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Effectiveness of a rehabilitation dog in fostering gait retraining for adults with a recent stroke: A multiple single-case study

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Abstract. *Introduction:* Gait retraining approaches and walking aids currently used for patients with recent stoke present limitations regarding their utilization in clinical and real life settings. A rehabilitation facility implemented an innovative approach using a rehabilitation dog for gait retraining and as a walking aid.
Objective: To explore the effectiveness of rehabilitation dog, both as a gait retraining approach and as a walking aid, to improve walking speed and gait pattern.
Methods: Four participants, post recent stroke with hemiparesis, were recruited in a rehabilitation unit. A multiple single-case ABA design was used. The three-week training period focused on gait retraining using a rehabilitation dog. For each session, walking speed with the rehabilitation dog and the cane was documented. In each phase (ABA), the gait pattern was analyzed.
Results: Mean (SD) age of the participants was 58 (3.2) years old; time since stroke was 88 (61.41) days. For three participants, walking speed was significantly increased after retraining with the dog. The four participants showed improvement of their gait pattern across phases and walked significantly faster with the dog than with the cane.
Conclusion: This pilot study suggests that a rehabilitation dog is an interesting gait retraining approach for a clinical setting and an effective walking aid following stroke.

Keywords: Gait training, rehabilitation dog, stroke, walking speed, gait pattern

1. Introduction

Approximately 80% of individuals regain some locomotor function after a stroke, but many remain with significant gait deficits [24]. Different rehabilitation approaches to gait retraining are used in clinical practice [21] to reduce the consequences of walking deficits and walking aids can be used to foster the realisation of life habits. However, there are currently limits and challenges associated with every known approaches for gait retraining and for the utilisation of common walking aids [8,37]. Innovative techniques should be experimented with, and the use of rehabilitation dogs could be one of them.

Common approaches [2,18] of gait retraining include the Bobath-Based approach [7,8,14], the Motor Relearning Program [5,6], and using a treadmill with and without body weight support [19,25,29,38]. However, studies [31,37] have found that focusing on walking itself was more effective than choosing a specific gait retraining approach or developing lower limb strength, balance or cardiorespiratory function. Moreover, despite promising results [38,39], the efficacy of locomotor training on treadmill may be restricted in clinical practice because of limited access to the equipment and

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Fig. 1. Weight shifted posture of a stroke patient walking with a cane.

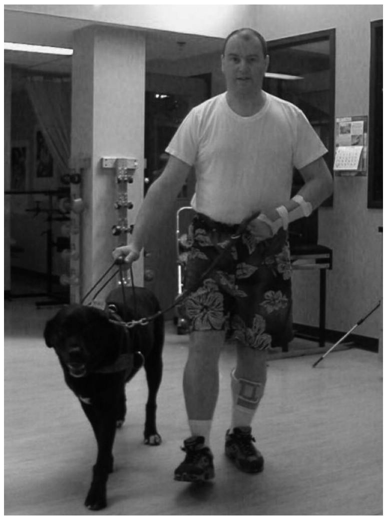

Fig. 2. Posture of a stroke patient walking with a rehabilitation dog.

the physical demand on therapists to manually help patients who require substantial physical assistance. Furthermore, the treadmill does not stimulate the functional components of moving around such as changing direction, stopping frequently and distractions that occur in an everyday environment.

Given these disadvantages of the different approaches, clinicians have tended to use conventional walking aids such as the quad cane, walker and straight cane. Although these are originally walking aids, they are also used to practice walking, and thus are also used as a gait retraining approach. However, lack of fluidity is observed when utilizing common walking aids: patients often bend forward, put a significant amount of weight on the walking device, or reduce their walking speed [7,8,14,25,29,38]. Many authors [7,8,14] do not recommend those devices for training.

The idea to use an alternative training approach by training rehabilitation dogs to replace conventional walking aids and to serve as a gait retraining approach emerged following clinical observations. These observations suggest that clients walking with a service dog (which is a dog belonging to the patient and helping him/her to achieve different life skills activities, including walking) seem to have better fluidity of movement, more normal gait and take larger steps than when they use conventional walking assistive devices [33,34] (see Figs 1 and 2; two videos can be seen at: Patient walking with is cane: http://www.centredereadaptationestrie.org/spip.php?rubrique347&fsize=14&lang=fr.

Same patient walking with our rehab dog five minutes later: http://www.centredereadaptationestrie.org/spip.php?rubrique349&fsize=14&lang=fr.

In contrast to service dogs, rehabilitation dogs would be specifically trained and used with many type of clients.

The dog's role as a therapeutic method has been documented to motivate children to do various tasks as well as to walk [1,28], to assist its master if necessary [1, 28] or foster the person's social and personal interactions [26,27]. The effect of using dogs as a gait retraining approach and a walking aid has been documented in the clinical setting where the idea emerged, but has never been systematically investigated. Therefore, the general objective of this study was to document, in a pilot study, the effectiveness of a rehabilitation dog to foster walking, both as a therapeutic method and as a walking aid with adults with hemiparesis.

2. Method

2.1. Participants

Participants were recruited from an inpatient rehabilitation unit in Sherbrooke, Québec, Canada. The inclusion criteria were: 1) diagnosis of a first stroke resulting in hemiparesis, 2) no major cognitive deficits identified using the MMMS [4]; 3) no severe left hemineglect; 4) ability to understand instructions; 5) score of at least 3 for the limb and 1 for the foot on the Chedoke McMaster Stroke Assessment (CMSA) [16]; 6) ability to stand without help (but they could use a technical aid to walk); and 7) ability to give informed consent. Potential participants were excluded if they had:

1) an untreated severe vestibular problem; 2) a serious uncontrolled medical problem (heart disease, hypertension); or 3) an allergy to dog. The first participant (S1) was a 56 years old man, 182 pounds (82.5 kg), 137 days post left capsulo-thalamic hemorrhagic stroke. The second one (S2) was a 57 years old man, 151 pounds (68.5 kg), 24 days post rupture of the right sylvian artery. The third one (S3) was a 63 years old female, 148 pounds (67 kg), 144 days post rupture of a sub-arachnoïd aneurysm on the left posterior communicant artery. The forth participant (S4) was a 57 years old man, 157 pounds (71 kg), 47 days post rupture of a left temporo-occipital arterio-venous malformation. The study was approved by Centre's Ethics Review Board.

2.2. Design

Single-case studies are often used to explore the effect of an innovative treatment for which there is no previous data [13,30]. In this case, there was no available data on gait retraining with rehabilitation dogs and thus a multiple single-case, ABA experimental design was used with four individuals. First, walking parameters were recorded during the baseline period (A). Walking retraining with the dog was then introduced (B – retraining with the dog) and the walking parameters were again recorded at each session. Finally, the walking parameters were measured after the end of the walking retraining phase (A – post-measures).

2.3. Intervention

Participants were enrolled in the study early in the gait training, outside of the parallels bars. Therapy sessions lasted 60 minutes and were done in general 4 times a week. Outside the therapy sessions, participants used walking aids appropriate to their abilities. During gait retraining, the dog was used for balance re-education, posture correction before and during walking, slow and fast walking, and navigating an obstacle course. The dog used for the purpose of this study was provided by Mira Foundation (see http://www.mira.ca/en/our-dogs/8/breeding_35.html for a full description).These dogs were selected and trained to respond to the demands and expectations of a rehabilitation dog. The therapists were coached by the trainers to work with the qualified dog. The dog wore a leather harness mounted with metal bars attached to a handle and patients used it as a walking aid (see Fig. 2). The rehabilitation dog was also used in some parts of the training to practice transfer from a sitting to a standing position or from chair to bed, and for re-education of the affected upper limb.

As an example, for the sitting-to-standing transfer retraining, the dog was placed in front of the participant, two to three feet away from him, with his back in the participant's frontal plane. The participant placed his hand on the dog's back. As he leaned forward, he started-to stand up. He was permitted to keep his balance on the dog's back if needed. Anterior flexion of the trunk is the desired movement to begin the transfer to standing. When the participant sat down, he continued to lean on but was not permitted to pull on the dog, which maximized the work done by the trunk and leg muscles. At every step in the retraining process with the dog, the physiotherapist placed the dog and the participant in the best position to trigger the use of the desired muscle groups.

2.4. Variables, instruments and procedure

Two main walking parameters were measured to document the effectiveness of the rehabilitation dog: walking speed and gait pattern. Walking speed [10] was measured in seconds over 10 meters at each session. Due to difference in therapy weekly frequency, all subjects did not have the same number of walking speed measures during baseline and post-measures (baseline/post-measures): S1 – 3/5, S2 – 4/3, S3 – 4/4, S4 – 4/3). During intervention, each subject had 11 measures of walking speed.

The participant's gait pattern was analyzed once each session with the Rancho Los Amigos Observational Gait Analysis [32], which was used to identify the main deficits in the walking phases and visually analyze the gait pattern. This gait analysis can demonstrate minor and major deviations. A minor deviation is a small modification to the normal gait pattern, such as an excessive knee flexion during the swing phase. A major deviation is a more severe modification such as pelvis hikes during swing.

Both variables were documented with the rehabilitation dog and with the participant's usual walking aid.

2.5. Analyses

Dog as a gait retraining approach: Data collected for *walking speed* with the dog and with the cane were combined to create a general indicator of walking speed (mean time required to complete 10 meters for the cane and the dog combined). These combined data were plotted on a graph to enable visual analysis. Visual

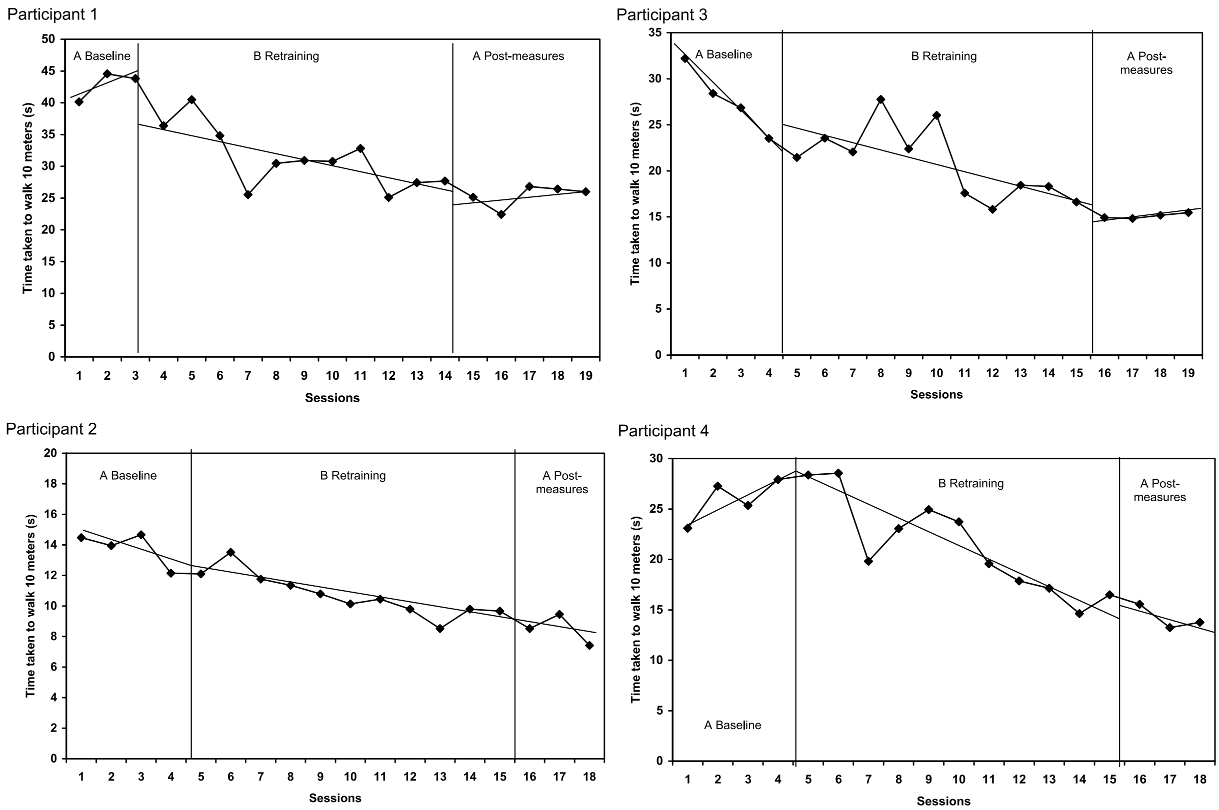

Fig. 3. Walking speed (general indicator) of the 4 subjects following retraining with the dog. Baseline sessions (A) : recording of walking parameters before the retraining phase. Retraining sessions (B) : walking retraining with the dog. Post-measures sessions (A – post-measures): recording of walking parameters after the end of the retraining phase.

analyses were done in order to detect a change in trend between baseline, retraining and post-measures. More specifically, following general guidelines [30], changes in level, variability, direction or slope were sought. Least square lines were also drawn to improved visual analyses [20]. Non parametric statistical analyses were done to support the results observed in the graphs. The differences between the study phases (baseline, retraining, post-measures) were estimated with the Kruskall-Wallis χ^2. Serial dependency was also assessed by an autocorrelation coefficient [15]. Serial dependency refers to the fact that, in times series data, the participant's performance at time X can be correlated with his or her performance at time X–1. Thus observations are not independent. Most of the data were autocorrelated ($r > 0.20$). Since autocorrelation is known to increase the probability of type I errors when there is a positive correlation [15], we chose a conservative p value of 0.010 [15,35]. *Gait pattern* analyses were done by combining results from walking with the dog and with the cane. A general indicator of gait pattern was computed by calculating the mean number of major and minor deviations obtained during baseline, retraining and post-measures. Statistical analyses were done on the 4 subjects as a group with the Friedman test.

Dog as a walking aid: A second analysis consisted in creating graphs for the *walking speed* obtained with the different walking aids (dog, cane), in each phase (baseline, retraining and post-measures). Visual analyses were done to appreciate the difference between them. The differences between the walking aids were analysed statistically with the Wilcoxon signed rank test. For gait pattern analyse, statistical analyses were done on the 4 subjects as a group with the Mann-Whitney U test.

3. Results

3.1. Effectiveness of the dog as a gait retraining approach

Walking speed: Visual analysis of the graphs sug-

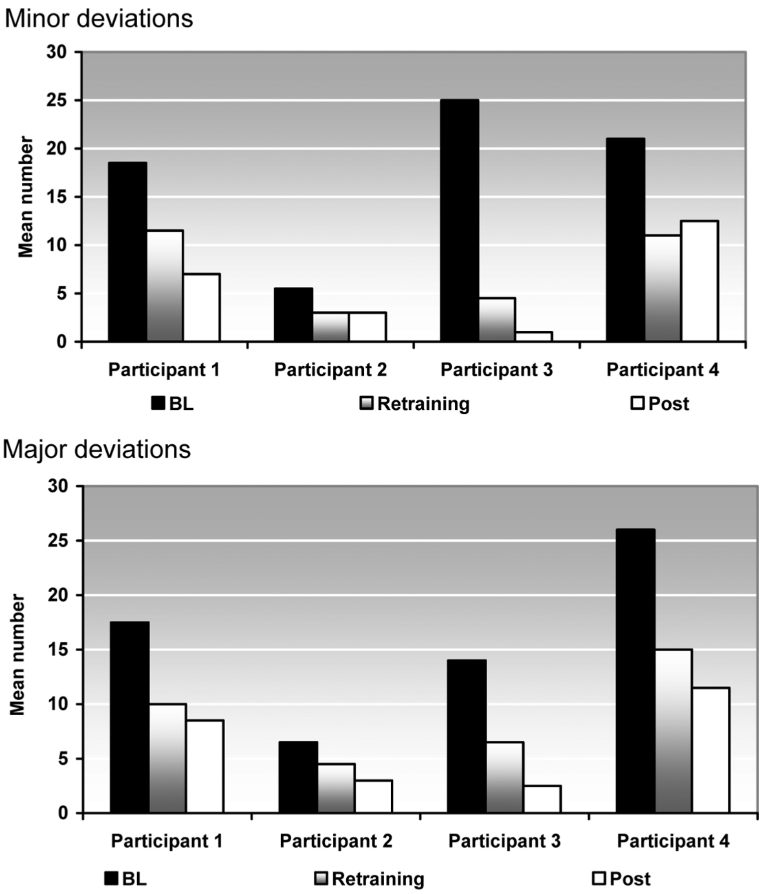

Fig. 4. Gait patterns of the 4 subjects following retraining with the dog. Bl = baseline; Post = post-measures.

gested an improvement in walking speed between baseline and the end of the retraining phase for participants 1 and 4 (see Fig. 3). This improvement was less evident for participants 2 and 3, who seemed to increase their walking speed gradually and continuously during the three phases. The statistical analyses supported these results: the differences between the three phases (baseline, retraining, post-measures) were highly significant for participants 1, 2 and 3 (respectively, Kruskall-Wallis tests $\chi^2 = 10.6$, $p = 0.005$; $\chi^2 = 11.5$, $p = 0.003$; $\chi^2 = 12.5$, $p = 0.002$) and at the limit of significance for participant 4 (Kruskall-Wallis $\chi^2 = 8.3, p = 0.016$).

Gait pattern: The visual analyses suggest that the 4 participants showed an improvement in their gait pattern between baseline and the end of retraining phase. (See Fig. 4). As a group, the 4 subjects showed a significant decrease in the number of minor (Friedman $\chi^2 = 6.5$, $p = 0.038$) and major deviations ($\chi^2 = 8.0$, $p = 0.018$).

3.2. Difference between walking aids: Comparison between the dog and the cane

Walking speed: The four participants walked faster with the dog than with the cane during the baseline and retraining phases (see Fig. 5). This difference, which can be seen on the graphs, was not significant during baseline (Wilcoxon signed rank tests; all p's > 0.07) but was highly significant for the retraining phase (Wilcoxon signed rank tests; all p's < 0.003). There is a reduction of the differences between the dog and the cane results over time, to two leading to very similar walking speed during post-measures for participants 2, 3 and 4.

Gait pattern: The graphs (see Fig. 6) suggest that the participants generally presented fewer deviations (minor and major) when walking with the dog than with the cane during the baseline. The improvement in gait pattern with the dog persisted during the retraining phase and maintenance phases for all the participants. However, these differences observed between the dog

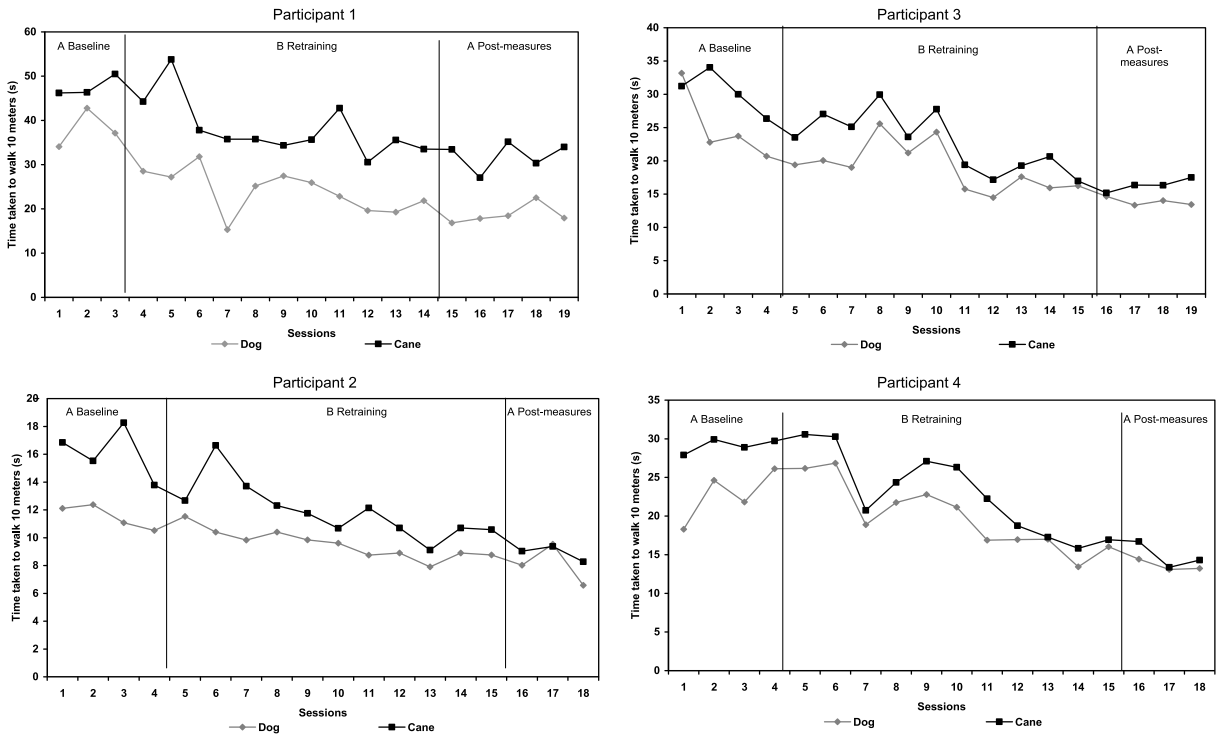

Fig. 5. Comparison of the 2 walking aids (dog, cane) in terms of walking speed. Baseline sessions (A) : recording of walking parameters before the retraining phase. Retraining sessions (B) : walking retraining with the dog. Post-measures sessions (A – post-measures): recording of walking parameters after the end of the retraining phase.

and the cane were not statistically significant (Friedman tests; all p's > 0.20).

4. Discussion

Objectives of this pilot study were to explore the effectiveness of a rehabilitation dog as a *gait retraining approach* and as a *walking aid* for in individuals with hemiparesis. The two locomotion parameters under study were walking speed and gait pattern. The results suggest that both improve over time, after a retraining period. More specifically, all the participants walked faster with the dog and tend to show an improvement in their gait pattern at the end of the retraining period.

Dog as a *gait retraining approach* could be an interesting option for clinicians. To improve walking [17, 31,37] many studies found that the best approach for clinicians was to practice walking directly, intensity and task-oriented training should be incorporated into the rehabilitation program [31,37]. Even if there are scientific and clinical evidences that the cane should not be used for gait retraining [7,8,14,25,29,38], clinicians tend to use it, as often no other options are available to practice walking in real life situation. As our results suggest that using rehabilitation dogs in therapy improves both speed and gait pattern, the dogs could be used to perform gait training in different setting. Gait training with the rehabilitation dog could thus be as interesting as treadmill, without the limit of the treadmill on a functional point of view.

Considering the objective to compare the dog with other *walking aids*, results suggest that the 4 participants walked faster with the dog than with the cane. This result is promising, since increasing walking speed in individuals with hemiparesis improves muscle use, joint range of motion and gait pattern symmetry [10, 23]. Thus, the rehabilitation dog could be an interesting alternative to the cane during retraining. Since there is a reduction of the differences between the dog and the cane's results over time, this suggests that the participants could also use the learning done with training dog and use it to walk without the dog. These results seems very important considering that walking with the cane, which is often necessary once rehabilitation is over, is a main issue in real life situations. In addition, the transition from the dog to a conventional walking aid never presented any clinical difficulties for our 4 participants.

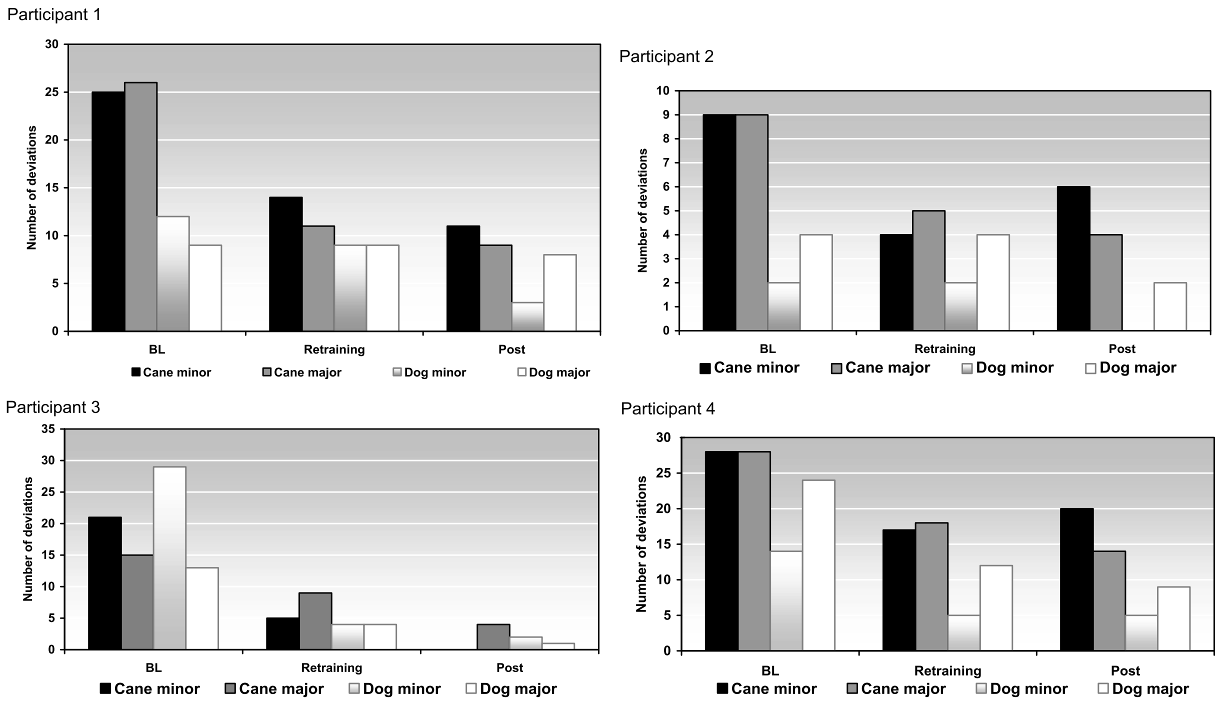

Fig. 6. Comparison of the two walking aids in terms of gait patterns (number of major and minor deviations). BL = baseline; Post = post-measures.

Apart from the parameters collected in this study, clinicians observed many other positive impacts of the dog's utilization that could be interesting to investigate in further studies. For instance, the participants' gait patterns showed spontaneous weight shift from the harness to the paresic lower limb when using the rehabilitation dog, probably as a consequence of the fear of hurting the animal. The importance of putting weight on the hemiparesic limb [9,12] to generate adequate sensory input and possibly activate the CPG has been documented [22,36]. More specifically, studies [9] show the importance of combining loading with correct positioning of the hip and the rehabilitation dog seems very promising in assisting to achieve both.

Another interesting clinical observation concerns the learning process related to gait training with a walking aid. Learning to use a cane or walker is an additional difficulty in locomotor re-learning, especially if the person has cognitive or speech disorders [3]. Furthermore, with the cane, the patient must learn how to move that static object. With the dog, the person only needs to follow the movement of the dog without analysing each part of his gait pattern. With the dog, it was often possible to eliminate this step since the participants had nothing to learn; all they had to do was hold the handle and walk. The dog adopts the same walking speed as the person and turns when the person changes direction. Since this training method is relatively simple, walking can be practiced often. Also, using a rehabilitation dog creates a rehabilitation context that is more accessible than training with a treadmill and has more flexibility since it allows for changes in direction and location of the training and interactions with the environment that are much closer to reality. The participants became aware of their environment during the training through this variety of therapeutic situations instead of focusing solely on walking. Repeated training sessions with the dog are not monotonous. It is a living being that puts the person in new situations, just as in everyday life. Finally, our participants had varying amounts of time since the stroke and were at different stages in their recovery, which suggests that a rehabilitation dog could be used with different populations of participants with stroke.

Although results of this pilot study are interesting and promising, they should be interpreted with caution. As the population was composed of individuals with quite recent stroke, the probable role of spontaneous recovery cannot be ignored. However, if patients' improvement was only due to spontaneous recovery, it could be presumed that a constant improvement would have been observed over time, thus across the three phases of the study. As opposed to that, visual analysis of the graphs suggests that 3 out of 4 patients showed a clear change in trend between the baseline and the retraining phases for walking speed. Similar results were reported in the literature [11], where rehabilitation outcomes with recent stroke patients were beyond those attributed to spontaneous recovery.

The major limitation of this study was the lack of a control group using another rehabilitation method. In addition, the research design would have been improved if the 4 subjects had begun the study at the same time, thus allowing the use of a multiple baseline design: clinical reality did not allow this. Another limitation of our study was the small number of participants and the fact that interventions were made with only one rehabilitation dog. However, the main purpose of this pilot study was to obtain preliminary findings on the rehabilitation dog.

A larger study would be indicated to verify the benefits of this therapeutic approach in comparison to other approaches and to other walking aids for locomotor recovery. For instance, based on our observations, the fluidity of movement appears to occur earlier during gait training with the dog, an interesting component that could be further investigated. The impact of a rehabilitation dog on other parameters should also be investigated; for example, psychological and affective variables such as self-confidence, fear of falling and social participation. A study measuring skills maintenance and participation in activities of daily living after the training program should also be done to confirm the benefits of the rehabilitation dog in subjects with hemiparesis. It would also be relevant to document the stability that a dog can offer to patients in term of postural oscillation during ambulation.

5. Conclusion

This exploratory study suggests that using a rehabilitation dog is a promising approach for improving walking parameters such as walking speed and gait pattern. Further work needs to be done on this innovative approach to better describe its different aspects.

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Competing interests

None declared.

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Contributors

LR participated in the design of the study, carried out the data collection, analysis and interpretation, drafted and revised the manuscript.

HC participated in the design of the study, data analysis and interpretation, drafted and revised the manuscript.

NB carried out the data analysis and interpretation, drafted and revised the manuscript.

CC participated in the design of the study, data analysis and interpretation, drafted and revised the manuscript.

NC participated by coaching the therapist throughout the integration of the dog in a health care facility.

CD participated by giving judicious comments during data collection.

All authors read and approved the final manuscript.

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