Effectiveness of a Wheelchair Skills Training Program for Powered Wheelchair Users: A Randomized Controlled Trial

R. Lee Kirby, MD, FRCPC,

Department of Medicine (Division of Physical Medicine and Rehabilitation), Dalhousie University,
Halifax, NS

William C. Miller, PhD,

Department of Occupational Science and Occupational Therapy, Vancouver, BC

Francois Routhier, PhD,

Department of Rehabilitation, Université Laval; Centre for interdisciplinary research in
rehabilitation and social integration, Institut de réadaptation en déficience physique de Québec,
Québec City, PQ

Louise Demers, PhD,

School of Rehabilitation, Université de Montréal, Montréal; Research Center, Institut universitaire
de gériatrie de Montréal, Montréal, PQ

Alex Mihailidis, PhD,

Department of Occupational Science & Occupational Therapy, University of Toronto, Toronto, ON

Jan Miller Polgar, PhD,

School of Occupational Therapy, Western University, London, ON

Paula W. Rushton, PhD,

School of Rehabilitation, Université de Montréal, Montréal, CHU Sainte-Justine Research Center,
Montréal, Québec

Laura Titus, PhD,

School of Occupational Therapy, Western University, London, ON

Cher Smith, MSc,

Department of Occupational Therapy, Capital District Health Authority, Halifax, NS

Mike McAllister, PhD,

Faculty of Computer Science, Dalhousie University, Halifax, NS

Corresponding Author: R. Lee Kirby, Nova Scotia Rehabilitation Centre, Room 206, 1341 Summer Street, Halifax, NS, Canada B3H 4K4, Phone: (902) 473-1268, Fax: (902) 473-3204, kirby@dal.ca.

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Chris Theriault, MSc,
Research Methods Unit, Dalhousie University, Halifax, NS

Kara Thompson, MSc, and
Research Methods Unit, Dalhousie University, Halifax, NS

Bonita Sawatzky, PhD
Department of Orthopaedics, UBC, Vancouver, BC

Abstract

Objectives—To test the hypothesis that powered wheelchair users who receive the Wheelchair Skills Training Program (WSTP) improve their wheelchair skills in comparison with a Control group that receives standard care. Our secondary objectives were to assess goal achievement, satisfaction with training, retention, injury rate, confidence with wheelchair use and participation.

Design—Randomized controlled trial (RCT).

Setting—Rehabilitation centers and communities.

Participants—116 powered wheelchair users.

Intervention—Five 30-minute WSTP training sessions.

Main Outcome Measures—Assessments were done at baseline (T1), post-training (T2) and 3 months post-training (T3) using the Wheelchair Skills Test Questionnaire (WST-Q 4.1), Goal Attainment Score (GAS), Satisfaction Questionnaire, Injury Rate, Wheelchair Use Confidence Scale for Power Wheelchair Users (WheelCon) and Life Space Assessment (LSA).

Results—There was no significant T2-T1 difference between the groups for WST-Q capacity scores ($p = 0.600$) but the difference for WST-Q performance scores was significant ($p = 0.016$) with a relative ($T2/T1 \times 100\%$) improvement of the median score for the Intervention group of 10.8%. The mean (SD) GAS for the Intervention group after training was 92.8% (11.4) and satisfaction with training was high. The WST-Q gain was not retained at T3. There was no clinically significant difference between the groups in injury rate and no statistically significant differences in WheelCon or LSA scores at T3.

Conclusions—Powered wheelchair users who receive formal wheelchair skills training demonstrate modest transient post-training improvements in their WST-Q performance scores, they have substantial improvements on individualized goals and they are positive about training.

Keywords

Wheelchair; rehabilitation; training; motor skills; RCT

Of people who use wheelchairs (excluding scooters) in North America, ~13% use powered wheelchairs.^{1–3} Powered wheelchairs can have a positive impact on well-being, self-esteem, pain, activity and participation.^{4–15} However, powered wheelchairs are not without problems.^{11,16} There can be functional difficulties with powered wheelchair use, such as difficulty maneuvering in indoor spaces, difficulty in handling for caregivers, and difficulty transporting the powered mobility devices in vehicles.⁸ Cognitive impairment can restrict the

usefulness of power wheelchairs for some users.^{17,18} Safety is also an issue for users of manual and powered wheelchairs, with 5–18% of community-dwelling wheelchair users experiencing wheelchair-related injuries each year.^{19–25} A high proportion of wheelchairs require repairs in the first 6 months after they are provided.^{26,27} Wheelchair abandonment can occur when users are faced with such difficulties.^{7,28–31}

One important aspect of the wheelchair-provision process that has become increasingly well recognized is training in wheelchair use.³² There is growing evidence of an association between wheelchair skills capacity and such broader issues as confidence³³ and participation.^{34–42} However, the reported prevalence of formal wheelchair skills training is low.^{43–50}

The Wheelchair Skills Training Program (WSTP)⁵¹ is a training protocol that draws on both the wheelchair literature (how to perform the skills) and the principles of motor skill learning (how to teach the skills).⁵² The value of wheelchair skills training with respect to increased capacity has been well documented for manual wheelchair use.^{53–62} There has also been some published work on powered wheelchair training,^{63–67} although the sample sizes have been small.

The goal of the current study was to assess the WSTP for powered wheelchair users on a larger and more heterogeneous sample. Our primary objective was to test the hypothesis that powered wheelchair users who receive the WSTP improve their wheelchair skills in comparison with a Control group that receives standard care. Our secondary objectives were to assess goal achievement, satisfaction with training, retention, injury rate, confidence with wheelchair use and participation.

METHODS

Study Design

This was a 6-site, single-blinded (testers), RCT with parallel groups. We assessed participants on 3 occasions – at baseline (T1), 3 days after training (T2) and 3 months after T2 (T3).

Ethical Issues

The project was approved by the research ethics boards of the participating institutions. All participants provided informed consent.

Sample Size

For the power analysis, based on previous studies^{54–57} we assumed mean pre-training WST-Q scores of 45%, a 25% relative improvement in the WST-Q capacity score (to 57%) at T2 for the Intervention group, a 5% improvement for the Control group (to 47%), a standard deviation (SD) of T2-T1 differences of 10%, an α level of 0.05 and a two-sample two-sided *t* test for the comparison of change scores. Based on these assumptions, a sample size of 64 would have 90% power.

Recruitment and Screening

Potential participants, a sample of convenience, were recruited through rehabilitation facilities, wheelchair seating programs, wheelchair equipment vendors and our community partners. Advertisements were used to supplement recruitment as needed. Screening at each site was conducted by a member of the research staff, based on observation, self-report and data from the health record.

Inclusion/Exclusion Criteria

Eligible participants consisted of powered wheelchair users who used or were expected to use powered wheelchairs for at least 4 hrs/week. Each participant must have had access to a power wheelchair for training, have been ≥ 18 years of age, have required no more than minimal assistance for communication and auditory comprehension, have been able to pay attention during the intake session, have been comfortably seated in the powered wheelchair that was used for the study and have been willing to participate (as evidenced by completion of the baseline assessment). Participants were excluded if they had a rapidly progressive disorder, significant visual impairments, unstable medical conditions that might make the use of a powered wheelchair dangerous or had emotional problems that might make participation unsafe or unpleasant.

Group Allocation

Centrally generated randomization tables⁶⁸ were used to allocate participants (1:1) to Intervention or Control groups, using sealed envelopes to conceal the sequence. We stratified the sample in an attempt to ensure that the groups were comparable with respect to age (≤ 50 years and > 50 years) and powered wheelchair experience (≤ 3 months and > 3 months) but no limits were imposed on the proportions of the sample that were younger/older or less/more experienced.

Wheelchair Skills Training Program (WSTP)

Participants in the Intervention group received up to 5 30-minute individual WSTP 4.1 training sessions⁶⁹ at a targeted frequency of 1–2 sessions per week. The training was conducted in a variety of locales, including in and around the participants' homes or other participant-specific environments. The participants' caregivers were encouraged to participate. Participants were encouraged to practice between formal training sessions. Training logs and questionnaires were used to document the date, duration and content of each training session (Appendix). Participants in both groups received standard care (if any).

Outcome Measures

Wheelchair Skills—The Questionnaire version of the Wheelchair Skills Test (WST-Q) and the WST have been well studied with respect to their measurement properties.^{33,70–77} WST-Q 4.1 provides pass/fail scores for the 32 individual skills and total percentage scores for capacity (“*can do*”) and performance (“*does do*”).^{51,75,78}

Goal Achievement—Training goals (5–10) were developed collaboratively by the participants and trainers (Appendix).⁶⁹ Goal-Attainment Scores (GAS) (%) was calculated⁵¹

(number of goals accomplished/number of goals addressed during training x 100%) from the data recorded by the trainer. The baseline GAS was 0% by definition.

Satisfaction-with-Training—At the final training session, we asked participants “Did you find any of the 5 formal training sessions stressful or uncomfortable?”, “Did you find the 5 formal training sessions useful?”, “Do you feel that you improved your ability to perform wheelchair skills as a user from these 5 formal training sessions?”, “Would you recommend these formal training sessions to others?”, “What did you like the least about these training sessions?” and “What did you like the most about these training sessions?”.

Injury Rate—At T1, T2 and T3 we asked about the number of acute wheelchair-related injuries (serious enough that medical attention was sought) in the previous 6 months for T1 and in the previous month for T2 and T3. The injury rates were normalized to the number of injuries/participant/year. We also asked about the nature of the injury.

Confidence with Wheelchair Use—At T3 we used the Wheelchair Use Confidence Scale for Power Wheelchair Users (WheelCon) WheelCon, a 59 item self-report scale (0–100).^{79–81}

Participation—As an indicator of mobility-related participation, at T3 we used a component of the Life Space Assessment (LSA),^{82–84} recording scores of 0–5 corresponding to being limited to the room where one sleeps, being in other rooms of the home, being outside the home, being in the neighbourhood, being outside the neighbourhood and being outside one’s town.

Data Collection Procedure

The T1 assessment included enrollment, informed consent, screening and collection of demographic, clinical, wheelchair and wheelchair-usage data to describe the sample, and group allocation. Participants in the Intervention group received up to 5 WSTP training sessions. Both groups received standard care, if any. We assessed participants on 3 occasions (T1, T2 and T3). Questionnaires were used to collect information about potential confounding variables (e.g. weather, seasonal factors, health changes) (Appendix). French-Canadian translations were available for all materials.^{81,85} All data were collected between May 15, 2012 and August 30, 2014.

Data analysis

We used SAS v 9.3^a statistical software for the analysis and an α level of 0.05. Our definition of a minimum clinically significant difference was 20%. Descriptive statistics were computed. The comparability of the groups was assessed qualitatively.^{86,87}

To test the hypothesis that those in the Intervention group improved their total percentage WST-Q capacity and performance scores at T2 in comparison with the Control group, we used analysis of covariance (ANCOVA) models with T2-T1 changes in scores as the

^aStatistical software. SAS v 9.3. SAS Institute Inc., Cary, NC, USA.

outcome variable. Analysis was adjusted for the T1 WST-Q score in each model. We dealt with withdrawals by using intention-to-treat (ITT) procedures with assumptions of no-change and mean-change in the outcome measure for those who withdrew. In addition to the ANCOVA assessments, we conducted multivariate analyses using the T2-T1 changes in WST-Q capacity and performance scores as the dependent measures and *a priori* independent measures (age, sex, T1 scores, group and powered wheelchair experience).

Retentions of training effects from T2 to T3 for the Intervention group in total WST-Q capacity and performance scores were analyzed using paired *t*-tests. To test the hypothesis that participants in the Intervention group have lower injury rates than those in the Control group at each time point, we used the Chi-square test of incidence rate difference. To test the hypothesis that participants in the Intervention group have better total WheelCon and LSA scores at T3 than those in the Control group, we used a two-sample Wilcoxon rank sums test and a cumulative logit model respectively.

RESULTS

Participants

Of the 116 enrolled participants, 5 (9%) in the Intervention group and 2 (3%) in the Control group withdrew (Figure 1).⁸⁸ The proportion of withdrawals for the two groups was not different ($p = 0.173$). The T1 data of the withdrawals were not qualitatively different from those who completed all 3 assessments.

Demographic, Clinical and Wheelchair Data

There were no clinically significant differences between the groups with respect to the demographic and clinical data (Table 1), wheelchair specifications (Table 2) or wheelchair-usage data (Table 3). Most of the participants were very experienced powered wheelchair users.

Wheelchair Skills

The total percentage WST-Q capacity and performance scores are shown in Table 4 and are illustrated in Figures 2 and 3. From the ANCOVA model of the total percentage WST-Q capacity scores, the least-squares mean (SE) change (T2-T1) scores adjusted for the covariates in the 2 groups were 3.1% (1.1) and 2.3% (1.0) for the Intervention and Control groups ($F_{1, 107} = 0.31$, $p = 0.600$). From the ANCOVA model of the total percentage WST-Q performance scores, the least-squares mean (SE) change (T2-T1) scores adjusted for the covariates in the 2 groups were 3.9% (1.5) and -1.0% (1.3) for the Intervention and Control groups ($F_{1, 107} = 6.01$, $p = 0.016$). Data on individual skills are shown in the Appendix. There were no clinically significant differences ($< 20\%$) in the scores between the groups and only a single such difference (for skill #5) from one time point to the next within the groups. However, there were many instances of clinically significant differences between the capacity and performance scores and the performance scores were always equal to or less than the capacity scores.

Goal Achievement

The mean (SD) GAS at the completion of training was 92.8 % (11.4) with a median (inter-quartile range [IQR]) of 100 (3). Up to 10 goals were recorded for each participant in the Intervention group (n = 51). The mean (SD) number of goals per participant was 5.8 (1.8) with a median (IQR) of 5 (16.7). The median number of training sessions for each goal ranged from 1–2. There were 297 free-text descriptions of goals. Of the 295 that could be coded, 269 (91.2%) were related to a motor skill, 4 (1.4%) were not and 22 (7.5%) were combinations. All (100%) were relevant to wheelchair users (vs their caregivers). Of the goals, 251 (85.1%) were well focussed (i.e. not combining more than 2 specific WSTP skills). Of the goals, 237 (80.3%) were related to specific WSTP skills. Of these the 10 most frequently cited were 25 citations (9.8%) for pot-holes, 24 (9.4%) for doors, 23 (9.0%) for rolling backwards, 23 (9.0%) for turning while rolling backwards, 20 (7.8%) for soft surfaces, 18 (7.0%) for ascending a 5-cm level change, 13 (5.0%) for descending a 5-cm level change, 13 (5.0%) for descending a 10° incline, 12 (4.7%) for sideways maneuvering and 12 (4.7%) for avoiding moving obstacles.

Satisfaction with Training

Of the 50 participants in the Intervention group who completed the post-training questionnaire, 39 (78%) found the training was neither stressful nor uncomfortable, 46 (92%) found it useful, 46 (92%) found they had improved their abilities to perform wheelchair skills and 50 (100%) reported that they would recommend training to others. Of the 29 comments about what they liked least about the training, 7 (24%) expressed some stress or fear (e.g. about specific skills), 6 (21%) felt the training was “too short”, 3 (10%) mentioned difficulties with transportation, 3 (10%) felt there were aspects about the setting that were not realistic enough and 3 (10%) found the training to be too easy or repetitive. Of the 50 comments about what they liked most about the training, 31 (62%) enjoyed the challenge and process of learning new skills, 10 (20%) were most positive about their trainers and 9 (18%) were positive about specific skills.

Retention

The mean WST-Q T3-T2 change scores for the Intervention group were -0.3% (95% Confidence Interval [CI] -2.7 to 2.1%) for capacity ($t[48] = -0.25$, $p = 0.800$) and -4.8% (95% CI -9.5 to -0.1%) for performance ($t[48] = -2.01$, $p = 0.047$).

Injuries

There were no injuries during study-related activities that were serious enough to seek medical attention. The number of acute injuries and the injury rates at other times are shown in Table 5. Of the 16 injuries reported in total, 8 (50%) were related to wheelchair skills – accidentally hitting the controls (2), falling during a transfer (2), scraping a hand or arm (2), falling from the wheelchair on grass (1) and striking a wall (1).

Confidence with Wheelchair Use

At T3 the mean (SD) total WheelCon score for the Intervention group (n = 49) was 81.2 (16.2) with a median (IQR) of 84.3 (20.4); for the Control group (n = 60), the mean (SD) was 84.0 (11.2) with a median (IQR) of 86.0 (17.7) ($Z = -0.6701$, $p = 0.503$).

Participation

At T3 the mean (SD) total LSA score for the Intervention group (n = 49) was 4.3 (0.8) with a median (IQR) of 4.0 (1); for the Control group (n = 60), the mean (SD) was 4.2 (0.8) with a median (IQR) of 4.0 (1) ($p = 0.532$).

DISCUSSION

We achieved our goal of assessing the effects of training on a moderately large and heterogeneous sample. The WST-Q capacity scores were unexpectedly high at all time points for both groups and the difference between the groups was not statistically significant. The WST-Q performance scores were also moderately high at all time points but slightly less so than for the capacity scores. The T2-T1 WST-Q performance change scores were higher to a statistically significant extent for the Intervention group than the Control group but the relative gain (median T2/T1 score x 100%) was only 10.8%, lower than the improvements that have been previously reported.^{53–62} That the gain was in performance rather than capacity suggests that, even though the trained participants could not do any more WST-Q skills than was the case before training, they were using the skills they had more often.

The reasons for lower performance than capacity scores are not clear from the current study, but could reflect the short time period for the performance question (“Have you performed this skill in the past month) during which the performance of some skills (e.g. disengaging the motors) might not have been necessary. Alternatively, some wheelchair users may have avoided attempting skills that they were capable of performing if they had anxiety or low confidence in performing those skills.

There are a number of possibilities for why the WST-Q data failed to demonstrate as much of a training effect as we had expected. The first possibility is that training failed to induce an effect. If so, this could have been due to the experienced participants whom we studied. Experienced powered wheelchair users may have little room for improvement. WST-Q scores can be limited by wheelchair users’ skill levels but also by their impairments. For instance, no amount of skill training would permit a person with complete tetraplegia to transfer from the ground into the wheelchair. Other possibilities are that we did not provide a sufficient dose of training (an interpretation supported by the failure of retention) or that we did not provide enough training in the participants’ own environments.

We were more successful in corroborating our hypothesis that participants in the Intervention group would achieve their training goals, with participants achieving a mean post-training GAS of 92.8% (a very substantial success rate given that the baseline GAS was 0% by definition). The satisfaction-with-training data were also very positive. The positive

GAS and satisfaction data suggest that there *was* a training effect, supporting the ceiling effect explanation for the modest rise in WST-Q scores.

Regarding the injury rates (that were consistent with those previously published),^{19–25} there was a statistically significant difference between the groups at T3 but, given the small number of injuries reported, the difference was not meaningful. At T3 there were no statistically significant differences between the groups in confidence as measured by WheelCon scores, the median scores for which were moderately high. Regarding our assessment of mobility-related participation, at T3 there were no statistically significant differences between the groups in LSA scores. The LSA scores for the Intervention and Control groups were high. Sakakibara et al⁸⁹ have shown strong relationships among WST-Q, WheelCon and LSA scores.

Study Limitations

There were a number of study limitations. We had a number of withdrawals but the proportion (6%) was relatively small for a longitudinal training study. There was no evidence to suggest that the participants who withdrew affected the results. The participants were generally very experienced. Although this has not created difficulties in earlier studies,^{55,60,62} it is likely that this contributed to ceiling effects for the WST-Q, WheelCon and LSA scores. Although involving 6 sites permitted us to meet our recruitment targets in a practical length of time, the sites varied with respect to their wheelchair-provision models of care, standard care, funding arrangements, geography, climate and language. These and other confounding variables may have contributed to the variability of the data and have had a negative impact on statistical power.

We did not use an active control intervention, reasoning that one would be unnecessary because attention would be unlikely to affect our primary outcome measure (the WST-Q). However, given that one of the two most compelling outcome measures in support of training (namely the satisfaction-with-training data) was subjective, an active control might have been useful. There were other limitations due to our study design. Although the GAS and satisfaction-with-training data were very positive, they were only collected for the Intervention group, precluding statistical comparisons of the groups. The dose and nature of training may have been suboptimal. Our injury data only included more serious injuries and we did not include injuries to others. It would have helped to have had WheelCon and LSA scores at T1 and T2 so that the change scores could have been compared.

Future studies will be needed to address these limitations. For instance, we believe a similar study should be carried out on new powered wheelchair users with lower baseline WST-Q scores, with a goal-setting process for both groups, using a larger dose of training, performing the training in the participants' own environments with their caregivers in attendance, using an active control group and including a more detailed satisfaction survey. Despite the study limitations and the need for further study, this project was the largest study of its kind to date, the study has answered a number of important questions about the WSTP for powered wheelchair users and it has raised other questions that will need to be addressed.

CONCLUSIONS

Powered wheelchair users who receive formal wheelchair skills training demonstrate modest transient post-training improvements in their WST-Q performance scores, they have substantial improvements on individualized goals that they set and they are positive about training.

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LIST OF ABBREVIATIONS

CI	Confidence Interval
GAS	Goal Attainment Score
IQR	Inter-quartile range
ITT	Intention to treat
LSA	Life Space Assessment
RCT	randomized controlled trial
SD	Standard deviation
SE	Standard error
T1	First assessment (baseline)
T2	Second assessment (post-training or equivalent time period for Control group)
T3	Third assessment (3 months after T2)
WheelCon	Wheelchair Use Confidence Scale
WST-Q	Wheelchair Skills Test – Questionnaire version
WSTP	Wheelchair Skills Training Program

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Appendix

Training Logs

There were 253 training sessions. Of the 54 participants who started training, 4 (7%) had only a single session (all of these participants withdrew from the study), 1 (2%) had 4 training sessions and the remaining 49 (91%) had 5 training sessions. Of the 246 training sessions that were timed, the mean (SD) duration was 35.5 (9.0) minutes and the median (IQR) was 33 (10.0) minutes. Of the 248 training sessions for which such data were recorded, 153 (61.7%) took place in and around the rehabilitation center or hospital and 32 (12.9%) took place in and around the participants' residences. Four participants (8%) reported having had a caregiver in attendance during at least one training session.

Relationship between WST-Q Capacity and Performance Scores

We used Spearman correlation coefficients and Sign tests to compare and contrast the T1 total percentage WST-Q capacity and performance scores for the full sample ($n = 116$), testing the hypotheses that the two are highly correlated but that capacity exceeds performance. The correlation coefficient between the total percentage WST-Q capacity and performance scores was 0.654 ($p < 0.001$) and the mean capacity score was higher by a mean (SD) difference of 11.5% (11.5) and median (IQR) of 6.7% (13.7) ($p < 0.001$).

Multivariate Analyses of WST-Q Data

Each independent variable was tested for interaction with study group; none were statistically significant and therefore not included in the model. The multivariate model for the total percentage WST-Q capacity score revealed a statistically significant effect due to T1 scores ($F_{1,104} = 33.14$, $p < 0.001$) but not due to group ($F_{1,104} = 0.27$, $p = 0.579$), age ($F_{1,104} = 0.06$, $p = 0.698$), sex ($F_{1,104} = 0.0$, $p = 0.895$) or powered wheelchair experience ($F_{1,104} = 0.65$, $p = 0.422$). The multivariate model for the total percentage WST-Q performance score revealed significant effects due to group ($F_{1,104} = 6.01$, $p = 0.016$) and T1 scores ($F_{1,104} = 12.63$, $p = 0.001$) but not for age ($F_{1,104} = 0.04$, $p = 0.835$), sex ($F_{1,104} = 0.23$, $p = 0.633$) or powered wheelchair experience ($F_{1,104} = 0.24$, $p = 0.627$).

WST-Q Individual Skills

The capacity and performance data for individual skills are shown in Table A1.

Potential Confounding Variables

At T1, T2 and T3 we recorded whether there were any significant weather, seasonal factors or other events that could have affected outdoor wheelchair use during the previous month. At T2 and T3 we asked about any changes since the previous assessment in health status, any non-study changes in the wheelchair, wheelchair set-up or programming and if the participant had practiced wheelchair skills with his/her non-study therapist (if any), alone or with his/her caregiver. The T2 and T3 questionnaire data are shown in Table A2. During the T1-T2 and T2-T3 periods, 13–30% reported having had changes in their powered wheelchairs and 11–21% reported having had health changes. Regarding wheelchair skills practice other than as part of the study, 5–14% reported having practiced with a therapist and 15–18% reported having practiced with a caregiver. Practice alone was most common (43–76%), with the highest percentage of participants reporting doing so at T2 in the Intervention group. At T1 participants reported that weather, seasonal factors or other events in the past month had interfered with their use of their powered wheelchairs for 33 (61%) participants in the Intervention group and 32 (52%) in the Control group. At T2 27 (50%) of the participants and at T3 28 (57%) reported such interference.

Table A1

WST-Q capacity and performance data for individual skills

Individual Skill	Intervention Group			Control Group		
	T1 (n = 54)	T2 (n = 50)	T3 (n = 49)	T1 (n = 62)	T2 (n = 60)	T3 (n = 60)
1. Moving the joystick unit out of the way and back again						
Capacity	47/48 (98)	42/43 (98)	42/43 (98)	47/51 (92)	46/49 (94)	48/50 (96)
Performance	46/48 (96)	41/43 (95)	40/43 (93)	47/51 (92)	43/49 (88)	43/50 (86)
2. Turning the wheelchair power on and off						
Capacity	54 (100)	50 (100)	49 (100)	61 (98)	60 (100)	60 (100)
Performance	54 (100)	50 (100)	47 (96)	61 (98)	60 (100)	58 (97)

Individual Skill	Intervention Group			Control Group		
	T1 (n = 54)	T2 (n = 50)	T3 (n = 49)	T1 (n = 62)	T2 (n = 60)	T3 (n = 60)
3. Changing from one controller setting and speed to another						
Capacity	54 (100)	50 (100)	49 (100)	59/61 (97)	58/59 (98)	57/58 (98)
Performance	54 (100)	50 (100)	47 (96)	59/61 (97)	58/59 (98)	55/58 (95)
4. Tilting the seat backwards and forwards						
Capacity	30/30 (100)	27/27 (100)	29/29 (100)	28/28 (100)	28/28 (100)	27/27 (100)
Performance	30/30 (100)	27/27 (100)	28/29 (97)	28/28 (100)	28/28 (100)	26/27 (96)
5. Reclining the backrest while the seat remains in its original position and then getting back upright						
Capacity	9/9 (100)	3/5 (60) [@]	3/4 (75)	3/4 (75)	3/5 (60)	3/5 (60)
Performance	8/9 (89)	2/5 (40) [#]	3/4 (75)	3/4 (75) [#]	3/5 (60)	3/5 (60)
6. Disengaging the motors of the chair, so that someone could push it, then re-engaging them						
Capacity	23 (43)	25 (50)	24 (49)	31 (50)	31 (52)	32 (53)
Performance	12 (22) [#]	8 (16) [#]	12 (25) [#]	11 (18) [#]	8 (13) [#]	9 (15) [#]
7. Charging the wheelchair batteries						
Capacity	44 (82)	42 (84)	39 (80)	48 (77)	45 (75)	49 (82)
Performance	41 (76)	39 (78)	36 (74)	40 (65)	43 (72)	43 (72)
8. Making the wheelchair go straight forward on a smooth level surface for 10m						
Capacity	54 (100)	50 (100)	49 (100)	62 (100)	60 (100)	60 (100)
Performance	54 (100)	50 (100)	48 (98)	62 (100)	60 (100)	58 (97)
9. Rolling forward 10 m in 30 seconds						
Capacity	52/52 (100)	49 (98)	49 (100)	59/60 (98)	59 (98)	60 (100)
Performance	52/52 (100)	48 (96)	47 (96)	59/60 (98)	55 (92)	58 (97)
10. Moving the wheelchair a longer distance (~ 100 m)						
Capacity	54 (100)	49 (98)	49 (100)	61 (98)	59 (98)	60 (100)
Performance	54 (100)	47 (94)	42 (86)	59 (95)	56 (93)	58 (97)
11. Avoiding collisions						
Capacity	54 (100)	47 (94)	47 (96)	59 (95)	60 (100)	60 (100)
Performance	39 (72) [#]	28 (56) [#]	20 (41) [#]	38 (61) [#]	32 (53) [#]	32 (53) [#]
12. Moving straight backward for 5m						
Capacity	48 (89)	48 (96)	45 (92)	55 (89)	58 (97)	57 (95)
Performance	39 (72)	41 (82)	37 (76)	47 (76)	48 (80)	39 (65)
13. Turning forwards around a corner to the left or right						
Capacity	54 (100)	50 (100)	49 (100)	61 (98)	60 (100)	60 (100)
Performance	54 (100)	50 (100)	47 (96)	61 (98)	58/59 (98)	57 (95)
14. Turning backwards around a corner to the left or right						
Capacity	46 (85)	48 (96)	44 (90)	51 (82)	56 (93)	57 (95)
Performance	39 (72)	44 (88)	38 (78)	48 (77)	47 (78)	51 (85)
15. Turning the wheelchair around so that it is facing in the opposite direction, to the left or right						
Capacity	49 (91)	48 (96)	46 (96)	58 (94)	57 (95)	58 (97)

Individual Skill	Intervention Group			Control Group		
	T1 (n = 54)	T2 (n = 50)	T3 (n = 49)	T1 (n = 62)	T2 (n = 60)	T3 (n = 60)
Performance	44 (82)	46 (92)	40 (82)	54 (87)	50 (83)	50 (83)
16. Maneuvering the wheelchair sideways to the left and right						
Capacity	45 (83)	45 (90)	46 (96)	55 (89)	60 (100)	58 (97)
Performance	35/53 (66)	41 (82)	39 (80)	48 (77)	49 (82)	48 (80)
17. Opening a door from either direction, passing through it and closing it						
Capacity	44 (82)	44 (88)	40 (82)	44 (71)	46 (77)	47 (78)
Performance	42 (78)	42 (84)	36 (74)	38 (61)	40 (67)	41 (68)
18. Reaching overhead 1.5 m						
Capacity	50 (93)	46 (92)	45 (92)	56 (90)	56 (93)	56 (93)
Performance	48 (89)	42 (84)	39 (80)	51 (82)	47 (78)	48 (80)
19. Picking an object off the floor						
Capacity	41 (76)	38 (76)	42 (86)	42 (68)	43 (72)	44 (73)
Performance	37 (69)	38 (76)	39 (80)	36 (58)	38 (63)	38 (63)
20. Relieving the weight from the buttocks						
Capacity	51 (94)	50 (100)	47 (96)	59 (95)	57 (95)	57/59 (97)
Performance	48 (89)	49 (98)	46 (96)	53 (86)	53 (88)	52/59 (88)
21. Transferring from the wheelchair to another level surface and back						
Capacity	43 (80)	41 (82)	37 (76)	49 (79)	46 (77)	49 (82)
Performance	42 (78)	37 (74)	35 (71)	48 (77)	45 (75)	45 (75)
22. Moving the wheelchair up a 5° incline						
Capacity	52 (96)	48 (96)	46 (96)	60 (97)	60 (100)	59 (98)
Performance	49 (91)	45 (90)	41 (84)	53 (86)	53 (88)	54 (90)
23. Moving the wheelchair down a 5° incline						
Capacity	52 (96)	49 (98)	46 (96)	61 (98)	60 (100)	60 (100)
Performance	49 (91)	46 (92)	41 (84)	55 (89)	54 (90)	54 (90)
24. Moving the wheelchair up a 10° incline						
Capacity	44 (82)	44 (88)	42 (86)	56 (90)	54 (90)	56 (93)
Performance	34 (63)	34 (68) [#]	29 (59) [#]	44 (71)	41 (68) [#]	42 (70) [#]
25. Moving the wheelchair down a 10° incline						
Capacity	45 (83)	43 (86)	42 (86)	55 (89)	54 (90)	56 (93)
Performance	36 (67)	38 (76)	30 (61) [#]	44 (71)	40 (67) [#]	43 (72) [#]
26. Moving the wheelchair across a 5° side-slope in both directions						
Capacity	48 (89)	46 (92)	45 (92)	56 (90)	55 (92)	55 (92)
Performance	35 (65) [#]	38 (76)	31 (63) [#]	45 (73)	38 (63) [#]	40 (67) [#]
27. Moving the wheelchair across a soft surface						
Capacity	49 (91)	50 (100)	47 (96)	59 (95)	56 (93)	57 (95)
Performance	37 (69) [#]	40 (80) [#]	36 (74) [#]	47 (76)	41 (68) [#]	36 (60) [#]
28. Moving the wheelchair over a pothole or gap						

Individual Skill	Intervention Group			Control Group		
	T1 (n = 54)	T2 (n = 50)	T3 (n = 49)	T1 (n = 62)	T2 (n = 60)	T3 (n = 60)
Capacity	36 (67)	43 (86)	43 (88)	44 (71)	45 (75)	48 (80)
Performance	19 (35) [#]	32 (64) [#]	26 (53) [#]	31 (50) [#]	28 (47) [#]	27/59 (46) [#]
29. Moving the wheelchair over an obstacle like a door threshold						
Capacity	48 (89)	47 (94)	46 (96)	53 (86)	57 (95)	57 (95)
Performance	40 (74)	39 (78)	38 (78)	44 (71)	49 (82)	42 (70) [#]
30. Moving the wheelchair up a 5 cm level change						
Capacity	44 (82)	41 (82)	44 (90)	47 (76)	49 (82)	53 (88)
Performance	31 (57) [#]	34 (68)	33 (67) [#]	35 (57)	36 (60) [#]	37 (62) [#]
31. Moving the wheelchair down a 5 cm level change						
Capacity	47 (87)	44 (88)	45 (92)	53 (86)	53 (88)	57 (95)
Performance	35 (65) [#]	36 (72)	32 (65) [#]	40 (65) [#]	36 (60) [#]	41 (68) [#]
32. Getting from the ground into the wheelchair						
Capacity	22 (41)	21 (42)	21 (43)	28 (45)	29 (48)	29 (48)
Performance	11 (20) [#]	10 (20) [#]	12 (25)	10 (16) [#]	9 (15) [#]	9 (15) [#]

N (%) values are shown. The denominators are only shown where there were No Part scores or missing data (a total of 9 missing data elements from a total of 7 cells).

The skill descriptions are paraphrased.

Abbreviations: T1 is baseline, T2 is after training, and T3 is at 3-month follow-up.

[#] Clinically significant difference (20%) between capacity and performance.

@ Clinically significant difference (20%) between the indicated value and that at the previous time point in the same group.

Table A2

Questionnaire data from T2 and T3

Parameter	Response	Intervention Group		Control Group	
		T2 (n = 50)	T3 (n = 49)	T2 (n = 60)	T3 (n = 60)
PWC changes in previous period?	Yes	11 (22)	15 (31)	8 (13)	18 (30)
Health changes in previous period?	Yes	9/49 (20)	11 (21)	11 (18)	7 (11)
Practice skills with therapist?	Yes	7 (14)	4 (8)	7 (12)	3 (5)
Practice skills alone?	Yes	38 (76) [*]	31 (63)	26 (43)	26 (43)
Practice skills with caregiver?	Yes	9 (18)	8 (16)	9 (15)	10 (16)

Values shown are n (%). The denominator is only shown where there were missing data.

Abbreviations: T2 is after training, and T3 is at 3-month follow-up.

^{*} Clinically significant difference (20%) between the groups.

Figure 1.
CONSORT diagram, showing the pool of participants who were screened, enrolled, allocated to groups and completed the study.

Figure 2.

Box-and-whisker plot of the total percentage Wheelchair Skills Test Questionnaire (WST-Q) capacity scores for the two groups at baseline (T1), post-training (T2) and at follow-up 3 months post-training (T3). The mean values are represented by diamonds, the median values by horizontal lines within the boxes, the interquartile ranges (from quartile 1 to quartile 3, i.e., the 25th and 75th percentiles) by the box limits. The T bars (whiskers) represent those points greater and less than 1.5 times the IQR values. The open circles represent outliers beyond the whiskers.

Figure 3.

Box-and-whisker plot of the total percentage Wheelchair Skills Test Questionnaire (WST-Q) performance scores for the two groups at baseline (T1), post-training (T2) and at follow-up 3 months post-training (T3). The mean values are represented by diamonds, the median values by horizontal lines within the boxes, the interquartile ranges (from quartile 1 to quartile 3, i.e., the 25th and 75th percentiles) by the box limits. The T bars (whiskers) represent those points greater and less than 1.5 times the IQR values. The open circles represent outliers beyond the whiskers.

Table 1

Demographic and clinical data at T1

Parameter	Subparameter and/or Unit	Statistic Reported	Intervention Group (n = 54)	Control Group (n = 62)
Age	Years	Mean (SD)	53.8 (12.5)	53.1 (14.5)
Sex	Male	n (%)	24 (44)	35 (56)
Primary language	English	n (%)	38 (70)	38 (61)
	French	n (%)	16 (30)	19 (31)
	Other	n (%)	0 (0)	5 (8)
Living situation	House or townhouse	n (%)	11 (20)	15 (24)
	Apartment or condo	n (%)	32 (59)	44 (71)
	Assisted living center or group home	n (%)	4 (7)	2 (3)
	Long-term-care facility or nursing home	n (%)	4 (7)	1 (2)
	Other	n (%)	3 (6)	0 (0)
Diagnosis accounting for wheelchair use	Multiple sclerosis	n (%)	8 (15)	15 (24)
	Spinal cord injury	n (%)	9 (17)	6 (10)
	Stroke	n (%)	2 (4)	4 (6)
	Amputation	n (%)	3 (6)	2 (3)
	Arthritis	n (%)	2 (4)	1 (2)
	Other	n (%)	30 (56)	34 (55)
Duration of diagnosis	Years	Mean (SD)	19.8 (16.9)	21.8 (16.9)
		Median (IQR)	15.0 (24.0)	19.0 (21.0)
Experience driving an automobile	Yes	n (%)	42 (78)	42 (68)
	Years	Mean (SD) Median (IQR)	28.7 (16.1) 30.0 (18.0)	29.5 (17.2) 30.0 (24.5)

Abbreviations: IQR = interquartile range, T1 = baseline assessment. SD = Standard Deviation

Table 2

Wheelchair specifications at T1

Parameter	Subparameter and/or Units	Statistic Reported	Intervention Group (n = 54)	Control Group (n = 62)
Manufacturer	Invacare	n (%)	18 (33)	17 (27)
	Pride	n (%)	10 (19)	17 (27)
	Quickie	n (%)	13 (24)	9 (15)
	Orthofab	n (%)	6 (11)	10 (16)
	Permobil	n (%)	1 (2)	4 (6)
	Other	n (%)	6 (11)	5 (8)
Drive	Mid-wheel	n (%)	26 (48)	37 (60)
	Rear-wheel	n (%)	24 (44)	23 (37)
	Front-wheel	n (%)	4 (7)	2 (3)
Control mechanism	Joystick	n (%)	53 (98)	62 (100)
	Sip and puff	n (%)	1 (2)	0 (0)
	Head control	n (%)	0 (0)	0 (0)
Control box	Movable	n (%)	47 (87)	50 (81)
Speed control	Variable other than by joystick	n (%)	46 (85)	52 (84)
Modes	Number	Mean (SD) Median (IQR)	3.6 (1.4) 4 (2)	3.4 (1.7) 4 (4)
Motors	Able to be disengaged	n (%)	54 (100)	62 (100)
Tilt mechanism	Present	n (%)	30 (56)	28 (45)
Recline mechanism	Present	n (%)	5 (9)	2 (3)
Power lift	Present	n (%)	3 (6)	6 (10)
Footrests	Present	n (%)	52 (96)	60 (97)
	Can be moved out of the way	n (%)	51/53 (96)	58 (94)
Armrests	Present	n (%)	52 (96)	62 (100)
Headrest	Present	n (%)	33 (60)	32 (52)

The denominators are only shown where there were missing data

Abbreviations: IQR = interquartile range, T1 = baseline assessment. SD = Standard Deviation

Table 3

Wheelchair and wheelchair usage data at T1

Parameter	Subparameter and/or Unit	Statistic shown	Intervention Group (n = 54)	Control Group (n = 62)
Experience using any powered wheelchair	Years	Mean (SD) Median (IQR)	6.1 (5.8) 5.0 (9.3)	7.0 (8.9) 3.3 (9.8)
Experience using current powered wheelchair	Years	Mean (SD) Median (IQR)	2.1 (2.4) 1.3 (2.8)	2.6 (5.1) 0.9 (2.9)
Average daily use of current powered wheelchair	Hours	Mean (SD) Median (IQR)	7.7 (5.3) 6.8(9.0)	7.1 (5.2) 5.5(10.0)
Location of powered wheelchair use	Home	n (%)	37 (69)	43 (69)
	Community	n (%)	52 (96)	61 (98)
	Work/volunteer	n (%)	27 (50)	29 (47)
	School	n (%)	8 (15)	9 (15)
	Recreation/sports	n (%)	39 (72)	42 (68)
	Other	n (%)	18 (33)	19 (31)
Assistance needed for powered wheelchair use	Standby only	n (%)	2 (4)	2 (3)
	Verbal only	n (%)	0 (0)	4 (6)
	Physical	n (%)	18 (33)	24 (39)
	None	n (%)	34 (63)	32 (52)
Formal training in powered wheelchair use	Yes	n (%)	30 (56)	25 (40)
	Practice included time outdoors	n (%)	16 (30)	18 (29)
	Duration (hours)	Mean (SD) Median (IQR)	3.7 (7.4) 2.0 (2.0)	3.6 (5.9) 2.0 (2.0)
Experience using manual wheelchair	Never	n (%)	7 (13)	9 (15)
	In past	n (%)	16 (30)	22 (35)
	Currently	n (%)	31 (57)	31 (50)
	Duration (years)	Mean (SD) Median (IQR)	12.1 (14.1) 5.0 (17.0)	11.9 (14.0) 7.0 (20.0)
	Average daily use (hours)	Mean (SD) Median (IQR)	3.8 (4.8) 1.0 (7.0)	2.9 (5.1) 0.0 (2.0)

Abbreviations: IQR = interquartile range, T1 = baseline assessment. SD = Standard Deviation

Table 4

Total percentage WST-Q capacity and performance scores

Score	Statistic shown	Intervention Group			Control Group		
		T1 (n = 54)	T2 (n = 50)	T3 (n = 49)	T1 (n = 62)	T2 (n = 60)	T3 (n = 60)
Capacity (%)	Mean (SD) Median (IQR)	86.9 (11.6) 87.1 (16.7)	89.7 (11.1) 93.3 (10.6)	89.3 (12.5) 93.3 (9.7)	86.3 (12) 86.7 (13.8)	89.0 (10.0) 92.0 (15.0)	90.6 (9.1) 93.3 (10.2)
Capacity change from previous time (%)	Mean (SD) Median (IQR)	NA	3.1 (8.4) 1.5 (6.7)	-0.3 (8.4) 0 (6.1)	NA	2.2 (10.0) 0 (6.7)	1.5 (5.4) 0 (3.3)
Performance (%)	Mean (SD) Median (IQR)	75.6 (14.7) 77.0 (21.0)	79.5 (15.6) 85.3 (22.3)	74.5 (20.3) 80 (18.8)	74.5 (15.8) 77.4 (17.2)	74.0 (15.4) 76.7 (18.3)	73.5 (19.3) 76.7 (22.4)
Performance change from previous time (%)	Mean (SD) Median (IQR)	NA	3.8 (9.4) 3.3 (13.1)	-4.8 (16.4) 0 (16.1)	NA	-0.9 (12.1) 0 (13.5)	-0.4 (14.6) 3.3 (16.3)

T1 is baseline. T2 is after training, and T3 is at 3-month follow-up.

* Clinically significant difference (20%) between the groups.

Table 5

Injuries serious enough to seek medical attention and injury rates

Injuries	Intervention Group			Control Group		
	T1 (n = 54)	T2 (n = 50)	T3 (n = 49)	T1 (n = 62)	T2 (n = 60)	T3 (n = 60)
Number in previous period ¹	3	0	6	6	1	0
Injury rate (injuries/participant/year	0.108	0	1.464	0.192	0.204	0 [*]

T1 is baseline, T2 is after training, and T3 is at 3-month follow-up.

¹The previous period was 6 months for T1 and 1 month at T2 and T3.

^{*}The difference between the groups was significant (p = 0.007).