

A task-orientated intervention enhances walking distance and speed in the first year post stroke: a randomized controlled trial

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Objective: To evaluate the efficacy of a task-orientated intervention in enhancing competence in walking in people with stroke.

Design: Two-centre observer-blinded stratified block-randomized controlled trial.

Setting: General community.

Subjects: Between May 2000 and February 2003, 91 individuals with a residual walking deficit within one year of a first or recurrent stroke consented to participate.

Interventions: The experimental intervention comprised 10 functional tasks designed to strengthen the lower extremities and enhance walking balance, speed and distance. The control intervention involved the practice of upper extremity activities. Subjects in both groups attended sessions three times a week for six weeks.

Main measures: Six-minute walk test (SMWT), 5-m walk (comfortable and maximum pace), Berg Balance Scale, timed 'up and go'.

Results: At baseline, subjects in the experimental ($n=44$) and control ($n=47$) groups walked an average distance of 209 m (SD = 126) and 204 m (SD = 131), respectively, on the SMWT. Mean improvements of 40 m (SD = 72), and 5 m (SD = 66) were observed following the experimental and control interventions, respectively. The between-group difference was 35 m (95% confidence interval (CI) 7, 64). Significant between-group effects of 0.21 m/s (95% CI 0.12, 0.30) and of 0.11 m/s (95% CI 0.03, 0.19) in maximum and comfortable walking speed, respectively, were observed. People with a mild, moderate or severe walking deficit at baseline improved an average of 36 (SD = 96), 55 (SD = 56) and 18 m (SD = 23), respectively, in SMWT performance following the experimental intervention.

Conclusions: Study findings support the efficacy of a task-orientated intervention in enhancing walking distance and speed in the first year post stroke, particularly in people with moderate walking deficits.

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Introduction

In the developed world, stroke is the second leading contributor to years of life lost due to disability.¹ The activity most affected by stroke is walking, with as many as 80% initially losing this ability.²⁻⁶ Fortunately, walking ability rapidly improves in the first five weeks following a stroke,^{5,6} and recovery may continue beyond three^{4,6,7} and even six months.^{4,5} For many, however, the recovery of walking ability is incomplete.³ It has been noted⁸⁻¹⁰ that people returning home after rehabilitation walk at average speeds that are insufficient to cross the street safely, or even to walk safely in the community.¹¹ This lack of walking competency is of great concern.

In this paper, the term walking competency is used to describe a level of walking ability that allows individuals to navigate their community proficiently and safely. Elements of walking competency include walking at adequate speeds to cross the street safely, walking the distances necessary to accomplish basic and instrumental activities of daily living, independently negotiating kerbs, turning the head while walking and maintaining balance, maintaining stability despite unexpected perturbations, and demonstrating anticipatory strategies to avoid or accommodate upcoming obstacles.^{12,13}

Growing evidence indicates that task-orientated practice¹⁴⁻²⁷ performed at a high intensity^{15,18,23,24,28-31} may enhance walking competency in people with stroke to a greater extent than other methods. Task-orientated walking therapy, organized as a series of workstations in a circuit, has recently been shown to be beneficial in a small convenience sample of people with chronic stroke.¹⁶ The impact of the programme in the wider stroke population and at earlier stages is unknown. Thus, the objective of the study was to evaluate the efficacy of a task-orientated intervention in enhancing competence in walking in people with stroke. We hypothesized that people who received six weeks of training in walking-related tasks would demonstrate greater improvements in walking competency than people who received six weeks of upper extremity (UE) training.

Methods

Subjects

Subjects were recruited from nine hospitals and two rehabilitation centres in Montreal or Quebec City. Eligibility criteria included: (1) clinical diagnosis of a first or recurrent stroke, (2) residual walking deficit resulting from the most recent stroke, (3) mental competency, evaluated using the telephone version of the Mini-Mental State Examination,³² (4) ability to walk 10 m independently, using an aid or orthotic, with or without supervision, (5) ability to comprehend the instructions for the testing procedures, (6) residence in the community, (7) discharge from physical rehabilitation, and (8) time interval between the most recent stroke and time of recruitment of one year or less. The time post stroke was limited to one year in order to obtain a relatively homogeneous sample of individuals readjusting to community living. Reasons for exclusion were: (1) neurological deficit caused by metastatic disease, (2) recovery of walking ability, defined as the achievement of age- and gender-specific norms³³ on the 6-minute walk test³⁴ (SMWT) that were computed using a regression equation,³³ (3) discharge to a permanent-care facility, or (4) comorbidity precluding participation in either intervention.

Evaluations

Evaluations were conducted by trained evaluators at baseline, and on completion of the intervention (mean four days). Only raters who were unaware of the group assignment performed post-intervention evaluations.

Measurement

The SMWT³⁴ was selected as the primary measure of walking competency because the walking task requires three components that are required of an independent community ambulator: walking speed, balance, and submaximal endurance. Secondary measures included the 5-m walk³⁵ performed at a comfortable and maximum pace, the timed 'up and go' (TUG),³⁶ and the Berg Balance Scale.³⁷ Sociodemographic information and clinical features of the stroke were obtained through chart review.

Six-minute walk test

The SMWT³⁴ is a measure of exercise tolerance. In this study, subjects were instructed to walk back and forth, unaided if possible, along a 20-m walkway.³³ Rests were taken as needed. Evaluators provided standard encouragement every 30 seconds.³³ The maximum distance walked in 6 minutes was recorded. Two trials were completed, with a 30-minute rest period in between. The best performance was used in the analysis.

Five-metre walk

The 5-m walk³⁵ was used to compute comfortable and maximum walking speed. Subjects were instructed to walk a 9-m distance at a comfortable pace, unaided if possible, and were timed using a stopwatch over the middle 5-m section. Subjects were then asked to repeat the test at a maximal pace.

Timed 'up and go'

The TUG³⁶ is a measure of functional mobility. The time taken to stand up from an armchair, walk forward 3 m, turn, and return to the seated position is recorded. No physical assistance is given.

Berg Balance Scale

The Berg Balance Scale³⁷ is a measure of functional balance. The ability to maintain balance while performing 14 tasks required in everyday living is scored on a five-point scale, rendering a range of scores from 0 to 56. Higher scores reflect a better level of balance ability.

Randomization

Subjects were stratified³⁸ according to three levels of walking deficit defined by comfortable walking speed: mild (≥ 0.7 m/s), moderate (0.3 to < 0.7 m/s) and severe (< 0.3 m/s). The sequence of random assignments was computer generated in randomly ordered block sizes of two and four for each stratum, and maintained in sealed opaque envelopes. Envelopes were prepared prior to recruitment by persons not involved in the study. Envelopes were provided to the evaluator when a new subject was scheduled for assessment. Once consent and baseline assessment were complete, evaluators stratified subjects and unveiled their treatment assignment.

Interventions

Subjects in both groups participated in 18 sessions of task-orientated training, given three times a week for six weeks in a rehabilitation or hospital setting. The mobility intervention, inspired by Dean *et al.*,¹⁶ was a standardized programme, supervised by a physical or occupational therapist, of 10 walking-related tasks designed to strengthen the lower extremities and enhance walking balance, speed and distance in a progressive manner (Appendix). Subjects were challenged to maximize their performance and rested when necessary. The study therapist recorded the duration and level of difficulty achieved by a subject in each task on individualized log sheets every session. The log sheets were used as a reference to show subjects that they were improving. It was recommended to each subject to carry over the walking component of this programme at home.

The control group performed functional, UE tasks, such as manipulating cards, using a keyboard and writing. Tasks were done while sitting to minimize the load on the lower extremities and subjects were recommended to practice these tasks at home. In addition, any other activities, formal or informal, that subjects participated in was recorded.

Sample size

A sample of 60 persons was needed to detect a group difference of 28 m in average change in SMWT performance (type I error = 0.05, type II error = 0.10, expected drop-out rate of 10%). This calculation was based on the results of a pilot trial of a similar intervention (group difference on SMWT = 37 m, SD = 30.4).¹⁶ Walking 28 m is clinically meaningful as it represents the length of a crosswalk in a commercial area.¹²

Statistical methods

Data were analysed on the basis of intention-to-treat. Continuous variables were compared by independent sample *t*-tests, and differences between mean change scores were expressed with 95% confidence intervals (CIs). Because the Berg Balance Scale is scored on an ordinal scale, balance capacity was analysed using the nonparametric Wilcoxon rank-sum test. Comparisons of SMWT performances were made in each stratum.

The proportion in each group that deteriorated, achieved between 0 and 27 m, or 28 m or greater on the SMWT was compared using a chi-square test. Additionally, the mean change in SMWT performance in people with a first or recurrent stroke was compared in each group. The statistical software used for the analysis was SAS version 8.02. An alpha level of 0.05 determined significance in two-sided hypothesis testing.

The research ethics committees at both study sites approved the study protocol. Subjects provided voluntary, informed, written consent.

Results

Participant flow and handling of missing data

Between May 2000 and February 2003, 91 people were enrolled in the study (85 in Montreal and six in Quebec City). Forty-four subjects were randomized to the mobility intervention and 47 subjects to the UE intervention. Table 1 presents baseline characteristics of the study groups.

Figure 1 presents the flow of participants through the study, and provides details of recruitment, withdrawals and missing data. There were three missing SMWT scores at baseline owing to subjects failing the medical screen for this test. Values for these subjects were estimated from baseline maximum walking speed using simple linear regression. The impact of this estimation procedure on the estimated effect of the intervention was examined using a technique called

multiple imputation.³⁹ Two people who withdrew agreed to undergo a postintervention evaluation, leaving six subjects with missing postintervention data. When data were missing due to severe illness or pain, mean scores of people who deteriorated within the same group and stratum were imputed. Otherwise, the method of last value carried forward was used.

Subject compliance

In the mobility group, 38 subjects (86%) attended 17 or 18 out of 18 treatment sessions and completed 9 out of 10 tasks, on average, at each session. In the UE group, 34 subjects (72%) attended 17 or 18 sessions.

Outcomes and estimation

Table 2 presents the performance of subjects on measures of walking competency. The mobility group members improved their SMWT performance by an average of 35 m more than members of the UE group (95% CI 7, 64). Analyses conducted (1) with multiple imputations for missing SMWT scores at baseline, and (2) ignoring missing data, did not change the results. Following mobility training, subjects walked an average of 0.11 m/s (95% CI 0.03, 0.19) and 0.21 m/s (95% CI 0.12, 0.30) faster than subjects in the UE group on tests of comfortable and maximum walking speed, respectively.

The mean change in SMWT performance within each stratum of walking deficit measured at baseline was computed. In the mild, moderate and

Table 1 Baseline characteristics of study subjects

Characteristic	Mobility training (n=44)	UE training (n=47)
Age in years, mean (SD) range	71 (12) 38–90	73 (8) 51–91
Gender, no. (%): men/women	26 (59)/18 (41)	30 (64)/17 (36)
No. (%) living with: spouse/other/alone	26 (59)/10 (23)/8 (18)	30 (64)/8 (17)/9 (19)
Side of hemiplegia, no. (%): left/right/bilateral	17 (39)/27 (61)/0	22 (47)/24 (51)/1 (2)
Type of stroke, no. (%): ischaemic/haemorrhagic	40 (91)/4 (9)	36 (77)/11 (23)
No. of strokes, no. (%): 1/2/4	39 (89)/5 (11)/0	41 (87)/5 (11)/1 (2)
No. days post stroke at baseline, mean (SD) range	239 (83) 86–374	217 (73) 57–386
No. co-morbid conditions, no. (%): 0/1–2/3–4/>4	2 (5)/13 (30)/17 (39)/12 (27)	3 (6)/19 (40)/18 (38)/7 (15)
No. (%) wearing an ankle-foot orthosis	11 (25)	14 (30)
No. (%) using: no aid/cane/walker	23 (52)/17 (39)/4 (9)	18 (38)/25 (53)/4 (9)

UE, upper extremity; SD, standard deviation; No., number.

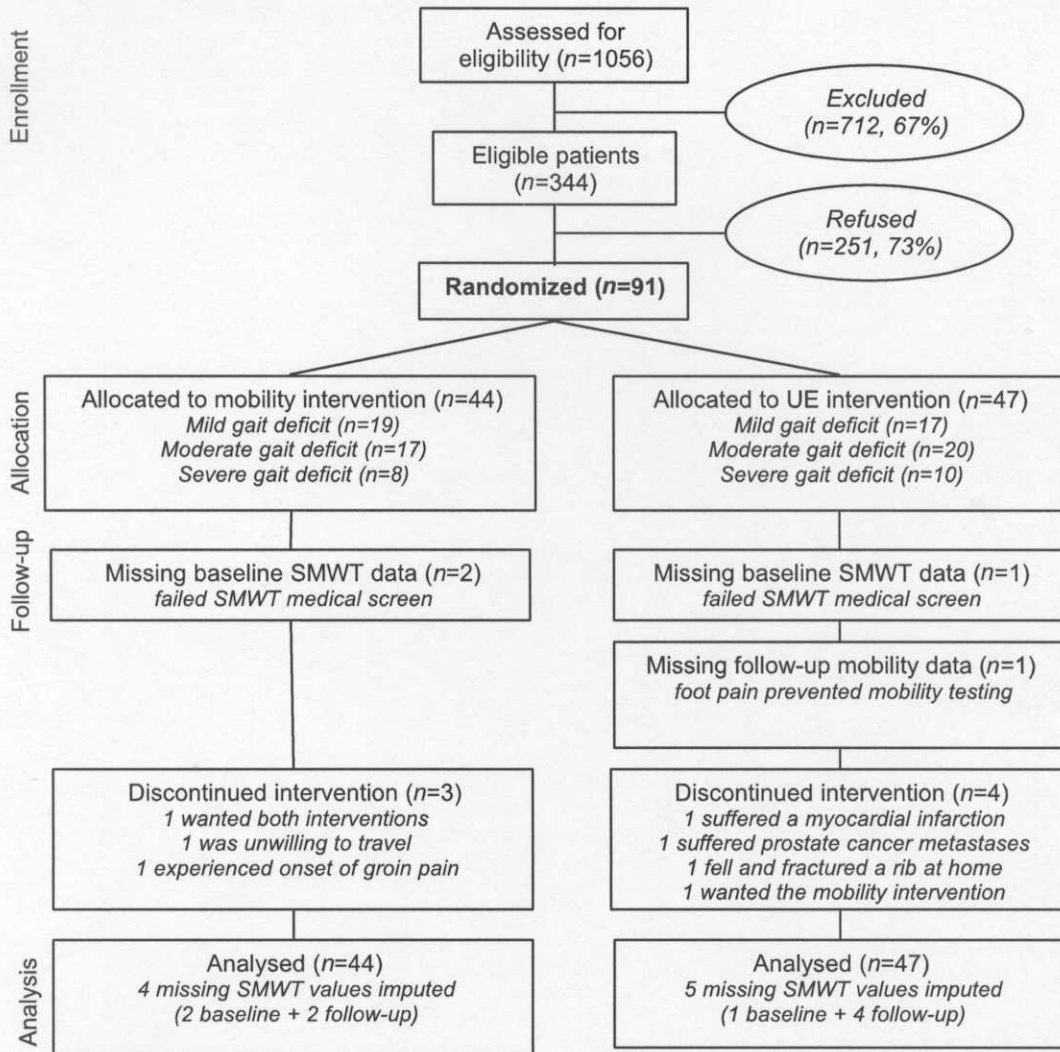


Figure 1 Flow of subjects through the trial (UE, upper extremity; SMWT, 6-minute walk test). Subjects were stratified according to three levels of walking deficit defined by comfortable walking speed: mild (≥ 0.7 m/s), moderate (0.3 to < 0.7 m/s) and severe (< 0.3 m/s).

severe strata, the mobility group improved by 36 m (SD = 96), 55 m (SD = 56) and 18 m (SD = 23), while the average change in the UE group was 17 m (SD = 100), -1 m (SD = 43) and -6 m (SD = 19), respectively. Group differences and 95% CIs in the mild, moderate, and severe strata were 19 m (-47 , 85), 55 m (22, 88) and 24 m (3, 46), respectively.

Table 3 shows that there was a significant effect of mobility training on the proportion of subjects in each group who deteriorated, achieved between 0 and 27 m, or 28 m or greater on the SMWT.

Subjects in the mobility group who had sustained a first ($n = 39$) compared to a recurrent stroke ($n = 5$) improved their SMWT performance by an average of 43 m and 17 m, respectively, following the intervention. People in the UE group who had sustained a first stroke ($n = 41$) improved their SMWT performance by an average of 8 m, whereas people who had sustained a recurrent stroke ($n = 6$) deteriorated by an average of 18 m, following the intervention.

Unblinding of outcome evaluators occurred for 18 (of 42) mobility and 16 (of 43) UE postinter-

Table 2 Performance on measures of walking competency

Measure	Mobility training (n=44)			UE training (n=47)			Group difference (95% CI)
	Mean	SD	Range	Mean	SD	Range	
Six-minute walk test (m)							
Pre	209	126	13–520	204	131	9–594	
Post	249	136	37–530	209	132	4–550	
Change	40	72	–61–381	5	66	–90–379	35 (7, 64)
Comfortable walking speed (m/s)							
Pre	0.64	0.33	0.10–1.41	0.61	0.37	0.08–1.90	
Post	0.78	0.40	0.10–1.58	0.64	0.37	0.01–1.29	
Change	0.14	0.18	–0.31–0.60	0.03	0.20	–0.76–0.46	0.11 (0.03, 0.19)
Maximum walking speed (m/s)							
Pre	0.79	0.45	0.12–1.84	0.81	0.49	0.08–2.33	
Post	0.99	0.56	0.11–2.33	0.80	0.49	0.01–1.93	
Change	0.20	0.26	–0.24–1.16	–0.01	0.18	–0.68–0.30	0.21 (0.12, 0.30)
Timed 'up & go' (s)							
Pre	24.4	18.8	7.9–88.9	25.5	21.7	7.0–100.0	
Post	23.2	20.6	6.3–93.7	27.1	27.1	7.3–154.4	
Change	–1.2	9.7	–22.3–51.7	1.7	13.5	–17.6–58.6	–2.9 (–7.8, 2.0)
Berg Balance Scale (/56)							
Pre	42	11	21–56	40	13	5–56	
Post	44	11	11–56	41	13	10–55	
Change	2	6	–12–18	1	6	–12–12	*

UE, upper extremity.

*Wilcoxon rank-sum test, $p=0.854$.

vention evaluations. Unblinding did not bias the estimated effect of the mobility intervention as evaluated in a multiple linear regression model.

Adverse events

Throughout the study, a total of 1638 mobility sessions were conducted, and four subjects experienced a fall. These individuals did not suffer an

injury and were able to continue their participation. Two additional falls occurred during evaluations but the subjects were able to continue with testing.

Discussion

Our study findings support the efficacy of a task-orientated intervention in enhancing walking distance and speed in the first year post stroke. Persons who began the study with a moderate walking deficit demonstrated the greatest gains in walking distance. Although participation in the mobility intervention resulted in positive effects on functional mobility and balance, these benefits were not significant.

It was not surprising that the greatest impact of the mobility intervention was on SMWT performance given that five out of the 10 mobility tasks

Table 3 Six-minute walk test results

Change in 6-minute walk test performance (m)	Mobility training (n=44) No. (%)*	UE training (n=47) No. (%)*
<0	9 (20)	26 (55)
0–27	13 (30)	13 (28)
≥28	22 (50)	8 (17)

UE, upper extremity.

* $\chi^2=14.7$, $p<0.001$.

provided subjects with the opportunity to walk continuously for up to 5 minutes (and up to 10 minutes for treadmill walking). This finding supports the effectiveness of task-specific training. Gains in endurance were comparable to those observed following a circuit training programme in people with a more chronic stroke.¹⁶

Greater improvements in walking distance than those found in the current study have been observed following treadmill training with partial body weight support²⁰ (pBWS), and a home-based therapeutic exercise programme.⁴⁰ Subjects in these two latter studies were at a more acute stage of recovery, thus, ongoing neurological recovery may be responsible for the discrepancy in SMWT results. Comparing the interventions of these other studies with the current study is of clinical interest to identify which training components are critical for enhancing walking distance. Treadmill training is a task that was common to the current study and the study by Visintin *et al.*,²⁰ which suggests that this strategy may be important in improving walking endurance. In the study by Duncan *et al.*,⁴⁰ the experimental intervention included progressive, interval training on a stationary bicycle (but not continuous walking activities), and this appears to have been the most influential factor in enhancing SMWT performance.

That significant but small effects on comfortable and maximum walking speed were observed following task-orientated walking training concurs with studies of people with acute⁴¹ and chronic¹⁶ stroke. The average gain in comfortable walking speed, however, did not extend beyond the limits of measurement error (i.e., -0.113 to 0.172 m/s)⁴² reported for the 10 m walk performed at a comfortable pace. In comparison, treadmill walking for 20–30 minutes daily has recently been shown to substantially improve gait speed in people past the acute stage of recovery.^{19–21,23,24} This is particularly true when the experimental protocol was designed to progress walking speed.⁴³ For example, Pohl and associates²⁴ observed an average gain of 1.02 m/s following a four-week, speed-dependent training protocol in subjects at an average of 16 weeks post stroke. In a more chronic group, Sullivan and coworkers²³ found that four weeks of treadmill training with pBWS at fast speed led to an average gain of 0.72 m/s. Thus, it would seem that more frequent training with

longer periods of continuous speed walking than was provided in the current study are necessary in order to substantially improve walking speed.

Surprisingly, no significant effects were observed on balance ability. This is in contrast with the trial conducted by Duncan *et al.*⁴⁰ in which subjects practised similar balance activities as in the current study but over an average of 33 visits. Subjects in this latter trial were also at more acute stage and were possibly still undergoing neurological recovery.

There was no effect of the mobility intervention on improving the time taken to rise from a chair, walk 3 metres and return to a seated position (TUG) either in our study or in the study by Dean *et al.*¹⁶ This result was perhaps not surprising as only one of the 10 tasks of the mobility intervention involved practising sit-to-stand.

The greatest disparity in SMWT performance between the groups was observed in people with a moderate walking deficit at baseline. A similar phenomenon has been noted in studies evaluating different organizations of care for stroke survivors.^{44,45} The performance of 10 mobility tasks, even with rest periods, led to a substantial training effect (55 m) in these individuals. The smaller effect observed in the mild stratum (36 m) may indicate that a more intensive intervention is necessary to train endurance in this subgroup. A circuit training approach¹⁶ that does not allow rest periods, or treadmill walking,²³ may lead to greater improvements. The smallest average gain on the SMWT (18 m) was observed in the severe stratum of the mobility group. That people with severe walking deficits have been observed to achieve greater gains in SMWT performance following treadmill training with or without pBWS²⁰ may indicate the treadmill as the modality of choice for this subgroup. A direct comparison of results is made difficult, however, as the subjects who received

Clinical messages

- Walking endurance and speed can be enhanced by task-orientated therapy even late after stroke onset.
- Attention alone does not result in measurable gains.

treadmill training in the study by Visintin *et al.*²⁰ were at a more acute stage of recovery. Clearly, further study is necessary to identify interventions for different levels of walking deficit that optimize multiple elements of walking competency post stroke.

Limitations

Maintenance of blinding during outcome evaluations is a challenge of rehabilitation trials, and this study was no different. During some of the evaluations, subjects made references to the intervention they had received and these unblinded evaluators. Any potential for unblinding to bias the study results was minimized by the use of objective outcome measures, as well as standard instructions and encouragement during testing.

Another challenge of clinical trials is the potential for selection bias caused by subject withdrawal. Outcome data on all mobility measures were missing for five subjects due to pain or the progression of comorbid diseases. Deletion of these data seemed inappropriate because we can assume that subjects would have performed worse than baseline, if they had been evaluated, due to their deteriorated physical condition.⁴⁶ Thus, values that reflected a worsened physical state were imputed to obtain an unbiased estimate of the effect of the intervention.

Finally, clinical trials are notorious for recruiting only a small proportion of the clinical population because of the need to select subjects who would not be harmed or inconvenienced by the intervention. The observation that the majority of people who refused could not tolerate the travel for attendance at the clinic sessions emphasizes the need to translate the proven efficacy of this programme rapidly to community-based settings. Given the nature and structure of the activities provided, they could easily be accomplished in a home or community environment.

Conclusion

The mobility intervention permitted gains in walking distance, particularly in people with a moderate walking deficit, which were not observed in the UE group. This result is generalizable

primarily to people who were able to walk an average of eight months after sustaining a first stroke – characteristics that describe the great majority of the study sample. Future research should focus on defining clinically meaningful change in SMWT performance in people with stroke, and on identifying interventions that benefit multiple elements of walking competency for people with different levels of deficit. An evaluation of the impact of offering the mobility programme within the community in terms of physical outcomes, well-being and cost is also warranted.

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Appendix – Components of the mobility intervention

Task	Target	Description and progression
Warm-up	ROM and flexibility	Marching on the spot, arm lifts, ankle circles, stretching of the trunk, thigh, and calf muscles.
Step-ups	Balance	Five minutes of placing each foot alternately on a step, progressing to stepping onto a step (step-ups), to a higher step, and to decreasing UE support; time divided evenly between leading with right versus left foot.
Balance beam	Balance	Five minutes of walking forwards, sideways, and backwards between two parallel lines, 20 cm apart, progressing to using one line, to using a balance beam, and finally to lateral stepping on the floor, feet crossing over in front or in back, and then alternating.
Kicking ball	Balance	Five minutes of kicking a ball against a wall, progressing to decreasing UE support, to increasing the distance from the wall, to kicking to a target, and to dribbling the ball around pilons; time divided evenly between kicking with right versus left foot.
Stand up and walk	Balance LE strength walking	With four standard armchairs placed at four corners of a square, 5 min of repeatedly standing up and walking to the chair directly in front, sitting, then standing up and walking to the chair on the left, etc., progressing from using arms to not using arms, and to decreasing the seat height.

Appendix (Continued)

Task	Target	Description and progression
Obstacle course	Walking balance	Five minutes of stepping over an obstacle, stepping onto, along, and down from an aerobics step, walking over a mat, up a ramp, and returning, progressing by increasing the height and number of obstacles, and from completing the course walking forwards to walking backwards.
Treadmill	Walking endurance	Ten minutes of walking at a comfortable pace, progressing from using arms to not using arms, by increasing treadmill speed, and by adding an inclination.
Walk and carry	Walking balance	Five minutes of continuous walking carrying a grocery bag, progressing to carrying a bag in each hand, to increasing the weight of the bag, to carrying a laundry basket, and to stopping on command.
Speed walk	Walking endurance	Five minutes of continuous walking at maximum speed, progressing to running.
Walk backwards	Walking	Five minutes of continuously walking backwards, progressing from receiving physical assistance to receiving no assistance.
Stairs	LE strength	Five minutes of going up and down a flight of stairs, progressing from taking one step at a time to taking alternating steps, from using to not using the handrail, and to achieving a greater number of flights.

ROM, range of motion; UE, upper extremity; LE, lower extremity.