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# Adaptive physical activity improves mobility function and quality of life in chronic hemiparesis

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**Abstract—**This study investigated the effects of an adaptive physical activity (APA) program on mobility function and quality of life (QOL) in chronic stroke patients. Twenty subjects with chronic hemiparesis completed a 2-month, combined group, class-home exercise regimen that emphasized mobility training. APA improved Berg Balance Scale scores (35 +/– 2 vs 45 +/– 2, $p = 0.001$), 6-minute walk distances (114 +/– 15 vs 142 +/– 7 m, $p < 0.001$), and Short Physical Performance Battery scores (3.2 +/– 0.4 vs 5.2 +/– 0.6, $p < 0.001$). Barthel Index scores increased (75 +/– 4 vs 84 +/– 4, $p < 0.001$), but Lawton scores were unchanged. Geriatric Depression Scale ($p < 0.01$) and Stroke Impact Scale (SIS), Mobility, Participation, and Recovery improved with APA ($p < 0.03$). APA has the potential to improve gait, balance, and basic but not instrumental activities of daily living profiles in individuals with chronic stroke. Improved depression and SIS scores suggest APA improves stroke-specific outcomes related to QOL.

**Key words:** activities of daily living, adaptive physical activity, exercise, group exercise, hemiplegia, home exercise regimen, mobility, quality of life, rehabilitation, stroke.

## INTRODUCTION

Many stroke survivors have chronic deficits that limit physical activity and cause subsequent physical deconditioning, which propagates disability and worsens cardiovascular disease risk [1–3]. Exercise can improve ambulatory function and fitness even years after stroke [4–7]. Yet few studies have considered the design of exercise programs that are feasible for community dissemination [8–10]. Numerous behavioral and psychosocial issues

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**Abbreviations:** ADL = activities of daily living, APA = adaptive physical activity, AUSL = Azienda Unità Sanitaria Locale, BBS = Berg Balance Scale, GDS = Geriatric Depression Scale, QOL = quality of life, SIS = Stroke Impact Scale, SPPB = Short Physical Performance Battery, VA = Department of Veterans Affairs.

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associated with chronic disability and aging influence exercise adherence and can serve as barriers to such health-promoting behaviors [9]. While both home- and hospital-based programs are reported in the literature [4,8,11], the exercise settings and behavioral reinforcement strategies that are optimal for improving mobility and quality of life (QOL) outcomes are unknown.

Based on task-oriented exercise and social learning models that facilitate exercise behaviors in frail older adults, we developed a structured adaptive physical activity (APA) program with gymnasium and home components for chronic stroke survivors [7–8,12–13]. Group exercises targeting improved gait and balance were used to enhance social support, with a parallel home exercise regimen to build self-efficacy for habitual physical activities that enhance daily function and QOL. This pilot study investigated the efficacy of APA for improving mobility, activities of daily living (ADL) profiles, and stroke-specific outcomes related to QOL in chronic stroke survivors as a step toward community-based clinical trials.

## METHODS

Men or women >40 years with mild-moderate hemiparetic gait following stroke (>9 months) were recruited from Azienda Unità Sanitaria Locale (AUSL) 11 of the Tuscany region in Italy. Mild-moderate hemiparetic gait was defined as visible asymmetry with reduced gait stance or reduced stance, increased swing time, and the ability to ambulate >10 m (with assistive device as needed). Participants received medical clearance from their general practitioner and the Rehabilitation Health Authorities, and all subjects provided informed consent, consistent with the Helsinki Declaration. The Mini-Mental State Examination and Geriatric Depression Scale (GDS) were used to screen for dementia and depression, respectively [14–15]. Exclusion criteria included dementia, severe aphasia, heart failure, or other medical condition(s) that precluded participation in low-intensity exercise [16].

APA consisted of 2 months of twice weekly, 1-hour sessions of group mobility, balance, and stretching exercises at the hospital gymnasium. Mobility training included subjects walking for 12 minutes on a course outfitted with parallel bars to practice stepping over 10 cm-high boards, traversing 3 steps, and walking laterally, all with handrail support. Exercises at the parallel bars included weight shift from leg to leg, half-squat, turn in place, leg-trunk flexion, and extension exercises (eight repetitions of each). Seated upper- and lower-limb stretching exercises that focused on range of motion, including trunk mobility, constituted the remainder of the hour and provided interim rest periods between the more physically demanding activities. As approved by the study physical therapist, participants performed a similar home regimen three times a week that included walking, stair climbing, and stretching exercises. Class was conducted with a ratio of one physical therapist to eleven participants, with compliance monitored at each gymnasium visit by the study coordinator, who verified participation using participants' diary-logbook.

We administered a battery of standardized instruments for two baseline assessments one month apart to establish neurological status stability and repeated the testing <1 week posttraining. The Motricity Index measured stroke impairments [17–18]. Mobility function was evaluated with the Short Physical Performance Battery (SPPB) [19–20], 6-minute walks [7], and the Berg Balance Scale (BBS) [21]. The Barthel Index and Lawton scores were used to assess basic and instrumental ADL profiles [22–23]. The Stroke Impact Scale (SIS) examined participant-rated outcomes related to QOL [24]. Since both exercise and social support can affect mood, the GDS was repeated after APA [25]. Evaluators were not blinded in this uncontrolled pilot study.

All data are expressed as mean ± standard error with significance at $p < 0.05$ (two-tailed). Paired $t$-tests examined differences between repeated baseline and pre- versus posttraining timed walks. Wilcoxon matched pairs signed rank tests evaluated nonparametric variables. We used simple regression to examine relationships between variables and their change across APA.

## RESULTS

Of the 22 subjects who were enrolled, 20 completed the APA program. One dropped out because of an injury unrelated to the study; one subject withdrew after <2 weeks of being noncompliant to the program. Participants who completed the APA included 11 women and 9 men, age 70 ± 1.7 years (range 55–85) who were 56 ± 19 months (range 9–306) poststroke, with body mass index 28.6 ± 1.1 (range 23–42). No differences were found on any measures between baselines 1 and 2 (**Table 1**). The GDS revealed 79 percent of participants had scores >6,

**Table 1.**
Repeated baseline and post-adaptive physical activity (APA) impairment, mobility function, and basic and instrumental activities of daily living (ADL) data for 20 individuals who completed program. Data are mean ± standard error; *p*-values test significance between mean of baseline versus post-APA training.

| Outcome Variable | Baseline 1 | Baseline 2 | Post-APA | *p*-Value |
|---|---|---|---|---|
| **Motricity Index** | | | | |
| Upper Limb | 6.6 ± 1.1 | 6.5 ± 1.1 | 8.7 ± 1.3 | 0.002 |
| Lower Limb | 7.6 ± 0.8 | 7.5 ± 0.8 | 9.2 ± 1.0 | 0.016 |
| Trunk Control | 75.5 ± 5.0 | 76.8 ± 4.7 | 78.1 ± 5.6 | 0.2* |
| **6-Minute Walk Distance (m)** | 116 ± 15 | 113 ± 14 | 142 ± 17 | 0.005 |
| **Berg Balance Scale** | 34.0 ± 2.0 | 35.0 ± 1.7 | 45.0 ± 1.6 | 0.001 |
| **Short Physical Performance Battery (total)** | 3.15 ± 0.44 | 3.30 ± 0.41 | 5.15 ± 0.60 | 0.001 |
| **Barthel Index** | 74.8 ± 4.0 | 75.3 ± 3.9 | 83.8 ± 3.7 | 0.001 |
| **Lawton Instrumental ADL Scale** | 63 ± 4 | 65 ± 4 | 64 ± 4 | 0.9* |

*Not significant.

indicating significant depressive symptoms [25]. Training compliance was 97 percent attendance for classes, with full compliance to home exercise. Two individuals complained of minor back pain, which was transient and did not interrupt training. No study-related adverse events occurred.

### Functional Outcomes

APA reduced stroke impairments and improved all mobility outcomes (**Table 1**). Motricity Index paretic upper- and lower-limb scores improved. Six-minute walk distances increased 24 percent and BBS scores 10 points. SPPB and all subscales improved (**Figure**). APA improved basic but not instrumental ADL scores. The Barthel Index improved by 9 points, while Lawton scores were unchanged. No relationships were found between age or latency since stroke and improvements with APA in any functional outcome measures ($p > 0.2$).

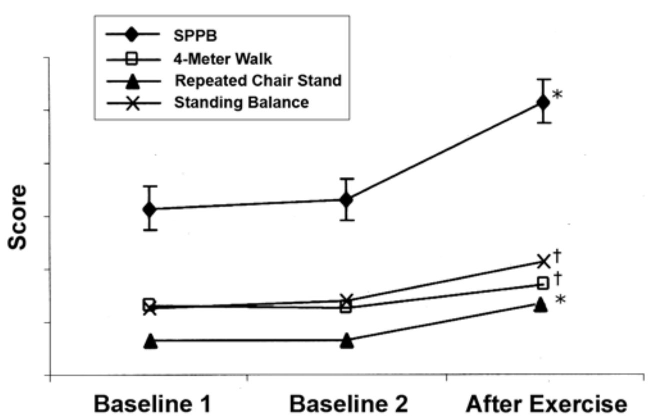


**Figure.**
Short Physical Performance Battery (SPPB) composite and subscores at repeated baseline testing and post-adaptive physical activity. Data are mean ± standard error for SPPB composite score. $^{*}p < 0.001$, $^{\dagger}p < 0.03$.

### Quality of Life Related Outcomes

SIS Mobility, Participation, and Recovery improved during APA (**Table 2**), with a trend toward improved Activity ($p = 0.053$) and Memory ($p = 0.06$). GDS scores also improved, but the proportion of subjects with scores indicating significant depressive symptoms was not significantly different (15/19 vs 12/19, pre- vs post-APA, $p = 0.2$). Improved GDS scores were related to increased SIS Mobility ($r = 0.36$, $p = 0.01$) but unrelated to any other outcomes.

## DISCUSSION AND CONCLUSIONS

The major finding is that a 2-month APA program reduced stroke impairments and improved mobility function in individuals with chronic stroke. The gains in gait and balance translate into improved basic but not instrumental ADL profiles. APA further improved selected SIS domains and depression scores. These findings provide evidence that a group exercise class combined with a home program is effective in reducing stroke impairments and improving mobility function and QOL-related outcomes for older chronic stroke survivors.

The functional gains with APA are robust and clinically significant. BBS scores improved 10 points, including 70 percent with gains >6 points. A 6-point increase in BBS is clinically important [26], while a 10-point difference

**Table 2.**
Repeated baseline and post-adaptive physical activity (APA) Geriatric Depression Scale and Stroke Impact Scale (SIS) scores. Data are mean ± standard error. Significance values are for Wilcoxon matched pairs signed rank tests between mean of baseline versus post-APA training.

| Outcome Variable | Baseline 1 | Baseline 2 | Post-APA | *p*-Value |
|---|---|---|---|---|
| **Geriatric Depression Scale** | 9.6 ± 1.0 | 9.5 ± 0.9 | 7.7 ± 0.9 | 0.01 |
| **SIS** | | | | |
| Mobility | 54 ± 5 | 55 ± 6 | 74 ± 6 | 0.002 |
| Participation | 30 ± 6 | 31 ± 5 | 40 ± 5 | 0.03 |
| Recovery | 48 ± 5 | 45 ± 5 | 57 ± 5 | 0.03 |
| Activity | 42 ± 6 | 43 ± 6 | 48 ± 5 | 0.053 |
| Memory | 68 ± 6 | 64 ± 6 | 71 ± 5 | 0.06 |
| Mood | 50 ± 4 | 47 ± 3 | 48 ± 3 | 0.33* |
| Communication | 69 ± 4 | 69 ± 4 | 70 ± 6 | 0.15* |
| Force | 36 ± 6 | 32 ± 5 | 38 ± 5 | 0.12* |
| Hand | 24 ± 7 | 21 ± 6 | 35 ± 8 | 0.15* |

*Not significant.

predicts reliance on a less-dependent assistive device and discharge destination [27]. Six-minute walk distances increased 24 percent, similar to gains reported with 6 months of treadmill training [28]. We found that APA produced a significant increase in Barthel Index scores. In contrast, a randomized study of 3 months of community-based physiotherapy in 359 chronic stroke patients found only modest gains in gait speed and no change in Barthel Index [29]. Why APA improved basic but not instrumental ADL profiles is unclear but may relate to the task-specificity of APA for targeting mobility exercises. By contrast, the finding of improved upper-limb Motricity Index scores was unexpected since functional upper-limb training was not a formal component of the APA program. However, many of the APA exercises did engage the affected upper limb, and the gains in gait and balance may have enabled more effective upper-limb use during daily activities leading to improved Motricity Index scores. Our results add to a growing body of literature that intensive task-specific training can improve key functional outcomes, including gait and balance, in chronic stroke patients. [30–33]

Recent studies have focused on group exercise models for chronic stroke that may be administered in a more cost-effective manner at the community level. A number of training programs including modified cycle ergometry, water aerobics, treadmill, and lower-limb group exercises are proven in randomized studies to increase fitness levels and selected functional outcomes [34]. Four weeks of treadmill combined with overground walking training is reported to increase walking speed 20 percent but not improve stroke-specific disability indices in chronic hemiparesis [11]. A randomized study by Pang et al. found that a 19-week community exercise program improved leg strength and 6-minute walk distances but not BBS scores [8]. Similarly, regular water aerobics as well as aerobics plus strength training are reported to increase overground walking by 16 and 21 percent in chronic stroke survivors, respectively [35]. Our findings corroborate recent studies that structured group exercise programs that include components of weight-shifting and agility significantly improve mobility and balance for older individuals with chronic stroke deficits [36]. A unique aspect of APA is the combination of gymnasium work for social reinforcement and parallel home exercises to facilitate the transfer of mobility-related behaviors into daily habits. This combination may contribute to the observed improvements in multiple self-reported SIS domains related to QOL. Further studies are needed to determine the optimal setting(s) and dose intensity of exercise that durably improve function and QOL in the chronic stroke population.

In summary, APA improves gait and balance function, enhances basic ADL profiles, and improves GDS and SIS domains related to QOL poststroke. Our results are limited by the noncontrolled design, small sample size, and lack of blinding to outcomes. However, no differences were found between repeated baseline testing a month apart, which shows stability for all functional measures in subjects that are a mean >4 years poststroke and would otherwise not be expected to improve [37]. Since age of 85 years and latency of 25 years poststroke did not alter treatment response, APA has the potential to improve function and QOL for many individuals who are aging with the chronic disability of stroke. Larger studies are underway to determine whether community-based APA improves rehabilitation and health outcomes in the chronic stroke population.

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