Efficacy and Retention of the French-Canadian Version of the Wheelchair Skills Training Program for Manual Wheelchair Users: A Randomized Controlled Trial

Francois Routhier, PhD, **R Lee Kirby, MD, FRCPC**, **Louise Demers, PhD**, **Malgorzata Depa, MSc**, and **Kara Thompson, MSc**

Centre for Interdisciplinary Research in Rehabilitation and Social Integration, Institut de réadaptation en déficience physique de Québec, Québec, QC, Canada (Routhier); Division of Physical Medicine and Rehabilitation, Department of Medicine, Dalhousie University, Halifax, NS, Canada (Kirby); School of Rehabilitation, Université de Montréal, Montréal, QC (Demers, Depa); Montréal Universitary Geriatric Institute Research Centre, Montréal, QC, Canada (Demers, Depa); and Biostatistics, Department of Medicine, Dalhousie University, Halifax, Nova Scotia, Canada (Thompson)

Abstract

Objectives—To test the hypotheses that, in comparison with a Control group that received standard care, users of manual wheelchairs who also received the French-Canadian version of the Wheelchair Skills Training Program (WSTP) would significantly improve their wheelchair-skills capacity and that these improvements would be retained at 3 months.

Design—Multi-center, single-blind randomized controlled trial (RCT).

Participants—39 manual wheelchair users, a sample of convenience.

Setting—3 rehabilitation centers in Montreal, Quebec, Canada.

Intervention—Participants were randomly allocated to the WSTP or Control groups. Participants in both groups received standard care. Participants in the WSTP group also received a mean of 5.9 training sessions (mean total duration of 5 hours and 36 minutes).

Main Outcome Measures—The French-Canadian version of the Wheelchair Skills Test (WST) (Version 3.2) was administered at baseline (T1), post-training (T2, a mean of 47 days after T1) and at follow-up (T3, a mean of 101 days after T2).

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.

Results—At T2, the mean $\pm$ SD total percentage WST capacity scores were 77.4 $\pm$ 13.8% for the WSTP group and 69.8 $\pm$ 18.4% for the Control group (p = 0.0296). Most of this difference was due to the Community-level skills (p=0.0018). The total and subtotal WST scores at T3 decreased by 0.5% from the T2 values, but differences between groups at T3, adjusting for T1, did not reach statistical significance (p 0.017 at a Bonferroni-adjusted α level of 0.005).

Conclusion—WSTP training improves wheelchair skills immediately after training, particularly at the Community-skills level, but this study did not show statistically significant differences between the groups at 3 months.

Keywords

Wheelchair; Training; Rehabilitation; Motor skills

Wheelchairs can have a highly positive impact on their users' lives[1] but they are not without problems, including their frequent need for repairs,[2] their role in overuse injuries[3,4] and acute injuries that can occur during use.[5–9] One important aspect of the wheelchair-provision process that has become increasingly well recognized is training in wheelchair use.[10] There is growing evidence that manual wheelchair skills capacity improves with training[11–16] and for an association between manual wheelchair skills capacity and participation.[16–18] However, formal wheelchair skills training is still relatively uncommon.[19–21] Although there are a variety of possible reasons for this (e.g. time constraints, limited funding, short lengths of stay), one of the reasons may have been the lack of standardized and readily available training resources.

In an attempt to address this perceived difficulty, the Wheelchair Skills Program (WSP) was developed in 1996.[22] The WSP consists of an evidence-based set of assessment and training protocols, the Wheelchair Skills Test (WST) and the Wheelchair Skills Training Program (WSTP). The WSTP represents an attempt to combine the best available evidence on motor-skills learning with the best evidence on how to perform specific wheelchair skills. The WSTP for manual wheelchairs has been found to be safe and more efficacious than standard care in both rehabilitation-center and community settings.[13,14] Despite these promising results, when this study began, published evidence regarding the WSTP had come from only a single center. Since then, Ozturk and Ucsular[15] found similar short-term improvements in Turkey. However, the retention of benefits beyond a few days has not been reported in any of the earlier WSTP studies.

Our primary objective was to test the hypothesis that, in comparison with a Control group that received standard care, users of manual wheelchairs who received the French-Canadian version of the WSTP[23] would significantly improve their wheelchair-skills capacity (as represented by total percentage WST scores). Our secondary objectives were to test the hypothesis that these improvements would be retained at 3 months, to assess differences in subgroups of skills (Indoor, Community and Advanced levels), to describe differences in individual skills and to determine if the WSTP is safe.

METHODS

Participants

We studied 39 manual wheelchair users, a sample of convenience. The sample-size estimate for the primary objective was based on a power analysis using data from earlier studies.[13,14] A sample size of 12 in each group was estimated to have 80% power to detect a main-effect difference in mean WST scores of 14.8% assuming that the common standard deviation (SD) was 12.2%, if using a two-group t-test with a 0.05 two-sided significance level. We over-sampled in anticipation of drop-outs and to provide greater power to meet our secondary objectives.

Setting

The study was conducted in 3 rehabilitations centers located in Montréal. These centers were the Institut de réadaptation Gingras-Lindsay-de-Montréal (IRGLM), the Centre de réadaptation Lucie-Bruneau (CRLB) and the Institut universitaire de gériatrie de Montréal (IUGM). Coordination among the sites was provided by the principal investigator. These sites were different with respect to the wheelchair-provision models of care, funding arrangements and language from the sites where the earlier studies[13–15] had been performed. The wheelchair-provision process at these 3 centers was similar in that the assessment, prescription and set-up were performed by occupational therapists and wheelchairs were available free of charge from the Province of Quebec.

Study Design

This was a multi-center, single-blind, randomized controlled trial (RCT). Blinding was carried out by isolating the personnel and processes for randomization, testing, training and data analysis. Due to the nature of the intervention, it was not possible to blind participants about whether they received training.

Ethical Issues

Ethical approvals for this study were obtained from the research ethics boards of the recruitment sites. Each participant provided his/her informed consent.

Recruitment and Screening

Potential participants were approached by clinicians at the rehabilitation centers or hospitals who were made aware of the inclusion and exclusion criteria for the study. If a potential participant agreed, he/she was then formally screened by a member of the research team regarding the inclusion and exclusion criteria. Eligibility to participate was based on the following criteria: was 18 years of age or older; used a manual wheelchair daily; was receiving therapy at one of the recruitment sites; was willing and able to take part in the study (as evidenced by participating in at least the baseline assessments); was fluently French-speaking; was competent to give informed consent (or had a proxy with power of attorney); had the permission of the clinical occupational therapist working with the participant to participate (so the study would not be in conflict with other studies or care directions); had enough ability to develop skills included in the WSTP, in the subjective

opinion of the occupational therapist; did not have an unstable medical condition (e.g. angina, seizures, as confirmed by the clinician who referred the participant); and did not have an emotional or psychiatric problem of a type or extent that might make participation unpleasant.

Demographic and Clinical Data

To describe the sample, we recorded demographic and clinical data at baseline, specifically age (years), sex (male/female), height (cm), weight (kg), rehabilitation-center site, clinical status (inpatient/outpatient), diagnosis accounting for wheelchair use and date of onset of diagnosis.

Wheelchair-Usage and Wheelchair Data

At baseline we recorded wheelchair-usage data by self-report, specifically, the extent of experience with any wheelchair (years), the extent of experience with the current wheelchair (weeks), the frequency of wheelchair use (hours/day), the method of wheelchair propulsion (combinations of hands and feet used) and the location of wheelchair use (home, work, school, community and/or recreation/sports). Wheelchair specifications were recorded at baseline using the Wheelchair Specification Form.[22] We also recorded whether any changes in the wheelchair were noted at the following testing sessions, but we did not record the reason for or nature of any such changes.

Group Allocation

Participants were randomly allocated to the WSTP or Control groups by the principal investigator using a table of random numbers.[24] For the purpose of having approximately equal representations of musculoskeletal and neurological impairments in the two groups, we used this diagnostic-group criterion (musculoskeletal vs neurological) to stratify the groups.

Intervention – Wheelchair Skills Training Program (WSTP)

Routhier et al have previously reported on the process used to translate WSP materials from English to French-Canadian.[25–27] The French-Canadian version of the WSTP was used, following the procedures in the 113-page WSP Manual.[23] Each participant was trained by 1 of 3 occupational therapists, each of whom had received trainer training. Participants received a target of 4–8 training sessions, each 45–60 minutes long, during a period of 2–4 weeks. The actual number of sessions and their duration were recorded. Training was stopped after 8 sessions or when no improvement was noted by the trainer.

Outcome Measures

Wheelchair Skills Test (WST)—A variety of tools have been used to assess wheelchair skills. We elected to use the WST because it has been highly ranked in independent surveys of such tests,[28,29] because it has been well studied with respect to measurement properties[30–33] and because it corresponds well with the skills trained during the WSTP. Wheelchair skills were tested according to the WST procedures outlined in the French-Canadian version of the WSP (Version 3.2) Manual.[23] WST 3.2 consists of 57 skills (listed

later), including 30 at the Indoor level, 13 at the Community level and 14 at the Advanced level. Each skill was scored (pass/fail) on the basis of defined criteria. For the small number of participants who were unable to complete the objective WST assessments post-training or at follow-up due to transportation difficulties, the questionnaire version of the WST (WST-Q)[34–36] was administered to minimize what would otherwise have resulted in missing data due to drop-outs. For the purposes of this study, the WST and WST-Q results were considered equivalent because of the high correlations between total scores.[34–36] Testers were two occupational therapists, each of whom had been trained in WST administration.

The numerator for the total percentage WST score was the total raw score (the number of skills passed). The denominator was the total possible score (i.e. 57 minus the number of skills that were not applicable because the wheelchair did not have the part [e.g. footrests that could not be removed]). Subtotal WST percentage scores were similarly calculated for the Indoor, Community and Advanced skill levels.

Safety—The tester served as a spotter during WST testing and the trainer served as a spotter during training, following the principles described in the WSP Spotter Manual (16 pages).[22] Testers and trainers recorded any adverse wheelchair-related incidents (e.g. actual injuries or tips/falls with the potential for injury) during testing or training.

Procedure

Prior to the first testing session (T1), we conducted screening, obtained informed consent and allocated participants to group. At T1, we collected baseline demographic, clinical, wheelchair-usage, wheelchair and WST data. Those in the WSTP group then received WSTP training in addition to standard care. Participants in the Control group received only standard care. Details about standard care were not recorded for either group. (Estimates from an earlier study by MacPhee et al[13] suggest that inpatient rehabilitation in a Canadian rehabilitation center might include about 15 hours of training that is variable in format.) Within 1 week after completing training, participants in the WSTP group were retested (T2). The T2 evaluations for the Control group were carried out at a target latency of 3–5 weeks after T1. Retention tests (T3) were administered to all participants at a target latency of 3 months after T2. Participants were permitted to have the testers or trainers remove or reposition their rear anti-tip devices for testing or training.

Data analysis

Data were recorded in a spreadsheet[a] on a personal computer. The statistical software used was SAS (version 9.2).[b] Total WST percentage scores and subtotal percentage scores (for Indoor, Community and Advanced levels) were calculated for each participant. Group success rates were calculated for each skill.

Descriptive statistics were determined for all data. The choice of statistical tests was based on the nature and distribution of the data. The comparability of the WSTP and Control groups was evaluated for selected baseline and study-process data. Specifically, we used the

Fisher exact test for clinical setting, wheelchair use at work, wheelchair use at school and wheelchair changes during the course of the study. We used the Chi-square test for sex, wheelchair use at home, wheelchair use in the community and wheelchair use for recreation/sports. We used the Wilcoxon rank-sum test for age, height, weight, length of time from onset of diagnosis to T1, duration of experience with any wheelchair, duration of experience with the current wheelchair, amount of time between T1 and T2 and amount of time between T2 and T3. We used logistic regression for propulsion method (3 levels of categorical variable). Variables with more than two categories and insufficient data in each category (specifically diagnosis accounting for wheelchair use, rehabilitation center and frequency of wheelchair use) were not compared using statistical tests. For the group comparability assessments, we used a Bonferroni-adjusted α level of 0.004 (0.05/14) to control for multiple comparisons.

Regarding outcomes, we compared the total and subtotal percentage WST scores at T2 using Analyses of Covariance, adjusting for the T1 values. An α level of 0.05 was used for the primary outcome measure (total percentage WST scores for the between-group comparisons at T2). When looking at retention from T2 to T3, paired t tests were used to make within-group comparisons. To assess whether any differences between the groups could be seen at T3, we also used an ANCOVA model for T3 total and subtotal WST scores, adjusting for T1 values. For the secondary comparisons, the α level was Bonferroni-adjusted to 0.005 (0.05/11).

We dealt with missing data due to drop-outs by using intention-to-treat (ITT) procedures, qualitatively comparing the drop-outs in each group from the perspective of demographic, clinical and wheelchair data. We performed sensitivity analyses in two ways to investigate the impact of missing WST values on the T2 comparisons. First, we carried forward T1 WST scores for those without T2 values and second, we used the mean within-group T1 values for T2 values. For the T2-T3 sensitivity analysis, for those subjects with missing values at T2 or T3, we only used the latter method, to avoid forcing there to be no change for the missing participants and thereby biasing results toward non-significance (our hypothesis).

For wheelchair components and individual skills, we did not conduct statistical comparisons between the groups because our sample size would not have provided adequate power. For the individual skills, we used descriptive comparisons, using a difference of 25% in the success rates between the 2 groups and the 3 time periods as our threshold for a clinically meaningful difference. We reported the mean of left-and right-side scores for this purpose.

RESULTS

Participants

Figure 1 shows the participant flow.[37] Two potential participants were eliminated prior to enrollment due to not meeting the inclusion and/or exclusion criteria. Because the participants were recruited from inpatient and outpatient populations at 3 sites, we do not have an accurate estimate of the size of the potential participant pool of manual wheelchair users from which our sample was drawn. As such, this was a sample of convenience.

Overall, 8 (21%) of the 39 participants dropped out of the study, 1 (5%) of the 19 from the WSTP group (during the T1-T2 interval) and 7 of the 20 from the Control group (4 [20%] during the T1-T2 interval and 3 [15%] during the T2-T3 interval). The reasons for dropping out were loss of interest (4) and scheduling difficulties (4). Table 1 summarizes the demographic and clinical data at baseline. The WSTP and Control groups were not significantly different with respect to the baseline comparisons performed.

Wheelchair-Usage and Wheelchair Data

Wheelchair-usage data are shown in Table 2. Most participants had minimal prior wheelchair experience, propelled their wheelchairs with two hands, used their wheelchairs for over 4 hours each day and used their wheelchairs both indoors and in the community. There were no statistically significant differences between the groups at baseline. Table 3 summarizes the wheelchair-component data at baseline and shows that the wheelchairs used by the two groups were qualitatively similar. In the T1-T2 interval, the wheelchairs of 3 (14%) participants changed (2 in the Training group and 1 in the Control group), but there was no significant difference between the groups in the incidence of such changes (p = 1.000). In the T2-T3 interval, the wheelchairs of 11 (52%) participants changed (4 in the Training group and 7 in the Control group), but there was no significant difference between the groups in the incidence of such changes (p = 0.198).

Training Data

The training log was lost from one participant. For the other 18 members of the WSTP group, the mean ± SD number of training sessions was 5.9 ± 1.8. The mean total duration of training was 336 ± 90 minutes spread over a mean of 27 ± 13 days.

Wheelchair Skills Tests

Of the 55 evaluations on participants in the WSTP group (including all T1, T2 and T3 evaluations), 53 (96%) were WSTs and 2 (4%) were WST-Qs. Of the 49 evaluations on participants in the Control group, 42 (86%) were WSTs and 7 (14%) were WST-Qs. The mean ± SD durations of the T1-T2 intervals for the WSTP and Control groups were 51 ± 23 days and 43 ± 17 days (p = 0.126). The mean durations of the T2-T3 intervals for the WSTP and Control groups were 99 ± 12 days and 103 ± 15 days (p = 0.152).

The WST data are shown in Table 4 and illustrated in Figures 2A–D. For the total percentage WST scores at T2 (adjusted for the T1 values), there was a statistically significant difference between the WSTP and Control groups (p = 0.0296). For the Community-level WST subtotal scores, there was also a significant difference between the groups (p = 0.0018). The differences in WST subtotal scores were not statistically significant for the Indoor or Advanced levels. There were no statistically significant changes for either group between T2 and T3 for the total WST scores or the subtotal scores at the Indoor, Community or the Advanced levels using paired t tests. For the ANCOVA models for T3 adjusting for T1, exploring if differences between the WSTP and Control groups were still apparent at T3, the p values were 0.217 for the total WST scores, 0.957 for the Indoor-level WST scores, 0.017 for the Community-level WST scores and 0.209 for the

Advanced-level WST scores. None of these p values were statistically significant using the Bonferroni-adjusted α level of 0.005.

Qualitatively there were no major differences in the demographic, clinical, wheelchair-usage or wheelchair data between the drop-outs from the WSTP and Control groups. When the sensitivity analysis was completed for the T2 total WST data, carrying the T1 values forward for T2, the difference between the WSTP and Control groups remained significant (p = 0.013). However, if average values were used for the drop-outs, the difference between the WSTP and Control groups was not significant (p = 0.080). With the T2-T3 sensitivity analysis, there was no statistically significant difference in total WST scores from T2 to T3 for the WSTP (p=0.995) or Control (p=0.688) groups.

The success rates for the individual skills are shown in Table 5. Of the 43 individual skills listed, 15 (35%) skills for the WSTP group and 0 (0%) skills for the Control group met the criterion of a ≥25% improvement between T1 and T2. For the T2-T3 interval, 0 (0%) skills for the WSTP group and 0 (0%) skills for the Control group met the criterion of ≥25% difference between the time periods.

Safety

There were no adverse incidents during training. However, 3 potentially serious incidents were recorded during the 104 testing sessions (i.e. in 3% of sessions). In the first incident, while attempting to pass over the 30cm pothole, the casters of the participant's wheelchair dropped into the pothole, the wheelchair tipped forward and the participant slid to the floor. In the second incident, while attempting the 13cm threshold skill, when the rear wheels were on top of the threshold, the participant's wheelchair tipped forward and he slid to the floor. In the third incident, while she proceeded up a short incline to get onto the cross slope, the wheelchair tipped over backwards and the participant hit her head on the floor. In none of the three cases did any ill effects arise due to the incidents.

DISCUSSION

Our findings are consistent with the prior studies of wheelchair-skills training in general[11,12,16] and the WSTP in particular.[13–15] There was a 18% relative pre- vs post-training (T1 vs T2) improvement in total WST scores for the WSTP group in the current study, slightly lower than reported earlier.[13–15] For the Community-level WST subtotal scores, the WSTP and Control groups improved by 34% and 7%. The differences between the groups were statistically significant for the total WST scores and Community-level subtotal scores, but not for the Indoor- and Advanced-level subtotal scores. The Indoor-level subtotal scores were high at T1, so a ceiling effect may have contributed to our failure to demonstrate a difference due to training. For the Advanced-level subtotal scores, the relatively low but not significant p value of 0.119 suggests that a Type 2 error may have played a role, due to the small sample size.

Whether the improvements in the Control group's scores were due to good standard care (all were receiving therapy during the T1-T2 period), intrinsic learning or a combination of the two is unknown. Earlier studies of the WSTP[13–15] have also shown improvements for

control groups. In the interval between the current study and the earlier studies published in 2004[13] and 2005,[14] there may have been an improvement in standard care due to the increased emphasis on wheelchair skills training in the Province of Quebec. Regarding the potential for an intrinsic training effect due to WST testing alone as an explanation for the Control group's improvement, the questionnaire version of the WST[34,35] might have been a better choice as an outcome measure.

The current study, the largest to date on the WSTP, provides a useful replication for the earlier work of MacPhee et al[13] and Best et al.[14] In addition, like the study by Ozturk and Ucsular[15] in Turkey, the current study went beyond those earlier studies in that it was carried out in a different language, culture and health-care setting, and in a site other than that of the WSTP developers. Taken together with other manual wheelchair training studies,[11,12,16] it seems reasonable to conclude that the evidence for manual wheelchair skills training is moving gradually beyond efficacy (positive results in an ideal setting) towards effectiveness (positive results in real-world settings).

The evidence in support of the retention of training benefits is a little less clear. As the data in Table 5 on the success rates for individual skills clearly show, there were no clinically significant differences between T2 and T3. Also, as shown in Table 4, the mean or median values at T3 did not decrease in comparison with the T2 values by more than 0.5% for either group. However, the ANCOVA models for T3 total and subtotal WST scores, adjusted for T1, assessing whether differences between the groups could still be seen at T3, showed no statistically significant differences between the 2 groups at 3 months. The p value of 0.017 for the Community-level WST scores was not statistically significant using the Bonferroni-adjusted a level of 0.005. This failure to reach the level of statistical significance, especially at the Community-level WST level, may be a Type 2 error accounted for by the drop-outs between T1 and T3, reducing the power of the analysis. A larger study and/or one with more complete follow-up of enrolled participants will be needed for definitive determination whether gains with this intervention are retained long-term. The trend found in our study for sustained improvements in performance is consistent with the 10-week follow-up used in the uncontrolled study in Afghanistan by Armstrong et al.[12]

The success rates for the individual skills support the suggestions from the analysis of subtotal WST scores that the improvements due to training were primarily related to skills at the Community and Advanced levels. The data on individual skills will be useful in the future refinement of the WSTP (e.g. by exploring the reasons why training was not effective in improving the success rates of some skills).

Regarding the safety of wheelchair-skills assessment and training, fortunately there were no injuries. However, the 3 incidents that occurred during testing suggest the need for caution. The 2 incidents in which the wheelchair users slid forward out of their wheelchairs suggest that it may be wise to use a seat belt or a second spotter during the assessment of skills that present the risk of forward tips and falls. The rear-tipping incident underlines the importance of caution while the person who is being tested is moving between skills. Using the questionnaire version of the WST[34–36] as the outcome measure is preferable from the safety perspective.

Study Limitations

This study had a number of limitations, some of which have already been noted. The sample size was small and the drop-out rate was high, resulting in the study being under-powered for the analysis of subtotal WST scores at the Advanced-skill level and for the assessment of individual skills. There were more drop-outs in the Control group. This probably reflected the fact that they received no benefit (e.g. attention, training) from their participation. Although the results of the sensitivity analyses are reassuring, the differential loss to follow-up (more in the Control group) undermines definitive conclusions about the retention of gains long-term.

Given the nature of the study, it was not possible to blind those in the WSTP group to the training that they received. It is possible that they discussed their training with members of the Control group. This could have served to increase the scores for those in the Control group. Variations among recruitment sites with respect to the participants' characteristics and the standard care received by participants (about which we should have collected more information) could have contributed to the low study power. However, heterogeneity among rehabilitation centers should be considered an asset with respect to the future generalizability of our findings. There was no placebo intervention, so the participants in the WSTP group may have improved in part due to the extra 5–6 hours of attention that they received in comparison with the Control group. However, the motor skills literature indicates that practice is generally needed to improve motor skills.[22]

The participants in both groups were not highly experienced in wheelchair use. The changes in the characteristics of some of their wheelchairs (probably to ones that were improvements on those in use at baseline) could have had positive effects on skill performance, but any such bias would have favored the Control group.[16] A substantial number of participants acquired new wheelchairs in the T1-T2 and T2-T3 intervals. We do not have information on why the participants got new wheelchairs or in what ways they differed from the original wheelchairs. However, the acquisition of new wheelchairs in both intervals was fairly equally distributed between the WSTP and Control groups so there is no reason to believe that this affected the results. The retention period of 3 months was relatively short. The WST-Q was used instead of the WST for a small number of the assessments and this could have contributed to the variability in the WST scores. Also, WST-Q scores are known to provide slightly higher scores than the WST;[34–36] however, any such bias would have favored the Control group.

The net effect of many of the limitations itemized above (e.g. variations in sites, drop-outs, wheelchair changes, Control-group participants potentially hearing about training, use of the WST-Q in some cases) would have been to increase the variability of the WST scores. This would have the effect of reducing the power of the study and thereby making it more difficult to corroborate our hypothesis.

Future studies are needed to address these study limitations and to extend this work. Examples of studies that we believe are needed include studies with a larger sample size, better documentation of standard care, better documentation of wheelchair changes, better blinding, a placebo intervention, more experienced wheelchair users, a longer retention

period, better exploration of individual skills, assessment of training of caregivers and assessment of training of powered wheelchair users.

CONCLUSION

WSTP training improves wheelchair skills immediately after training, particularly at the Community-skills level.. Although data on participants who had follow-up at 3-months showed little decline in performance, there was substantive loss to follow-up with a resultant reduction in sample size and study power, such that differences between the WSTP and Control groups were no longer statistically significant. This study provides replication of earlier studies and it provides new data on the important issue of retention.

Acknowledgments

LIST OF ABBREVIATIONS

CRLB	Centre de réadaptation Lucie-Bruneau
IRGLM	Institut de réadaptation Gingras-Lindsay-de-Montréal
ITT	Intention to treat
IUGM	Institut universitaire de gériatrie de Montréal
RCT	Randomized controlled trial
SD	Standard deviation
T1	Evaluation at 1st time period (baseline)
T2	Evaluation at 2nd time period (post-training)
T3	Evaluation at 3rd time period (follow-up)
WSP	Wheelchair Skills Program
WST	Wheelchair Skills Test, objective version
WST-Q	Wheelchair Skills Test, questionnaire version
WSTP	Wheelchair Skills Training Program

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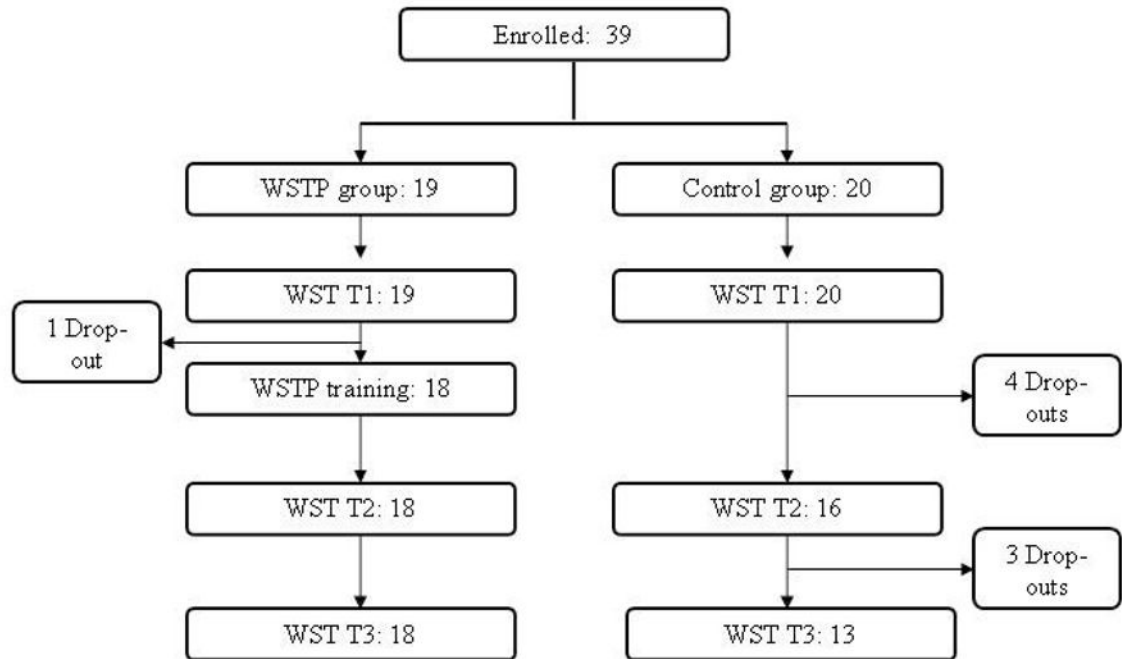
Figure 1.
Flow diagram reflecting participant involvement.

A. Total WST Scores

B. Indoor-level WST Scores
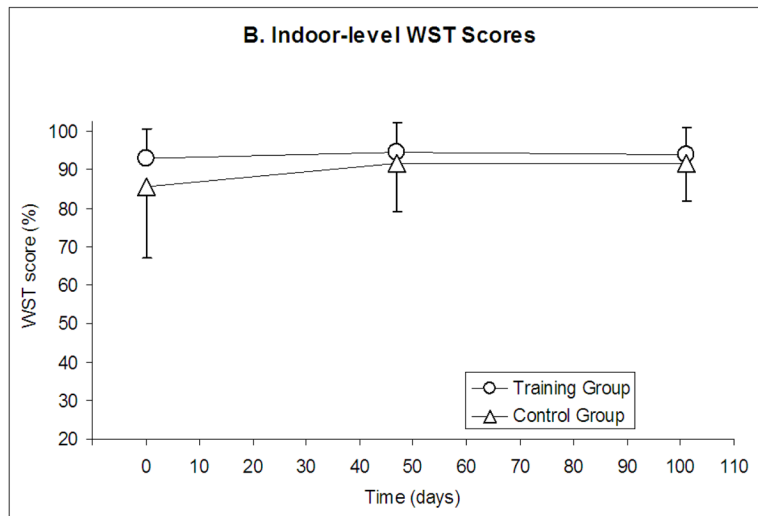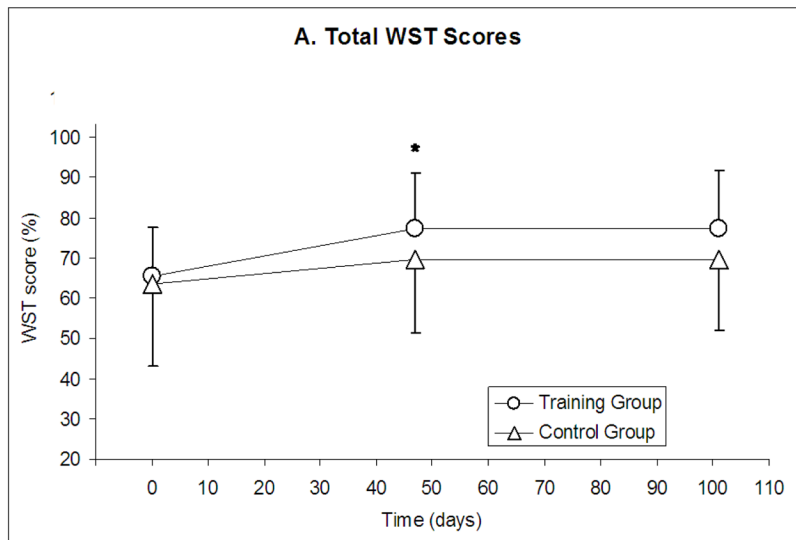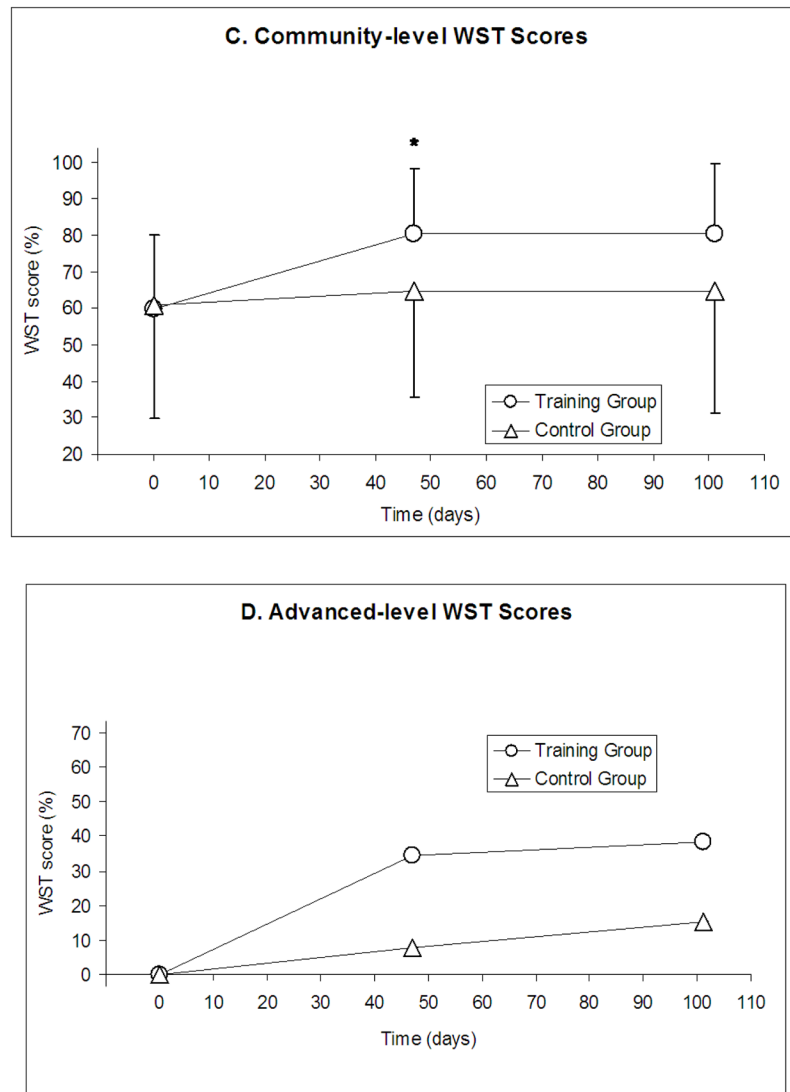
Figure 2.
Total and Subtotal WST Scores plotted against time. A. Total WST scores. B. Indoor-level WST scores. C. Community-level WST scores. D. Advanced-level WST scores. For 2A, 2B and 2C, the mean and standard deviation values are shown. For 2D, the median value is shown because the data were non-normal. T1 represents the baseline evaluation, T2 is the evaluation followed training (~47 days after T1). T3 is the follow-up evaluation (~101 days after T2). * indicates statistical significance (p = 0.0296 for Figure 2A and p = 0.0018 for Figure 2C).

Table 1

Participant Demographic and Clinical Data at Baseline

Characteristics	Parameter	WSTP Group (n = 19)	Control Group (n = 20)	P Value[*]
Age (years)	Mean ± SD	48.9 ± 18.9	43.1 ± 22.1	0.240
Sex (n [%])	Women	6 (31.6%)	6 (30.0%)	0.915
Height (cm)	Mean ± SD	164.5 ± 10.9	163.5 ± 11.5	0.307
Weight (kg)	Mean ± SD	83.7 ± 13.8	70.2 ± 17.0	0.025
Rehabilitation center site	CRLB	9 (47%)	6 (30%)	NA
	IRGLM	9 (47%)	12 (60%)	
	IUGM	1 (5%)	2 (10%)	
Clinical status (n [%])	Inpatient	14 (73.7%)	17 (85.0%)	0.451
Diagnosis accounting for wheelchair use	Amputations	5 (26%)	4 (20%)	NA
	MS	6 (32%)	2 (10%)	
	SCI	7 (37%)	12 (60%)	
	Other	1 (5%)	2 (10%)	
Time from diagnosis to T1 (years)	Median	0.4	0.3	0.656
	Range	0.1–10.3	0.1–11.7	

[*] The Bonferroni-adjusted α level is 0.004.

Abbreviations: CRLB = Centre de réadaptation Lucie-Bruneau, IRGLM = Institut de réadaptation Gingras-Lindsay-de-Montréal, IUGM = Institut universitaire de gériatrie de Montréal, MS = multiple sclerosis, NA = not applicable due to insufficient data in each category, SCI = spinal cord injury, SD = standard deviation.

Where the variance (the standard deviation as a percentage of the mean value) was high, we have reported the median value.

Table 2

Wheelchair-Usage Data at Baseline

Characteristic	Parameter	WSTP Group (n = 19)	Control Group (n = 20)	P Value[*]
Experience with any wheelchair (years)	Median	0.3	0.2	0.436
	Range	0.1–15.0	0.1–6.5	
Experience with current wheelchair (weeks)	Median	6.0	5.5	0.396
	Range	0.1–771	1–52	
Frequency of wheelchair use (hours/day)	<=2	1 (5%)	1 (5%)	NA
	2–4	3 (16%)	0 (0%)	
	4–6	6 (32%)	4 (20%)	
	6–8	3 (16%)	6 (30%)	
	>8	5 (26%)	8 (40%)	
Method of wheelchair propulsion	2 hands	14 (73.7%)	14 (70%)	0.798[*]
	Foot/feet only	1 (5.3%)	0 (0%)	
	2 hands + 1–2 feet	4 (21.1%)	6 (30.0%)	
Location of wheelchair use	Home	15 (79%)	12 (60%)	0.200
	Work	1 (5%)	1 (5%)	0.970
	School	1 (5%)	0 (0%)	0.487
	Community	13 (68%)	13 (65%)	0.821
	Recreation/Sports	7 (37%)	6 (30%)	0.651

[*] The Bonferroni-adjusted α level is 0.004.

Abbreviation: NA = not applicable due to insufficient data in each category.

Where the variance (the standard deviation as a percentage of the mean value) was high, we have reported the median value.

[*] The p value from the logistical regression reflects a global test for the 3 levels of categorical variable

Table 3

Wheelchair Data at Baseline

Characteristics	Parameter	WSTP Group (n = 19)		Control Group (n = 20)	
		n	%	n	%
Manufacturer	Quickie	5	26	7	35
	Invacare	9	47	10	50
	Orthofab	5	26	1	5
	Everest & Jennings	0	0	2	10
Owner	Institution	10	53	13	65
	Province	1	5	0	0
	User	8	42	6	30
	Other	0	0	1	5
Frame	Folding	12	63	8	40
	Rigid	7	37	12	60
Seat type	Sling	17	94	19	100
	Rigid	1	6	0	0
Seat height	Adult	12	75	15	79
	Hemi	4	25	4	21
Seat belt	Yes	1	5	2	10
Cushion	Yes	19	100	20	100
Backrest	Sling	16	89	18	90
	Rigid	2	11	2	10
Backrest height	Low	1	6	1	5
	Scapula	15	88	18	90
	Shoulder top	1	6	1	5
Adjustable axles	Yes	16	94	15	88
Tires	Pneumatic	18	100	17	85
	Solid	0	0	3	15
Brakes	Scissor	1	6	1	5
	Toggle	17	94	18	95
Brake extensions	Yes	10	53	7	37
Rear anti-tip devices	Yes	18	95	17	85
Footrests	One	4	22	4	21

Characteristics	Parameter	WSTP Group (n = 19)		Control Group (n = 20)	
		n	**%**	**n**	**%**
	Two	11	61	9	47
Removable armrests	Yes	11	58	9	45
Backpack	Yes	3	16	2	10

Table 4

Total and Subtotal WST Scores

Score	Group	T1 (Baseline)	T2 (Post-training or equivalent)	P values (WSTP vs Control at T2)	T3 (Follow-up)	P values (T2 vs T3)
Total	WSTP	65.4 ± 12.4	77.4 ± 13.8	0.0296[*]	77.4 ± 14.3	0.990
	Control	63.7 ± 20.7	69.8 ± 18.4		69.7 ± 17.6	0.641
Indoor	WSTP	92.9 ± 7.9	94.5 ± 7.8	0.575	94.0 ± 7.0	0.781
	Control	85.6 ± 18.5	91.8 ± 12.5		91.6 ± 9.7	0.751
Community	WSTP	59.8 ± 20.1	80.2 ± 17.8	0.0018[*]	80.2 ± 19.5	1.000
	Control	60.7 ± 31.1	64.7 ± 28.9		64.8 ± 33.8	0.472
Advanced	WSTP	Median 0 Range 0–77	Median 34.6 Range 0–100	0.119	Median 38.5 Range 0–100	0.631
	Control	Median 0 Range 0–77	Median 7.7 Range 0–77		Median 15.4 Range 0–77	0.337

[*] Statistically significant at an α level of 0.05 for the primary outcome.

[**] Statistically significant at a Bonferroni-adjusted α level of 0.005.

The mean ± standard deviation values are shown. Where the variance (the standard deviation as a percentage of the mean value) was high, we have reported the median value and the range.

Table 5

Individual Skill Success Rates

Skill	Skill Level	WSTP Group						Control Group					
		T1 (n = 19)		T2 (n = 18)		T3 (n = 18)		T1 (n = 20)		T2 (n = 16)		T3 (n = 13)	
		n	%	n	%	n	%	n	%	n	%	n	%
Brakes, apply *	Indoor	19	100	16.5	92	16.5	92	17	85	13.5	84	10.5	81
Brakes, release *	Indoor	19	100	17	94	17	94	17	85	15	94	11	85
Armrests, move away *	Indoor	13.5	71	11	61	9	50	12.5	63	10	63	6	46
Armrests, restore *	Indoor	11.5	61	10	56	8.5	47	12.5	63	10	63	6	46
Footrests, move away *	Indoor	9	47	7	39	7	39	5	25	2.5	16	3	23
Footrests, restore *	Indoor	9	47	7	39	7	39	4	20	2.5	16	3	23
Rolling forward	Indoor	19	100	17	94	18	100	20	100	16	100	13	100
Rolling backwards	Indoor	18	95	18	100	17	94	20	100	16	100	13	100
Turn in place *	Indoor	17.5	92	15.5	86	16.5	92	16.5	83	14	88	13	100
Moving turn, forward *	Indoor	19	100	18	100	18	100	20	100	15	94	13	100
Moving turn, backward *	Indoor	19	100	18	100	17.5	97	19.5	98	15	94	13	100
Sideways maneuvering *	Indoor	19	100	17	94	17	94	17	85	16	100	13	100
Reaching, ground	Indoor	17	90	18	100	18	100	18	90	15	94	13	100
Reaching, high object	Indoor	18	95	18	100	18	100	16	80	15	94	12	92
Transfer out of wheelchair	Indoor	17	90	17	94	17	94	16	80	15	94	12	92
Transfer into wheelchair	Indoor	15	79	16	89	17	94	15	75	14	88	10	77
Door, open away	Indoor	19	100	18	100	18	100	19	95	16	100	12	92
Door, open toward	Indoor	19	100	18	100	17	94	17	85	16	100	12	92
Obstacle 2cm	Indoor	16	84	17	94	17	94	17	85	14	88	11	85
Increased rolling resistance, carpet	Indoor	19	100	18	100	18	100	17	85	14	88	11	85
Street crossing	Community	19	100	17	94	18	100	18	90	13	81	11	85
Fold wheelchair	Community	3	16	9	50†	11	61	6	30	6	38	5	39
Unfold wheelchair	Community	4	21	9	50†	13	72	6	30	6	38	5	39

Skill	Skill Level	WSTP Group						Control Group					
		T1 (n = 19)		T2 (n = 18)		T3 (n = 18)		T1 (n = 20)		T2 (n = 16)		T3 (n = 13)	
		n	%	n	%	n	%	n	%	n	%	n	%
Obstacle 13cm	Community	3	16	8	44†	5	28	3	15	2	13	2	15
Cross slope*	Community	19	100	17.5	97	17.5	100	17	85	13	81	11	85
Increased rolling resistance, gravel	Community	12	63	17	94†	15	83	14	70	13	81	9	69
Pothole, 15cm	Community	13	68	18	100†	17	94	14	70	13	81	10	77
Pothole, 30cm	Community	10	53	15	83†	14	78	10	50	9	56	7	54
Incline 5°, ascent	Community	18	95	18	100	18	100	16	80	15	94	11	85
Incline 5°, descent	Community	18	95	17	94	18	100	16	80	15	94	11	85
Level change 5cm, ascent	Community	10	53	15	83†	15	83	14	70	12	75	10	77
Level change 5cm, descent	Community	10	53	16	89†	15	83	14	70	12	75	10	77
Incline 7.5°, wheelie forwards descent	Advanced	1	5	8	44†	8	44	5	25	3	19	5	39
Level change 15cm, ascent	Advanced	0	0	3	17	2	11	2	10	1	6	1	8
Level change 15cm, descent	Advanced	0	0	3	17	1	6	2	10	1	6	1	8
Level change 15cm, wheelie forwards descent	Advanced	0	0	1	6	1	6	0	0	0	0	1	8
Wheelie, no-hands rest	Advanced	3	16	9	50†	9	50	7	35	6	38	3	23
Wheelie, stationary	Advanced	4	21	10	56†	10	56	6	30	7	44	6	46
Wheelie, rolling forward	Advanced	3	16	9	50†	9	50	4	20	6	38	5	39
Wheelie, rolling backward	Advanced	3	16	8	44†	8	44	5	25	6	38	4	31
Wheelie, turn in place*	Advanced	3	16	7	39	9.5	53	6	30	6	38	5	39
Wheelie, moving turn forwards*	Advanced	2.5	13	8.5	47†	8.5	47	4	20	6	38	5	39
Wheelie, moving turn backwards*	Advanced	3	16	8	44†	8	44	5	25	6	38	5	39

* Although the left and right sides were scored separately, the mean values of the two are shown, which explains how a non-integer n value is possible.

† These skills met the criterion of ≥25% difference in success rates between T1 and T2 in the same group. (No skills met the criterion of ≥25% difference in success rates between T2 and T3 in the same group.)