work at a higher relative exercise intensity to complete the same daily functional activities than others who have higher VO_2max.[38] This reduction in fitness reserve can contribute to reduced activity endurance, which was identified as the most striking area of difficulty for older adults with stroke living in the community.[19] Thus, improvement in VO_2max in older adults with stroke may have tremendous effect on functional abilities.

Apart from its influence on function, low VO_2max has also been related to a greater risk of various forms of

Table 1. Subject Characteristics

Characteristic	Intervention Group (n = 32)	Control Group (n = 31)
Demographics		
Female, n	13	13
Age, mean ± SD	65.8 ± 9.1	64.7 ± 8.4
Caucasian/Asian/Black, n	20/11/1	18/13/0
Walking aid: walker/crutch/quad cane/cane, n	6/1/1/3	5/0/2/2
American Heart Association Stroke Functional Classification: I/II/III/IV/V, n	5/17/9/1/0	2/19/8/2/0
Mini-Mental State Examination score, mean ± SD	27.6 ± 2.3	28.2 ± 1.9
Education, years, mean ± SD	13.9 ± 3.8	13.9 ± 3.4
Had inpatient rehabilitation after acute hospital stay, n	24	26
Had outpatient physical therapy after discharge home, n	20	21
Stroke characteristics		
Paretic side, left, n	19	22
Ischemic stroke, n	18	19
Poststroke duration, years, mean ± SD	5.2 ± 5.0	5.1 ± 3.6
Comorbidity, n		
Hypertension	17	20
Diabetes mellitus	4	6
Arthritis	6	6
Depression	7	8
Osteopenia/osteoporosis, n		
Paretic femoral neck	17/3	14/6
Nonparetic femoral neck	19/2	15/5
Medications/supplements, n		
Beta-blockers	4	5
Bone resorption inhibitors	2	3
Calcium	6	6
Multivitamins	8	7

SD = standard deviation.

CVD[8,39] and premature death from all causes and specifically from CVD.[40,41] These findings thus have important implications for stroke survivors, considering that poor VO_2max is prevalent in this group[5,6] and that a large proportion (up to 75%) of older individuals with stroke have some form of CVD.[10] Cardiac disease is also the leading cause of death in stroke survivors.[10]

Six participants were unable to progress beyond the initial training target heart rate zone. Reduced ambulatory and balance skills may have made it more difficult for them to increase walking speed as training progressed. Despite the failure to train beyond 40% to 50% HRR, these six individuals still averaged an impressive 18.4% increase in VO_2max. These individuals (3 women, 3 men) tended to have lower baseline VO_2max (mean = 20.2 mL/kg/min), which would partially explain their higher percentage gain. Thus, positive outcomes can be obtained despite training at low intensities. This is in agreement with the previous finding that intensity as low as 30% VO_2 reserve (i.e., the difference between maximum and resting VO_2) was effective in improving cardiorespiratory fitness in less fit but healthy individuals.[42]

The intervention group also improved significantly more in 6MWT distance and paretic leg muscle strength than the control group, as predicted by the research hypothesis. The improvement in 6MWT distance is particularly important, given that the deficit in walking endurance is striking in individuals with chronic stroke.[19] Muscle strength is correlated with gait velocity,[32] walking endurance,[32,43] and BMD[44] in individuals with stroke. Because decreased ambulatory capacity[19,32] and osteoporosis[16,44] are major concerns for this group, increasing muscle strength may also have important implications.

Previous studies in older adults have reported beneficial effects of exercise on bone health. For example, one study reported that a 6-month high-intensity resistance exercise program resulted in a significant 2.0% increase in femoral neck BMD in elderly men and women, whereas controls had a 1.6% decrease.[45] A 1-year high-impact aerobic exercise program for older adults aged 50 and older resulted in a maintenance of hip BMD, compared with a significant 1.9% reduction in controls.[46]

This study provides the first evidence that regular exercise is beneficial for hipbone health in the chronic stroke population. Femoral neck BMD on the paretic side was maintained in the intervention group, whereas a significant 2.5% decrease was observed in controls. In this study, it was assumed that the pretest and posttest scores for each primary outcome variable were the same for the dropouts. It is thus possible that the posttest paretic hip BMD of the dropout in the control group may have been overestimated, but this possibility would not affect the interpretation of the results. First, the number of dropouts in the control group was small (n = 1). Second, overestimating the posttest paretic hip BMD value of dropouts in the control group would tend to underestimate the difference in posttest scores

Table 2. Outcome Measurements

Outcome Measure	Intervention Group (n = 32)			Control Group (n = 31)			P-value
	Pretest	Posttest	Δ (95% CI)*	Pretest	Posttest	Δ (95% CI)*	
Primary							
Maximal oxygen consumption, mL/kg per minute	22.5 ± 5.2	24.5 ± 5.3	2.0 (0.8–3.1)	21.5 ± 4.3	21.8 ± 4.5	0.3 (− 0.8–1.4)	.03†
6-minute walk test distance, m	328.1 ± 143.5	392.7 ± 151.1	64.5 (45.3–83.8)	304.1 ± 123.8	342.4 ± 133.4	38.4 (25.6–51.1)	.03†
Paretic leg muscle strength, N	182.6 ± 74.3	223.2 ± 99.9	40.6 (21.0–60.2)	194.9 ± 68.8	205.3 ± 79.4	10.4 (− 5.1–25.9)	.02†
Nonparetic leg muscle strength, N	248.5 ± 85.6	276.7 ± 88.8	28.2 (7.4–49.2)	265.6 ± 87.8	272.0 ± 84.0	6.4 (− 12.4–25.2)	.12
Berg Balance Score (range 0–50)	47.6 ± 6.7	49.6 ± 4.4	2.1 (0.8–3.3)	47.3 ± 6.1	49.2 ± 5.8	1.9 (0.8–3.0)	.85
Physical Activity Scale for Individuals with Physical Disabilities, metabolic equivalent h/d (range 0.0–199.5)	7.9 ± 7.8	13.7 ± 10.9	5.8 (1.9–9.7)	10.6 ± 9.8	18.6 ± 16.8	8.0 (3.6–12.4)	.45
Paretic femoral neck BMD, g/cm^2	0.73 ± 0.13	0.72 ± 0.14	− 0.00 (− 0.02–0.01)	0.72 ± 0.15	0.70 ± 0.15	− 0.02 (− 0.03 to − 0.01)	.04†
Nonparetic femoral neck BMD, g/cm^2	0.72 ± 0.12	0.72 ± 0.12	− 0.01 (− 0.02–0.00)	0.74 ± 0.17	0.74 ± 0.17	0.00 (− 0.01–0.01)	.11
Secondary (cycle ergometry)							
Respiratory exchange ratio	1.13 ± 0.13	1.17 ± 0.14	0.04 (0.00–0.09)	1.11 ± 0.11	1.19 ± 0.13	0.08 (0.03–0.12)	.23

* Paired *t* test.
† $P < .05$ (time-by-group interaction, two-way analysis of variance).
N = Newtons; BMD = bone mineral density; Δ = change from pretest to posttest; CI = confidence interval.

between the intervention and control groups. Despite this, the results remained statistically significant.

The reduction of BMD in the control group (2.5%) is consistent with a previous study[16] that reported a 2.2% decline in proximal femur BMD over a 5-month period in a sample consisting mostly of ambulatory subjects with stroke. The reduction in BMD reported in this study is clinically significant, considering that femoral neck BMD in older men and women (aged 70–79) is only 5.5% and 9.4% lower than those 10 years younger, respectively.[36] With the presence of risk factors such as poor balance and mobility, any departure from healthy BMD values would further increase the risk of hip fractures.[47] Mechanical loading is important in maintaining bone mineral.[48] Low VO_2max, poor mobility, and low weight bearing have also been linked to low femoral neck BMD.[17,49] By targeting these specific impairments and incorporating weight-bearing activities with the paretic leg, the FAME program succeeded in maintaining femoral neck BMD in chronic stroke.

Nevertheless, the results do not support the hypothesis that the intervention group would have more improvement in balance and PASIPD scores than the control group. The improvement of balance in the control group may have been due to the undertaking of several activities that involved trunk stability and reaching function, which may improve lower limb weight bearing and sit-to-stand function.[22] The fact that the control group also underwent an intensive exercise program, which may in turn promote activity and participation, may explain the absence of a between-group difference in PASIPD score.

The study has several limitations. First, the results are generalizable to a selected group of community-dwelling individuals with chronic stroke only. Second, except for balance and PASIPD, the amount of improvement in the intervention group was not specific to the initial level of impairment; perhaps factors like motivation played an important role. More improvement in balance was correlated with a lower baseline Berg score, but this correlation should be interpreted with caution because the Berg scale has a ceiling effect with higher levels of balance function.[50] Third, no attempts were made to help participants to develop exercise habits on a long-term basis. It is not known whether the participants continued to exercise after the termination of the program. A larger sample size and long-term follow-up would be required to determine the long-term benefits and adherence to an ongoing exercise program. It would also be interesting to determine whether the FAME program would reduce the actual risk of cardiac events, osteoporosis, or fractures. Whether extending the duration of the program would increase femoral neck BMD also requires further study. Nevertheless, the positive outcomes from this trial justify a multicentered trial to further study the efficacy and cost-effectiveness of the FAME program.

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Appendix 1. Fitness and Mobility Exercise Program Provided to Intervention Group

Station 1: Cardiorespiratory fitness and mobility
1. Brisk walking
2. Sit-to-stand: progressed by reducing the height of chair
3. Alternate stepping onto low risers: progressed by increasing the height of the stepper, reducing arm support, or both

Duration: 10 minutes initially, with increment of 5 minutes every week, up to 30 minutes of continuous exercise as tolerated
Intensity: started at 40% to 50% HRR, with increment of 10% HRR every 4 weeks, up to 70% to 80% HRR, as tolerated
Station 2: Mobility and balance
1. Walking in different directions
2. Tandem walking
3. Walking through an obstacle course
4. Sudden stops and turns during walking
5. Walking on different surfaces (carpet, foam)
6. Standing on foam, balance disc, or wobble board
7. Standing with one foot in front of the other
8. Kicking ball with either foot

Progressed by reducing arm support, by increasing speed of movement, or both
Station 3: Leg muscle strength
1. Partial squats: progressed by increasing movement magnitude
2. Toe rises: progressed from bilateral to unilateral rises on either side

Progressed by increasing number of repetitions (from 2 sets of 10 to 3 sets of 15), reducing arm support, or both

HRR = heart rate reserve.

Appendix 2. Upper Extremity Program Provided to Control Group

Station 1: Shoulder muscle strength
1. Resistance band exercises (movements: shoulder flexion, abduction, extension, external rotation)
   Progressed by increasing the resistance of resistance band and increasing number of repetitions (from 2 sets of 10 to 3 sets of 15).

Station 2: Elbow/wrist muscle strength and range of motion
1. Dumbbell/wrist cuff weight exercises (movements: elbow flexion and extension, wrist flexion and extension)
   Progressed by increasing the weight, increasing number of repetitions (from 2 sets of 10 to 3 sets of 15), or both
2. Passive or self-assisted range of motion to paralyzed joints
3. Upper extremity weight-bearing on physio ball

Station 3: Hand activities
1. Hand muscle strengthening exercises using putty and grippers (movements: pinch, grip, finger extension)
   Progressed by increasing the resistance of the putty/grippers, increasing number of repetitions (from 2 sets of 10 to 3 sets of 15), or both
2. Playing cards
3. Picking up objects of various sizes and shapes
4. Electrical stimulation (Neurotrac Sports, Verity Medical Ltd., Hampshire, England) to wrist extensors (only for those with no active wrist movements, 10 subjects)
   Protocol:
   Frequency: 100 Hz; pulse duration: 150 microseconds; ON time: 10 seconds; OFF time: 10 seconds; ramp: 1 second; treatment time: 10–15 minutes